Appendix 3: Specifications

Exceptional service in the national interest

Sandia National Laboratories

Section 01065 – Environment, Safety, and Health for Construction Contracts

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 01065 – Environment, Safety, and Health for Construction Contracts

Table of Contents

List of Figures

List of Tables

Appendix B: Facilities Superintendent — Job Aid

Change Log

Date	Changes Made By	Type	Change Description
5/17/10	JCG	Subst	Reformatted the specification to FMOC standards and edited for grammar and punctuation. Added section 3.02, "Medical/Health Protection" and Appendix A, "Occupational Medicine Services."
6/22/10	JCG	Admin	Added a sentence to the end of paragraph T in section 3.04 to satisfy a corrective action. Changed the cover and footer date to June, 2010 and the Revision Number to 3.
8/26/10	DH	Subst	Corrected outdated attachments and provided reference to correct information. Removed Attachments A, B, and D and renumbered C to become Attachment A.
4/30/12	KLB/GK/BB	Subst	Revised section 3.04.C, D, R, and T to better reflect current requirements regarding excavation and penetration permits, digging, hoisting and rigging, and electrical work.
5/5/14	Greg Kirsch/Christy Churchwell	Subst	Under the ISMI section, the engineered safety requirements were added to Table 1.1
4/18/16	Tim Peterson	Subst	Updated formatting.
10/12/16	Greg Kirsch/Jennifer Sawayda	Subst	Made substantial additions to content; edited document and reformatted into correct document template.
12/7/2016	Jennifer Sawayda	Admin	Per request of Mary St. Lawrence, changed Radiological Work Permit to radiological Technical Work Document
8/28/2018	Greg Kirsch and Jennifer Sawayda	Subst	Worked on formatting tables, added high-risk activities to Definitions, added NM Environment Dept under “References,” added CSSP requirements under “Quality Assurance,” added High-Risk Activities and Pre-Task Planning under Contract-Specific Safety Plan, added Pre-Work Evaluation of Subcontractor Work Team row for Table 1.1, added Hazard Awareness and Identifying and Controlling Energy Sources under “Expectations” for Table 1.1, added “Assessment of Pre-Task Plan” row to Table 1.1, added more information for Section 3.3, changed FMOC to Facilities, on pg. 5 and p. 27, changed to NTESS as I believe it’s talking about the entity rather than the facility
9/26/18	Jennifer Sawayda, Greg Kirsch, Brad Elkin	Subst	Split Definitions section into Roles and Responsibilities and Definitions; added roles for Construction Manager, Sandia Construction Observer; added Activity Hazard Analysis under “Submittals”; made changes to “Quality Assurance” section; added information for Pre-Task Planning and High-Risk Work; added information on Digger-Derricks; added Appendix B; added information to Table 1.1; changed Sandia Project Lead to Sandia Project Manager and updated definition; changed Inspector to Sandia Construction Inspector in Section 1.3
1/03/19	Jennifer Sawayda	Admin	Removed reference to ESH100.4.RPT.3, *Report Occurrence*, in Table 1-1; this reference # is no longer valid as the policy system has been updated
3/07/19	Jennifer Sawayda	Admin	Fixed some of the acronyms

10/14/19	Jennifer Sawayda	Admin	Added paragraph on wall/ceiling/floor verification under Section 3.4

1.0 Part 1 – General

1.1 Summary

A. This section includes requirements and guidelines in performance of work concerning the protection of the environment and property and the safety and health of Contractors, Sandia National Laboratories (SNL) and Department of Energy (DOE) employees, visitors to SNL, and members of the public. The entire Environment, Safety, & Health (ES&H) program shall focus on safe-by-design intent, understanding the technical basis for the work and identifying and controlling energy sources, unacceptable consequences, risk assessments, and positive verification.

B. Related Sections

Refer to the following sections for related work:

1. Section 01505, "Construction Waste Management"
2. Section 01563, "Dust Control"
3. Section 26 04 75, "Primary System Safety Requirements"

1.2 References

A. American Conference of Governmental Industrial Hygienists

- Threshold Limit Values (TLVs) for Chemical Substances
- Physical Agents and Biological Exposure Indices (BEIs)

B. American National Standards Institute (ANSI)

Number	Title
Z41	Personal Protection - Protective Footwear
Z49.1	Sections 4.3 and E4.3 Welding, Cutting, and Allied Processes
Z88.2	Practices for Respiratory Protection
Z89.1	Industrial Head Protection
Z136.1	Safe Use of Lasers

C. American Society of Mechanical Engineers (ASME)

Number	Title
B30.5	Mobile and Locomotive Cranes

D. Code of Federal Regulations (CFR)

Number	Title
29 CFR 1926	Title 29-Labor, Part 1926-Safety and Health Regulations for Construction
29 CFR 1910	Title 29-Labor, Part 1910-Occupational Safety and Health Standards
10 CFR 851	Worker Safety and Health Program

E. New Mexico Environment Department

Number	Title
NMAC 20.9.2	Title 20 Environmental Protection, Chapter 9 Solid Waste, Part 2 Solid Waste Management General Requirements

F. Environmental Protection Agency (EPA)

832-R-92-005 *Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices*

G. National Fire Protection Association

Number	Title
70	National Electrical Code
70E	Standard for Electrical Safety Requirements for Employee Workplaces

1.3 Roles and Responsibilities

Sandia Contracting Representative (SCR)	Person authorized to act as official representative of SNL for specific purpose of administering Contract, including payment authorization and approval for change orders. SCR is the only person who may legally obligate SNL for expenditure of funds, change scope, change level of effort, change terms and conditions, negotiate, and sign documents legally binding SNL commitment. Obligations or promises, implied or expressed, by SNL personnel other than the SCR do not bind SNL in any manner.
Sandia Delegated Representative (SDR)	Person in the Contract who is authorized to act as delegated SNL representative for the specific purpose of review, inspection, and acceptance of work, and to interpret plans, specifications, codes, and standards. The SDR shall not exercise supervision over Contractor's employees.
Construction Manager (CM)	The CM supports the Project Manager, performs behavior-based safety (BBS) and contractor evaluation observations, and helps coordinate construction permits and outages with the Inspector. The CM is a daily point of interface with the contractor on performance and schedule issues and helps resolve construction and safety issues. The CM also coordinates work with the customer and infrastructure teams.
Sandia Construction Inspector (SCI)	The SDR's contract field representative to monitor, document, and report on the progress, quality, and safety of construction work in accordance with contract specifications and plans and applicable codes. The Inspector assists in coordinating outages for construction operations. The Inspector shall not exercise supervision over Contractor's employees.

Sandia Facilities Environmental, Safety, & Health Support Team	Persons authorized to act as official representative of SNL for the specific purpose of supporting SCRs, SDRs, and Sandia Construction Observers (SCOs) with ES&H observations and resolution of issues/concerns associated with Contractor safety performance. The team has representation from SNL's Safety Engineering, Industrial Hygiene, Environmental, Radiological Protection, and Asbestos programs.
Sandia Project Manager (SPM)	Person responsible for the overall project to include financial and schedule responsibilities, review, and acceptance of the Contract-Specific Safety Plan, and providing written justification/authorization for energized electrical work. The SPM shall not exercise supervision over Contractor's employees.
Sandia Construction Observers (SCO)	Facilities personnel and matrixed ES&H professionals from Corporate ES&H Programs who conduct oversight of contractor activities to ensure requirements are understood, planned, and implemented. The group is composed of trained and experienced Safety Engineers, Industrial Hygienists, Environmental/Waste Specialists, and Health Physicists who support Facilities by ensuring contractors have adequate mitigations in place to manage hazardous construction activities. SCOs use communication means that include the Job Site Hazard Evaluation, direct interface, and their approval of the Contract-Specific Safety Plan. SCOs also conduct site visits to validate control implementation, provide presentations at Quarterly Construction Safety Seminars, and conduct radiological training.

1.4 Definitions

Activity Hazard Analysis (AHA)	A documented plan that identifies and plans for the mitigation of hazards associated with activities. Activities are general classes of separately definable construction work (for example, excavation, foundations, structural steel, and roofing). Activities are not time- or location-specific. An AHA is a required section of the CSSP.
Pre-Task Plan (PTP)	A pre-task plan shall be conducted daily and revisited if conditions or personnel change. Documents such as checklist or permit, or knowledge (such as training) that identifies and plans for the mitigation of hazards associated with a task, can be referenced. A task is a specific segment of a particular scope of construction work that is time-, condition-, worker- and/or location-dependent. Critical thinking shall be utilized during this part of the analysis. A focus on what could go wrong during the day, such as weather, and changes to the process and personnel need to be evaluated regularly.

High-Risk Work	High-risk work is defined as work that may result in serious personal injury or a fatality if performed improperly. The increased risk is based upon characteristics inherent in the work task, location, materials, or proximity to other hazards. High-risk work activities include the following activities: • Critical crane lifts • Excavation within five feet of known hazardous energy utilities (electrical, natural gas, other pressurized systems, etc.) or personnel entry into an excavation > 5′ in depth • Energized electrical work • Work within ten feet of aerial high voltage power lines (> 50kV) • Wall, floor, or ceiling penetrations where a site investigation cannot identify all potential hidden hazards • Permit required Confined Space entry • Roof work within six feet of an edge not protected by standard guardrails, parapets, or similar physical barriers. • Elevated work over 100′ and/or that needs a rescue plan, scaffolding over 125′, tower operations, and elevated work over water or holding tanks

1.5 Submittals

A. Contract-Specific Safety Plan (CSSP)

Submit in accordance with Quality Assurance requirements for review and approval by the Sandia Project Manager (SPM) prior to commencement of onsite work.

B. Safety Plan Addendum

Submit modification to CSSP if required to address activity hazards not previously identified in CSSP.

C. Activity Hazard Analysis

In accordance with section 1.7.J, a task-specific activity hazard analysis (AHA) approved by Sandia shall be required for any work that may result in serious injury or a fatality if performed improperly. This type of work is defined as High-Risk Work.

D. Storm Water Pollution Prevention Plan

Submit in accordance with requirements of Quality Assurance article when required.

E. Fugitive Dust Control Permit

Submit an application for a Fugitive Dust Control Permit when required.

1.6 Quality Assurance

A. Regulatory Requirements

Comply with applicable ES&H laws, rules, and regulations, as amended, of the federal, state, and local governments, DOE, and SNL. Adhere to safety rules and regulations and access restrictions and emergency egress procedures that are unique to the Contractor's work at SNL-controlled premises, as defined in the following sections of this specification, the Contract documents, and as determined through consultation with the Sandia-Delegated Representative (SDR).

B. Flow Down of Requirements

The Prime Contractor shall flow down the requirements identified in this specification to subcontracts and visitors for all tiers. SNL personnel reserve the right to validate that subcontractors are knowledgeable about the CSSP requirements applicable to their work and that the work is being performed in accordance with a documented safety plan, as well as to stop work and resolve any non-compliance with applicable ES&H requirements for this contract and for subcontracts for all tiers associated with this contract.

C. Contractor Safety Officer

The Safety Officer shall ensure compliance and implementation of requirements in the CSSP and may or may not be the designated "competent person" as prescribed by 29 CFR 1926. The proposed Safety Officer shall be subject to acceptance by SDR based on the scope of work, anticipated hazards, and training and experience that meet the following minimum requirements:

1. **Education:** Two-year degree with course work in occupational health and safety, industrial hygiene, environmental engineering, or related field. Documented experience in safety inspection and coordination may be substituted on a year-for-year basis in lieu of formal course work.
2. **Experience:** Two years of documented experience in safety inspection and coordination.
3. Shall be knowledgeable of the following:
    a. Principles and practices of industry and construction site safety
    b. Safety and occupational health laws and procedures
    c. Methods of assessing safety hazards and controls
    d. Hazardous material storage and transfer procedures
    e. Emergency preparedness activities

D. Competent Person

When required by the Occupational Safety and Health Administration (OSHA) to provide a competent person, the following shall be completed prior to starting work requiring the competent person:

1. Identify the competent person.
2. Submit competent person's credentials, which may include a Professional Engineering license when required by 29 CFR 1926.
3. Competent person shall be on site when duties are required.

E. Prime Contractor Superintendent or Delegate

During periods of active construction, the construction contractor must have a designated representative on the construction worksite who has the following responsibilities:

1. Superintendent or Delegate shall be knowledgeable of the project's hazards and have full authority to act on behalf of the construction Contractor.
2. Superintendent or Delegate shall perform frequent and regular inspections of the construction work site to identify and correct any instances of non-compliance with the CSSP. Superintendent or Delegate shall document the inspections, including any non-compliance and corrective action taken. The CSSP shall describe the Contractor's methods for performing and documenting these workplace inspections. An example of an acceptable documentation method would be documenting the inspection in the Superintendent's daily log book. The documented inspection shall be maintained for the duration of the contract and made available for review upon request by the CM or SDR.
3. The superintendent shall perform a pre-work evaluation of sub-contractors using a tool such as the checklist provided in Appendix B to ensure the following;
   a. Knowledge of CSSP safety requirements that are applicable to their work.
   b. An evaluation of how these safety requirements will be implemented.
   c. Plan for how the requirements will be assessed, periodic management surveillances, supervisor pre-job briefs, and assessments.
4. Workers of all tiers shall be instructed to report hazards not previously identified or evaluated to the Superintendent or Delegate. If immediate corrective action is not possible, or the hazard falls outside of project scope, the Superintendent or Delegate shall perform the following:
   a. Immediately notify affected workers.
   b. Post appropriate warning signs.
   c. Implement necessary interim control measures.
   d. Notify the Construction Observer (CO) of the action taken.
5. A Prime contractor responsible for high-risk work shall ensure that an evaluation of superintendent qualifications has been performed to ensure knowledge of the CSSP and

contract requirements for safe execution of activity level work. If superintendent is changed during a project, the contractor shall resubmit the superintendent qualifications for SNL review.

6. Prime and Subcontractors shall certify on the SNL/NM Facilities Contractor Badge/Clearance Request Form that employees have received the following training:
   a. 10-hour OSHA training
   b. Training for Standard Specification Section 01065, "ES&H for Construction Contracts"
   c. Prime Contractor's CSSP

F. Contractor Safety Program Self-Assessment

The Contractor shall perform one written self-assessment of one element of its safety program per quarter. Examples of elements for self-assessment are training compliance, ladder inspection, fall-protection program, behavior-based safety (BBS) observations, and review of documented safety inspections. These self-assessments shall be made available for review upon request by the SPM or SDR.

1.7 Contract-Specific Safety Plan

A. General

The CSSP shall state the nature of the work, potential hazards anticipated, and how these hazards will be mitigated or how workers, including Subcontractors, service providers, area/building occupants, site visitors, and/or pedestrians in the vicinity of the construction activities, will be protected from hazards for each separately definable construction activity (e.g., excavation, foundations, structural steel, electrical, and roofing).

1. CSSP: Address OSHA CFR 1926, American Conference of Governmental Industrial Hygienists (ACGIH), and SNL-specific requirements. SNL requirements are identified in Section I and Section II (Standard Terms and Conditions) of the Contract, Uniform Construction Package (UCP), Jobsite Hazard Evaluation (JSHE), and this Specification. All requirements and recommendations identified in the JSHE shall be considered part of the CSSP unless an alternate hazard control/mitigation for the identified hazard has been submitted by the Contractor and accepted by the SPM.
2. The Prime Contractor may incorporate Subcontractors' CSSPs into a single CSSP package and submit for review and approval (any differences between the Prime Contractor's safety plan and the Subcontractors' safety plans shall be addressed prior to submitting the package for review). Example: The General Contractor may want to include electrical Subcontractors' safety plan sections involving NFPA 70E arc flash and lockout/tagout (LOTO) for electrical hazards.

B. Hazard Mitigation or Protection

Conform to requirements of this Specification as applicable to the work activity/task being performed. Mitigation or protection shall meet the intent of 29 CFR 1926 and 29 CFR 1910, as applicable. SNL ES&H requirements that exceed the requirements of 29 CFR 1926 or 29 CFR 1910 are identified in this Specification.

1. Address hazards that exist at SNL project site where work will take place. Include hazards identified in the SNL JSHE, as well as hazards that are introduced to project by construction process. Include protective measures (e.g., scaffolding and shoring, as required) identified by a Professional Engineer or other professional.
2. Contractors performing work at SNL facilities shall identify carcinogens that may be introduced to the project by the construction work. Carcinogens may be identified in the CSSP by including a listing of products or Safety Data Sheets (SDSs) that contain carcinogens.

C. Hazard Communication

Identify methods (including safety meetings) to inform workers, regardless of tier, of the nature of work, potential hazards anticipated, and how these hazards will be mitigated, or how workers will be protected from hazards, focusing on CSSPs, prior to commencement of work activities and/or tasks. Hazard communication to workers will include a clear link between the work activity/task, the hazards identified for the work activity/task, and the mitigation controls that will be implemented to protect personnel in the area, the worker performing the work activity/task, and the environment from the identified hazards. Documentation of hazard communication shall be maintained, identifying workers' names, dates of communication, activities, and/or tasks, hazards, and controls identified.

1. Contractors shall provide an inventory of all chemicals or chemical products anticipated for use on the project. The Contractor shall describe how the chemical or chemical product will be used and the controls that will be established to ensure they do not present an exposure hazard to construction workers or collocated SNL Members of the Workforce. An exemption to this requirement is consumer products used in the same form, quantity, and concentration as a product packaged for distribution and use by the general public (such as Windex®, Simple Green®, and WD-40® in packages sold for use by the general public).

D. Site Control

The Contractor is responsible for the safety of personnel on the construction job site and shall ensure that persons visiting the job site comply with safety requirements identified in the CSSP. Ensure that Contractor and Subcontractor employees and visitors on the project job site wear the necessary personal protective equipment (PPE). Contractor has responsibility and authority to deny access to any person entering a construction site if he or she does not have appropriate PPE headgear (ANSI Z89.1-approved hard hats). A 100 percent hard-hat usage rule is employed at all times during performance of work for SNL construction work, unless a written waiver is obtained from SDR. Visibly post the waiver at the job site or have the waiver in possession during performance of work.

1. **Disciplinary Process:** The CSSP shall include how the Contractor and Subcontractor disciplinary processes will apply to workers who fail to comply with the requirements of the CSSP.

E. Emergency Action

The Contractor shall be responsible for transporting personnel with non-life-threatening injuries that require medical attention to local medical facilities identified in the CSSP. Use form SF 2050-P*, Report of Occupational Injury/Illness.*

The Contractor Safety Officer (CSO) shall identify and document the Safety Officer's qualifications in accordance with Quality Assurance requirements.

F. Accident Scene Preservation

Personnel on the site shall make every effort to preserve the accident scene until the Sandia Incident Commander (IC), Safety Engineer, SCO, or SDR arrives onsite to assume control of the area.

G. CSSP Documentation

Keep onsite a copy of the accepted CSSP and documentation demonstrating personnel have received training on the CSSP to ensure all affected personnel are informed of foreseeable hazards and the requirement to follow protective measures. The CSSP shall be available to Subcontractors, COs, and SNL construction safety personnel.

H. Safety Plan Addendum

Before work activity is performed that involves hazards that were not addressed in the original CSSP, submit an addendum to the CSSP in the form of a modification for acceptance. New hazards may result from changes to the scope of work or unexpected site conditions. The addendum shall identify mitigation or control for a new hazard as described in the "Contract-Specific Safety Plan" section above.

I. Pre-Task Planning

The Pre-Task Plan (PTP) is a daily analysis tool for Contractors and Subcontractors to use to identify hazards and controls associated with the planned scope of work to be performed during the day. Special attention should be given to potential hazards not specifically covered in the CSSP and other pre-work planning, newly emerging hazards, or hazards resulting from a change in the scope of work. A PTP shall be conducted daily and revisited if conditions or personnel change. Documents such as checklists or permits, or knowledge (such as training) that identifies and plans for the mitigation of hazards associated with a task, can be referenced. A task is a specific segment of a particular scope of construction work that is time-, condition-, worker- and/or location-dependent. Critical thinking shall be utilized during this part of the analysis. A focus on what could go wrong during the day, such as weather, and changes to the process and personnel need to be evaluated regularly. Contractors are required to notify the SNL construction team (Safety, Inspection, Construction Manager) of high-risk activities. In the event the contractor is performing a high-risk work evolution during the day, the CM or SCO or alternate SNL representative shall review the PTP daily.

J. High-Risk Work

High-risk work is defined as work that may result in serious personal injury or a fatality if performed improperly. The increased risk is based upon characteristics inherent in the work task, location, materials, or proximity to other hazards. High-risk work activities include the following:

- Critical crane lifts
- Excavation within five feet of known hazardous energy utilities (electrical, natural gas, other pressurized systems, etc.) or personnel entry into an excavation > 5′ in depth
- Energized electrical work
- Work within ten feet of aerial high voltage power lines (> 50kV)
- Wall, floor, or ceiling penetrations where a site investigation cannot identify all potential hidden hazards
- Permit required Confined Space entry
- Roof work within six feet of an edge not protected by standard guardrails, parapets, or similar physical barriers.
- Elevated work over 100′ and/or that needs a rescue plan, scaffolding over 125′, tower operations, and elevated work over water or holding tanks

Work activities that have been determined to be high-risk activities will require the contractor to prepare and submit to SNL for approval a task-specific AHA. The task-specific AHA shall identify the appropriate hazard mitigation methods (e.g., engineering, administrative, PPE) for all work steps associated with the evolution. Any required supporting documents (e.g., permits, procedures, engineering calculations) shall be attached to the AHA.

The contractor safety representative shall provide oversight for the high-risk work and shall have specific training or experience for the type of high-risk work being performed. The AHA shall specify the level of oversight that is to be provided by the contractor.

A minimum of two persons shall be present for high-risk work activities and shall have the ability to make notifications should an emergency response be needed. The individual providing oversight for high-risk work cannot be a worker for the high-risk work evolution.

1.8 Jobsite Hazard Evaluation

A. General

This work site has been evaluated by SNL personnel for non-standard, industrial, ES&H concerns or conditions that preexist and may affect methods and procedures in the performance of work. Examples of pre-existing hazards may include but are not limited to laboratory chemicals, radiological material, asbestos, mold, beryllium, and lead.

1. A documented JSHE will be included with contract documents for construction work when pre-existing, non-standard, industrial, ES&H concerns have been identified. The documented JSHE does not include hazards that may be introduced during execution of work necessary to meet Contract “Statement of Work.”

2. Hazards introduced in performance of work shall be evaluated and mitigated in accordance with existing federal, state, and local regulations, including 29 CFR 1926, 29 CFR 1910, and applicable provisions of this Section.

B. Identified Pre-Existing Conditions

Take precautions for pre-existing conditions identified on the jobsite, per the JSHE attached in the Contract documents. Do not proceed without full knowledge and understanding of these conditions. If a corresponding description or identified paperwork or permit is not attached for the identified hazard, contact the SCR immediately. Additional requirements for work in radiological posted areas are found in Section 3.2 E.

C. Unidentified Hazard

If a hazard is encountered during the performance of work that has not been identified, contact the SCO or SDR for specific requirements prior to performing work that might affect the condition or concern.

1.9 Event Notification

A. General

When the Contractor becomes aware of an event that could adversely impact workers, the public, or the environment, or cause unplanned disruptions of normal operations, the Contractor shall barricade, as appropriate, to ensure workers and pedestrians in the area are not exposed to a hazard and notify the SCO, CM, SDR, SCR, or SPM of the event (when in doubt, report it). Leaving a message on voicemail or sending a page does not meet this requirement of notification; the Contractor must speak to the SCO, CM, SDR, SCR, or SPM.

To report an incident, use form SF 2050-P, *Report of Occupational Injury/Illness*, available on the Corporate Forms website.

B. Exposure

When the Contractor becomes aware of any monitoring results that indicate personnel exposure to chemical, biological, or physical hazards are above limits established by OSHA or ACGIH, the Contractor shall notify the SCO, CM, SDR, SCR, or SPM as soon as possible. Leaving a message on voicemail or sending a page does not meet this requirement of notification; the Contractor must speak to the SCO, CM, SDR, SCR, or SPM.

C. Emergency Events

If the event is an emergency, call 911 on any SNL telephone or (505) 844-0911 on an outside/cellular telephone. After calling for emergency support, the Contractor shall contact the SCO, CM, SDR, SCR, or SPM as soon as possible, but not later than 2 hours following the event.

D. Non-Emergency Events

If the event is not an emergency, the Contractor shall contact the SCO, CM, SDR, SCR, or Project Manager as soon as possible, but not later than 2 hours following the event.

E. If an event occurs during non-standard hours (standard hours are considered to be Monday–Friday, 7:30 a.m.–4:30 p.m.), notify the SCO, CM, SDR, SCR, or SPM of the event as soon as possible on the next regularly scheduled business day.

Note: Ensure barricading is installed as appropriate to provide awareness and protection to workers and pedestrian- or vehicle-traffic in the vicinity of the event.

1.10 Suspension of Work

A. General

All employees, Contractors, and visitors have the responsibility and authority to suspend inappropriate or unsafe work activities/tasks when those activities/tasks present clear and imminent danger to employees, Contractors, visitors, the public, or the environment. Personnel may suspend activities/tasks they observe or in which they are a participant, if they believe the activities/tasks present an imminent danger. To conduct this properly, we must understand the design intent and technical basis for the activity and controls. Each Contractor shall communicate the unacceptable consequences for work at this site.

Upon receiving a suspension of work request (oral or written), immediately cease activity/task and notify the SCI or SDR. Obtain the name and telephone number of the person requesting the suspension and the reason for the suspension of work. Work shall not continue on that activity/task until the issue has been resolved. The SCI or SDR may restart activity/task only after review and approval of the oral or written response submitted by the Contractor.

B. Stop Work Order

A Stop Work Order that affects the crew for a period greater than 1 hour shall be followed by issuance of a formal written Stop Work Order. Work may be restarted only with written work release from the SCR. A Stop Work Order shall include the following information:

1. Date and time when work was stopped
2. Reason for work stoppage
3. Requirements for Contractor to resume work
4. Date and time when SNL expects corrective actions to be completed, if required

C. Work Release

SCR shall provide a written work release that includes the following:

1. Reference to the Stop Work Order
2. Reason for work stoppage
3. Conditions for restart of activity/task

4. Specified date and time when work may resume

D. Hold Work Order

A Hold Work Order is a document issued through the contract that prevents work on some future task. This is a planning tool to require further evaluation of a condition or plan before a task is performed. For example, a Hold Work Order may be issued prohibiting the pouring of concrete until the rebar mat is inspected. A Contractor shall not perform the work described on the Hold Work Order until the signature of a Release Authority is obtained. Any Hold Work Orders issued shall be available onsite while applicable to the project being worked. The Hold Work Order does not affect any other restrictions listed elsewhere in this document. The Hold Work Order is not a Stop Work Order.

1.11 Integrated Safety Management System

A. General

Sandia personnel are committed to performing work safely and ensuring the protection of employees, the public, and the environment. To support these commitments, SNL personnel employ an Integrated Safety Management System (ISMS), which provides the framework for this specification, and the requirements established for contracted construction work at SNL.

B. ISMS Guiding Principles

The following guiding principles are the cornerstone of an effective safety management program:

1. **Contractor Management Responsibility for Safety:** Contractor management is accountable for the protection of the public, workers, and environment.
2. **Clear Roles and Responsibilities:** Clear and unambiguous lines of authority and responsibility for ensuring safety are established and maintained at all organizational levels within the company and its Subcontractors.
3. **Competence Commensurate with Responsibilities:** Personnel possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.
4. **Balanced Priorities:** Resources are effectively allocated to address safety considerations. Protecting the public, workers, and environment is a priority whenever work is planned and performed.
5. **Identification of Safety Standards and Requirements:** Before work is performed, associated hazards are evaluated and an agreed-upon set of safety standards and requirements are established, which, if properly implemented, provide adequate assurance that the public, workers, and environment are protected from adverse consequences.
6. **Hazard Controls Tailored to Work Being Performed:** Administrative and engineering controls to prevent and mitigate hazards are tailored to the work and associated hazards.
7. **Operations Authorization:** Conditions and requirements to be satisfied for operations to be initiated and conducted are clearly established and agreed upon.

C. Apply the ISMS work cycle shown in Figure 1.1 at the task or activity level for construction assignments. Depending on the size and complexity of the work activity/task, some elements of the work planning phase may not be used formally.

1. Refer to Section I of the Contract for specific requirements for prebid visits and conferences. The Contractor has the responsibility to visit the project site and submit questions about ES&H-related issues that may affect Contractor cost or performance prior to bid.
2. Table 1.1 provides requirements for demonstrating effective safety management during the execution phase of this Contract.

- **Plan Work:** Contract requirements are translated into work, expectations are set, activities and/or tasks are identified and prioritized, and resources are allocated.
- **Analyze Hazards:** Hazards associated with the work are identified, analyzed, and categorized.
- **Control Hazards:** Applicable standards and requirements are identified. Controls to prevent or mitigate hazards are identified; CSSPs are developed and controls are implemented.
- **Perform Work:** Contractor's readiness to perform contract work is confirmed and work is performed safely.
- **Feedback and Improve:** Feedback information on the adequacy of controls is gathered, opportunities for improving the definition of planning of work are identified and implemented, oversight is conducted, and when necessary, controls are modified to ensure a safe work environment.

Figure 1.1 ISMS Work Cycle

Table 1.1 Engineered Safety and ISMS Contractor Requirements

Work Cycle Phase	Contractor Requirements	Expectations
Plan Work		
Review of SNL Jobsite Hazard Evaluation Checklist	Understand existing conditions and controls that might affect worker safety and health.	Contractor will review JSHE and incorporate existing site hazards and controls into its CSSP.
Prebid Site Visit and Review Design Intent	Identify potential job and site hazards and hazard combinations.	Contractor will review its potential hazards and determine the effect on existing SNL hazards. Contractor will document how the combination of hazards will be controlled in its CSSP.
Prebid Conference	Resolve emergency-preparedness responsibilities and other safety issues not identified in Request for Quote.	Contractor will identify emergency action plan and document it in the CSSP.
Bid Submission	Commit adequate level of resources for job conditions.	Contractor will ensure adequate competency and level of resources are available and provided as submitted in bid.
Analyze Hazards		
Job Safety Analysis and Risk Assessment Approach	Evaluate job-specific activity/task and site-specific work requirements and hazards.	Contractor will review work requirements and hazard controls. Task hazard analysis shall be performed for high-hazard tasks (e.g., confined-space entry, critical lifts, hot work, excavation, penetration, energized electrical work, or respiratory protection). Ensure estimates of low probability of occurrence do not dominate early decision-making since human nature and external pressures tend to minimize the use of what would otherwise be sensible controls based on the severity of accident consequences.
SNL Hazard Information	Request and incorporate hazard identification and hazard control information supplied by SNL personnel.	Contractor will ensure that information from the JSHE is incorporated into its CSSP.
Job Task Analysis and Understanding the Technical Basis	Resolve job assignment and personnel fitness issues.	Contractor will ensure that workers have the appropriate training and skills for assigned tasks. The technical basis of an existing hazardous activity must be reconstructed sufficiently to ensure continued safe operations. The effort will be prioritized according to the severity of potential accident consequences.
Pre-work Evaluation of Subcontractor Work Team	Evaluate Subcontractor work group's knowledge of CSSP safety requirements applicable to their work and how the requirements will be implemented.	Contractor will ensure that Subcontractor workers have the appropriate awareness of the CSSP safety requirements and can demonstrate how they will be implemented for assigned tasks.

Work Cycle Phase	Contractor Requirements	Expectations
Control Hazards		
Safety Program and Define Unacceptable Consequences	Identify company safety management policies, processes, and procedures. Ensure there are clear responsibilities for accepting and suspending work.	Contractor’s Safety Program will be complete and contain its company-specific safety information. Unacceptable consequences include the following: • Accidents that result in a serious occupational injury • Significant violation of environmental regulations • Unplanned facility outages or interruptions that significantly impact critical mission work
CSSP – Identify and Control Hazards	Address all contract-specific safety requirements and protective measures, including combined requirements and combined controls.	The CSSP will incorporate company-specific information from the company safety program as well as contract-specific requirements. The CSSP will document how the combination of company-specific hazards and contract-specific hazards will be controlled. The Subcontractor’s addenda will be incorporated into the Prime Contractor’s CSSP. The CSSP will identify methods used by the Contractor to perform oversight and self-assessment of compliance with the CSSP.
Preconstruction Meeting (as appropriate)	Participate in preconstruction meeting with intent of understanding conditions/restrictions identified on the hazard evaluation checklist.	The Contractor, Subcontractors, and workers are aware of their responsibility to review the Prime Contractor’s safety program and CSSP prior to the start of work and as needed.

Work Cycle Phase	Contractor Requirements	Expectations
Hazard Awareness and Identifying and Controlling Energy Sources	Ensure employees, Subcontractors, and suppliers are informed of foreseeable hazards and protective measures associated with work activities, as appropriate, prior to initiating work. Ensure superintendent is qualified and has knowledge of the CSSP and contract requirements.	Supervisors are responsible for ensuring that work activities, work hazards, and work controls are clearly linked and flow down to all workers regardless of tier through documented training, safety meetings, toolbox talks, and pre-task meetings. For all high-risk work, the Prime Contractor shall submit PTPs to Sandia personnel for daily review and approval as scope changes. For projects that involve high-risk work, the Prime Contractor shall submit evidence to Sandia of the review of superintendent qualifications ensuring they have knowledge of the CSSP and contract requirements for safe execution of activity-level work. If a superintendent is changed during a project, the contractor shall resubmit evidence of superintendent qualification for SNL review. For all high-risk projects, the contractor safety letter shall state that the contractor will have a contractor safety representative or delegate present the following topics at the pre-construction meeting: 1. A detailed list of activities that constitute the scope of the project. Emphasize that for any change in scope, the change may not be started until approved by the Sandia Construction Manager. 2. When to pause or stop work, including pause/stop for scope changes. 3. The specific sections of the CSSP that apply to the project. 4. The high-risk activities to be performed during the project. 5. The PTP form, PTP requirements, and expectations for PTP use. Subcontractors and their workers will be knowledgeable about the Prime Contractor's CSSP. Workers attend documented safety meetings, toolbox talks, and pre-task meetings as required; positive verification is required. Workers are familiar with the hazards and work controls that result in safe working conditions. Stored energy must be identified and controlled with appropriate engineered and administrative controls designed to prevent or mitigate the consequences of accidental release. Kinetic, potential, electrical, electro-mechanical, thermal, pressure, and chemical are examples of energy sources that can be released directly or in another form as the result of an accident.

Work Cycle Phase	Contractor Requirements	Expectations
Work Authorization	Ensure that safety plans/corrective action plans are reviewed and work is authorized prior to initiating work or corrective actions.	The Contractor will obtain and follow all permits as required by SNL personnel. Permit information will be flowed down to Subcontractors and affected workers during documented toolbox talks, pre-task meetings, and safety meetings. Corrective actions will be completed as required.
Perform Work		
Job Supervision and Positive Verification	Ensure that all workers have appropriate safety supervision by Contractor management at all times.	Supervisors assume responsibility for the safety of the work site and workers. When unanticipated hazards or environmental risks are introduced, work will be paused until revised work planning, hazards, and environmental effects are analyzed and any additional controls are documented and approved, as appropriate. Positive verification requires that each team member affirm to the person in charge that his/her part of the system is in the state intended for safe operation. This can be done during pre-task analysis for less complex operations. If the team does not have concurrence, it should be assumed by the person in charge that it is not safe to proceed.
Safety Inspections	Conduct and document daily workplace inspections, with or without SNL personnel, to identify and correct hazardous conditions and instances of non-compliance with safety plan/requirements.	Supervisors are responsible for ensuring that daily inspections are documented and immediate action is taken for all identified non-compliance issues.
Emergency Response	Ensure that all personnel at the work site can recognize abnormal or unsafe conditions and know how to respond (e.g., “what-if scenarios”).	Train workers to recognize abnormal or unsafe conditions and understand how to respond to the conditions by controlling and reporting the condition. Every worker understands he/she has the responsibility and authority to suspend an activity/task if the worker believes it presents an imminent danger.
Corrective Actions	Implement interim controls for unsafe or abnormal conditions, including notification to workers and SDR.	The Contractor has controls in place to immediately address unsafe or abnormal conditions.
Feedback and Improve		
Self-Assessment	Identify opportunities for safety process and work performance improvements.	The Contractor will review daily inspection reports, lessons learned, and injury/illness reports to identify areas that require improvement.
Performance Reviews	Discuss performance strengths and weaknesses with employees and Subcontractors.	Information on strengths and weaknesses will flow down to Subcontractors and workers.

Work Cycle Phase	Contractor Requirements	Expectations
Assessment of Pre-Task Plans	Review and discuss the quality and effectiveness of in-process and completed PTPs with employees and Subcontractors.	The Contractor will review Subcontractor pre-work assessments, PTPs, etc. to determine if CSSP requirements are communicated to subcontractor personnel.
SNL Feedback	Communicate suggestions for SNL improvements to the SDR.	The Contractor will provide updated information and/or suggestions to the SCR that will add value to ongoing improvement programs. The Contractor will provide a means for workers to report unidentified or uncontrolled workplace hazards.

1.12 Worksite Identification

A. Construction Safety Bulletin Board

Provide and maintain a weather-tight safety bulletin board in a visible location. The bulletin board shall be used only to post official announcements.

1. For projects under $50,000, provide and maintain a legible, durable, and weatherproof 8 ⅛-inch by 11-inch sign in a visible location with the following information:

    a. Company Name

    b. Superintendent Name

    c. After-Hours Telephone Number

    d. SNL Contract Number

    e. SNL Contact Name and Telephone Number

2. For projects over $50,000, in addition to the information required above (Section 1.12 A.1), the bulletin board shall also include the following:

    a. Equal Opportunity Posters

    b. Employment Standards

    c. Project Davis-Bacon Wage Decisions

    d. DOE Safety Posters

    e. Contractor's Accident Prevention

    f. Fire Prevention

    g. Emergency Phone Numbers

    h. First Aid Plan

3. For all projects, an SNL-reviewed copy of Contractor's CSSP must be readily available at project site.

B. Hazard Identification Signage and Barricades

Provide appropriate hazard identification and barricades in accordance with 29 CFR 1926 to warn Contractor personnel and worksite visitors of specific work hazards and to communicate safe bypass information to non-construction personnel in the vicinity of the site. Prior to the start of work, ensure personnel onsite know and understand SNL signage that might be present onsite during performance of work.

1. Use flagging and tape barricades only for temporary or interior protection, unless otherwise accepted by the SCO. Use orange safety fencing or snow fencing around excavations and

trenching. Fencing shall be a minimum of 4 feet high (1.2 meters high) and secured vertically every 10 feet (3 meters).

2. Provide signage in compliance with 29 CFR 1926. Protect unattended sites with applicable signs and barricades at all times.

C. Documentation

The following documents shall be available for review at each project site:

1. Project plans, specifications, and work authorizations
2. All required permits
3. CSSP
4. SDSs for onsite chemicals

2.0 Products (Not Used)

3.0 Execution

3.1 Coordination of Work Affecting Ongoing SNL Operations

A. Overhead Work

Schedule work required to be performed above occupied areas for non-standard hours, unless specific and approved precautions, including signage, barricades, occupant consent, and any other precaution deemed necessary by SNL, is provided in advance of operation. Final approval for work in occupied areas during normal work hours must be received from SDR.

B. Utility or System Outages

Submit to the SCI an Outage Request Worksheet in advance of activity/task requiring utility or equipment shutdowns that will affect ongoing SNL operations, observing the advance-notice requirements thereon.

C. Removal of Administrative Tags

SNL personnel may use locks and/or tags to prevent unauthorized use of or access to equipment or systems. These locks and/or tags are not used for LOTO purposes (protection during the maintenance and servicing of equipment). The Contractor shall obtain permission from the SCI prior to removing any administrative lock and/or tag.

3.2 Medical/Health Protection

A. Occupational Medicine Program

Contractors at all tiers who are onsite for more than 30 work days in a calendar year or have employees who are enrolled for any length of time in a medical or exposure-monitoring program required by the 10 CFR 851, Worker Safety and Health Program rule and/or any other applicable federal, state, or local regulation shall have an Occupational Medicine Provider (OMP). Please see Appendix A, Occupational Medicine Services for more information.

1. Contractors shall submit the name of a credentialed provider, including the company name, address, telephone number, and the name of a management contact for their OMP in their Safety Plan. Complete a “Declaration of Occupational Medicine Provider.”

B. Emergency Action

For life-threatening injuries or illnesses, immediately call for medical assistance by dialing 911 on an SNL telephone or (505) 844-0911 on an outside/cellular telephone at the Albuquerque site.

1. Post medical and non-medical emergency telephone numbers conspicuously at the project site. Ensure that all employees are aware of medical and non-medical emergency telephone

numbers. Placards with emergency telephone numbers can be obtained from the SNL construction office.

2. Transport personnel with non-life-threatening injuries or illnesses that require medical attention to the Contractor's identified medical facility.
3. **Electrical Shock:** Accompany any employee that received an electrical shock to the SNL Medical facility during standard working hours for immediate medical attention, no matter how minor the shock appears. During non-standard hours, seek medical attention at an offsite facility. Notify the SCO or SDR immediately after transporting the individual to SNL Medical.

Notification of Accidents, Injuries, and Illnesses: Verbal notification to the SDR or SCO shall be performed as soon as possible. Submit form SF 2050-P, *Report of Occupational Injury/Illness* to the SDR within three days. The form is available on the Corporate Forms website.

4. Other
   a. **Non-Emergency Medical Incident:** Notify the CM, SPM, SDR, or SCO as soon as possible.
   b. **Serious or Life-Threatening Accident or Illness:** Notify the SDR, CM, or SCO immediately after taking emergency action.

C. Contractor's Industrial Hygiene Program

Conduct an assessment of worker exposure to reduce the risk of work-related disease or illness. Assess worker exposure to chemical, physical, biological, or ergonomic hazards through appropriate workplace monitoring (including personal, area, wipe, and bulk sampling), biological monitoring, and observation. Monitoring results shall be recorded. Documentation shall describe the activities, tasks, and/or locations where monitoring occurred; identify workers monitored or represented by the monitoring; and identify the sampling methods and durations, control measures in place during monitoring (including the use of PPE), and any other factors that might have affected sampling results. The Contractor shall be informed of the precautionary measures that need to be taken to protect workers during normal operating conditions of the workplace and in foreseeable emergencies; that is, the identification of inherent chemical, physical, biological, or ergonomic hazards in the workplace and the established corresponding control measures through the JSHE process (reference Section 1.8).

1. **General:** Comply with the current edition of the ACGIH TLVs for Chemical Substances and Physical Agents and BEIs when the ACGIH TLVs and BEIs are lower (more protective) than OSHA permissible exposure limits (PELs).
   a. Contractors must submit a Written Exposure Control Plan for Silica exposure that meets the requirements of 29 CFR 1926.1153 (g).

Note: Applicable OSHA-expanded health standards shall be complied with, even when ACGIH TVLs are used.

2. **Gases, Vapors, Fumes, Dusts, and Mists:** Use engineered, administrative, or PPE controls to keep employee exposures within prescribed limits.

   a. Controls must be evaluated to ensure the appropriate level of protection to the worker.

   b. Equipment and technical measures used to determine an occupational exposure shall be performed by a technically qualified person and conform to current analytical methods.

   c. For all welding, cutting, and brazing operations, the Contractor is required to submit a completed “Contractor Welding, Cutting, Brazing Exposure Assessment Form” (SF 2001-WLD) to the Division ES&H Customer Support Team Industrial Hygienist.

      i) The Contractor or Contractor’s qualified health and safety representative shall identify hazards and select and implement effective controls to ensure worker safety and health. Control measures (e.g., full face air-purifying respirators or local exhaust ventilation) may be required.

   d. The Division ES&H Customer Support Team Industrial Hygienist will document approval of the proposed control measures on the “Contractor Welding, Cutting, Brazing Exposure Assessment Form” (SF 2001-WLD).

   e. No work shall proceed without approval of the proposed control measures by the Division ES&H Customer Support Team Industrial Hygienist.

   f. Engineering controls equipment, such as local exhaust ventilation devices, shall be appropriate for their use and operated to manufacturer requirements. This may include incorporation of fire-prevention features for hot-work applications or processes or gauges to ensure high-efficiency particulate air (HEPA) filters are operating within the effective range. When the Contractor AHA requires local exhaust ventilation (LEV) units, the manufacturer and the serial number of the unit shall be identified. The Customer Support Team Industrial Hygienist can provide further criteria and examples of acceptable LEV units to help ensure units meet applicable requirements.

3. **Physical Hazards:** This includes noise (sound pressure levels), ergonomics, lasers, non-ionizing radiation, and thermal stress.

   a. **Noise, non-ionizing radiation, and thermal stress:** Comply with ACGIH TLVs.

   b. **Lasers:** Comply with ANSI Z136.1, *Safe Use of Lasers.*

      1) Class 1, 2, and 3a lasers may be used.

      2) Do not use Class 3b or Class 4 lasers without the written approval of the SNL/NM site Laser Safety Officer.

      3) When used for operations such as leveling floors, roads, and sidewalks, the laser beam shall not be directed above the horizon, through navigable airspace, or toward aircraft ground operations. The laser beam shall be backstopped with a non-reflective surface that is opaque (non-transparent) to the laser’s beam.

4) All outdoor laser operations other than described in 3.b (third bullet) must be reported to the SDR for SNL approval prior to laser operations being performed.

c. Comply with ANSI Z88.2, *Practices for Respiratory Protection.*

4. **SNL Oversight Compliance Monitoring:** SNL personnel have the authority to conduct reasonable investigations for oversight purposes, including but not limited to environmental (area) sampling and attaching personal sampling equipment/devices, such as dosimeters, pumps, and badges, to construction contract personnel to monitor or measure exposures. Monitoring results shall be provided to the Contractor.

D. Substance Abuse Prevention and Testing

Use of drugs (including misuse of prescribed substances) or alcohol onsite shall be grounds for removal of the individual from the work site and may include other corrective action, including Contract termination.

E. Radiological Safety

Employees may not enter an area that contains a posted radiological sign, as signified by a radiation symbol on a yellow background with black or magenta markings, without prior authorization and SNL-provided training appropriate for radiological hazards. Performance of work in all radiological posted areas, including controlled areas and radioactive material areas (RMAs) and <u>all</u> work in Technical Area V, requires the contractor to have a <u>**Customer Work Release**</u> (form 338) signed by the SNL space owner prior to initiating work.

1. If work is required in a posted area, and specific written instructions have not been issued, do not enter the area. Contact the SDR or SCO for instructions.
2. A JSHE is not required for work in controlled areas or RMAs unless:

   a. Additional hazards (chemicals, biohazards, etc.) have been identified

   b. The area is posted for additional radiation hazards (i.e. radiation area)

3. For performance of work in radiological areas posted as radiological buffer area (RBA), radiation area (RA), high radiation area (HRA), very high radiation area, airborne radioactivity area (ARA), contamination area (CA), or high contamination area (HCA), ensure the following:

   a. A JSHE for work activity/task performed in radiological areas is obtained.

   b. Employees understand and follow JSHE requirements.

   c. Obtain a radiological Technical Work Document (rTWD), when required by the Sandia Radiation Protection Department, and understand and follow the provisions and requirements.

   d. Employees shall be current on radiological training required for site or activity/task (e.g., General Employee Radiation Training, Rad-Worker I, or Rad-Worker II).

e. Employee shall be 18 years of age or older.
f. Comply with Contract requirements for work in radiological areas.
g. Comply with the CSSP for work as reviewed by SNL representatives.

4. **Dosimetry:** Workers with appropriate training and who have elected to work in radiological areas may be required to participate in SNL's external and internal dosimetry monitoring program. Contractors participating in the dosimetry monitoring program shall ensure their Thermoluminescent Dosimeters (TLDs) are current. TLDs must be returned to the SDR for exchange by the last day of the quarterly expiration date. Failure to exchange in a timely manner may result in loss of the TLD.
5. Each project involving use of an accountable radioactive source or radiation-generating device (RGD) requires prior approval by SDR and SNL's Radiation Protection Department. Examples of such devices include but are not limited to soil testing densitometers and XRF analytical devices for lead detection.
6. For clarifications, contact the Radiation Protection Department or refer to the *Radiological Protection Procedures Manual (RPPM)*.

3.3 Waste Management and Disposal

A. General Requirements

Construction project non-hazardous non-regulated waste shall be managed in accordance with Section 01505, "Construction Waste Management." Property items and equipment that may be reused for their intended purpose are not considered waste and shall be managed as U.S. government property. Waste generated during construction operations may be classified as regulated or hazardous waste. This section describes commonly generated waste types. Details for waste management are contained in Section 01505.

B. Construction and Demolition Debris

As defined by 20 New Mexico Administrative Code 9.1, "Construction and demolition debris" means materials generally considered to be not water soluble and non-hazardous in nature, including but not limited to steel, glass, brick, concrete, asphalt roofing materials, pipe, gypsum wallboard, and lumber from the construction or demolition of a structure project, and includes rocks, soil, tree remains, trees, and other vegetative matter that normally results from land clearing. If construction and demolition debris is mixed with any other types of solid waste, it loses its classification as construction and demolition debris. Construction and demolition debris does not include asbestos or liquids, including but not limited to waste paints, solvents, sealers, adhesives, or potentially hazardous materials.

C. Residue Material and Equipment

Intact and dismantled equipment and material removed while performing construction operations shall remain the property of the government. If the equipment and material is not reused in the performance of the project, the Contractor shall manage it as residue material and equipment. All residue material and equipment shall be staged by the Contractor and evaluated for hazardous and radioactive contamination by SNL personnel before being delivered to the reapplication yard.

D. Empty Containers

Containers that held non-regulated products shall not contain any free liquid in order to be disposed as construction and demolition (C&D) waste.

Containers that have free liquid or previously contained hazardous material shall be submitted to the hazardous waste management facility.

As a best business practice, use as much material that can be removed from containers. Place a small amount of floor dry absorbent material (kitty litter, vermiculite, etc.) to assist in the collection of any remaining material in containers.

Used aerosol cans that contain any amount of propellant or product must be managed as hazardous waste. At SNL/NM, if an aerosol can is empty of propellant and product, is no longer pressurized, and does not contain residue of an acute hazardous waste, it is considered an empty container and may be disposed of as regular trash.

- Do not spray out the remaining contents of an aerosol can for the sole purpose of emptying it.
- Never puncture an aerosol can.

E. Lamps

Fluorescent, sodium, and incandescent lamps shall be removed from light fixtures and managed as regulated waste, but not as C&D waste. These items shall be boxed and labeled to identify the contents. Notify the Construction Manager to coordinate waste pick up.

F. Light Ballasts

Remove ballasts from all light fixtures and submit the residue material for characterization by the Facilities ES&H (FESH) team.

1. Ballasts clearly labeled “No-PCBs” shall be placed in a container for disposal.
2. Ballasts that are NOT clearly labeled “No-PCBs” shall be managed as waste PCBs. Place waste <u>PCBs</u> and <u>PCB items</u> in a container that is capable of preventing the spread of contamination unless the PCBs are completely contained by the item, such as totally enclosed electrical equipment. Place waste contaminated items, such as PPE and rags, in a sealed plastic bag with a minimum 6-mil thickness to prevent the spread of contamination.
3. Light fixtures installed prior to 1980, with evidence of ballast leaks, shall be removed and treated as waste PCBs.
4. All waste PCBs must be double bagged or double wrapped with the words “Removed From Service on _______ (supply the correct date).”
5. Notify the Construction Manager to coordinate waste pick up within 30 days.

G. Oil-Containing Equipment

Equipment containing oil or other petroleum products shall be drained of oil and managed as residue material. Drained oil shall be managed as either Used Oil for recycle or chemical waste if contaminated. Notify the Construction Manager to coordinate waste pick up.

H. Chemical Waste/Hazardous Waste

At SNL chemical wastes are managed as regulated or hazardous wastes. This designation applies to all chemical wastes, used oil, asbestos-containing wastes, and PCB-containing wastes as examples. Because of regulatory liability, NTESS assumes responsibility for management and disposal of chemical wastes. Chemical wastes shall be managed as hazardous waste, unless specific guidance is provided in the Contract. Coordinate hazardous chemical waste disposal through SNL's Facilities ES&H Team. The procedure for disposal of chemical/hazardous waste is as follows:

Coordinate all waste management activities with the SNL Construction Manager and FESH waste management support. The following actions are required, and the FESH team will provide support in the following:

1. All items must be inventoried.
2. All containers need labels, and labels shall include contents, project number or name, and contact phone number.
3. Notify the SNL Construction Manager that waste is ready for pickup as soon as possible.
4. SNL personnel will pick up the waste and determine the appropriate disposal method.

I. NORM Materials

Naturally occurring radioactive materials (NORM) used in commercial products that have measurable radioactivity above SNL established policy (which includes State of New Mexico established limits) shall be managed as radioactive waste when declared waste and is not deemed for Reapplication. Some examples are as follows:

1. Chemicals with NORM
2. Ceramic insulators (with some exceptions)
3. Glass-containing thorium or uranium for coloring purposes
4. Smoke detectors

J. Radioactive Waste

Radioactive waste is not expected to be identified at this stage of the process. Radioactive hazards should be identified during the JSHE process. If material is discovered to be radioactive, then all work should be paused and the FESH team should be notified.

K. Mixed Waste

Mixed waste is not expected to be identified at this stage of the process. Mixed waste should be identified during the JSHE process. If material is discovered to be mixed during this activity, then all work should be paused and the FESH team should be notified. Mixed waste can only be generated with written SNL approval.

L. Transportation of Hazardous Waste

Facilities construction contractors are prohibited from transporting hazardous waste.

3.4 General Project Work Practices

A. Significant Hazards

Significant hazards that require a documented safety briefing, activity/task hazard analysis, or both are listed in this section. Examples of documentation include but are not limited to the following:

- CSSP
- AHA
- Permits
- JSHE

1. Contractors will ensure that work is conducted by qualified and trained workers. When applicable, activities will be conducted by workers who are certified, registered, or otherwise documented as qualified by their trade/profession, or who are licensed to perform that activity by the appropriate government organization.
2. JSHEs or AHAs and permits, such as confined space and radiological work, further address SNL-specific qualifications and training required for high-rigor activities.
3. Work control is built into numerous Facilities processes. For example, CSSP review; pre-job and other scheduled meetings; building permits; additional permits, such as hot work and cutting, welding, and brazing; and code and safety inspection by Facilities staff.
4. Feedback on Facilities construction activities is provided to Contractors by several means, such as immediate, on-scene feedback by inspectors, quarterly meetings, and the monthly newsletter.

A focus on the potential consequence and severity for work is required. Oftentimes, significant risk is overlooked because personnel are frequently around the hazards and become familiar with the activity, which can give a false sense of safety. Attention to potential and kinetic energy is required for proper hazard analysis.

B. Hidden Hazards Penetration

1. General: SNL personnel have adopted a five-step approach to minimize the effects of hidden hazards when performing penetration or excavation operations. This process includes the following: (1) drawing review; (2) site investigation; (3) detection using instrumentation, as appropriate; (4) use of appropriate tools; and (5) PPE.

2. Workers engaging in excavation or penetration operations shall use tools that are in good working condition and shall use PPE, electrically-rated gloves, ground-fault circuit interrupter (GFCI) protection, and double-insulated tools, as appropriate.
3. To mitigate risk, the Contractor shall ensure that adequate site investigation, using methods that would not penetrate hidden hazards (e.g., visual inspection or detection using instrumentation), is performed prior to any excavation or penetration operations. If hidden hazards cannot be identified through site investigation, the SDR shall be notified prior to excavation or penetration operations, and appropriate PPE shall be worn when performing excavation or penetration operations. (Refer to Section 3.4 C and D below for excavation and penetration permit requirements.)

Ground penetrating radar (GPR) is available for assessing proposed penetrations.

Wall, ceiling, and floor verification – Removal of energy sources or hazardous gases that pass through walls/floors/ceilings system shall be managed. A one hundred percent positive verification shall be conducted prior to cutting the energy source or hazardous gas on the opposite side of the wall/floor/ceiling. A sleeve that is pushed through the system or the dismantling of a conduit are examples of positive means of verification.

C. Excavation Permit

Obtain permit from the Construction Inspector.

1. Obtain an excavation permit prior to the start of the following operations:
   a. Digging, saw-cutting, drilling, coring, or trenching into soil, concrete sidewalks, or asphalt to a depth greater than 12 inches
   b. Excavation of soil beneath concrete sidewalks, slabs, or asphalt to a depth greater than 2 inches
   c. Excavation into subsurface soil in buildings beneath the slab
   d. Scraping, blading, or excavation of any area previously undisturbed or that appears to be undisturbed, such as areas covered by native vegetation, and blading or improvements to previously unimproved roads or paths
2. Area to be excavated shall be shown on drawing and identified in the field using white paint. Submit permit requests to the SCI no more than 14 days and no less than 6 days prior to start of excavation.
3. The excavation permit process involves environmental, cultural, and ecological site review to determine if environmental site impacts will occur due to excavation operations.
4. Confine excavation operations to those areas identified on permit.
5. The contractor's CSSP shall specifically address hand digging. Potential materials such as poly, ductile iron, polyvinyl chloride (PVC), or concrete; the soil type; and the depth of potential utility shall be evaluated. Consider these factors when matching the selection of tools and force to ensure minimal or no impact to the utilities.

D. Penetration Permit

Obtain permit from the Construction Observer.

1. Obtain penetration permit prior to the start of the following operations:

   a. Penetration into concrete slabs, floors, ceilings, roofs, or walls greater than 2 inches (50 mm) in depth (does not include precast concrete).

   b. Penetration into underground concrete duct banks. All duct-bank penetrations shall be reviewed by Facilities personnel for high-voltage hazards. If high-voltage hazards are identified on the penetration permit, the Supervisor authorizing the duct-bank penetration shall ensure that (1) a task-specific (each duct-bank penetration is considered a task) procedure is written and submitted to the duct-bank Penetration Coordinator (or Construction Observer, Construction Manager, or Project Manager) for review and acceptance, and (2) the Supervisor authorizing the duct-bank penetration shall attend and ensure attendance of the penetrator at the pre-task meeting that will be scheduled by the duct-bank Penetration Coordinator. The task-specific procedure shall be reviewed at the meeting.

   c. Penetrations where a site investigation cannot identify possible hidden hazards.

2. Area to be penetrated shall be shown on the drawing. Submit permit requests to the SCI no more than 14 days and no less than 6 days prior to start of penetration. If the penetration is inside a building, an outage request shall be submitted with the permit.

3. Permit is task-specific. Confine penetration to those areas identified on the permit.

4. Maintain a minimum of 1 inch from GPR markings. Any anomalies shall be treated as potential energized conductors.

GPR is available for assessing proposed penetrations.

E. Fire Safety

All construction operations in new and existing facilities shall, at a minimum, follow the requirements set forth in the International Fire Code (IFC) (ANSI Z49.1, Sections 4.3 and E4.3) and include the following:

1. Emergency vehicle access shall be provided as follows:

   a. Minimum 20-foot-wide vehicle pathway

   b. Must support weight of fire apparatus (75,000 lbs.)

   c. Minimum 13-foot, 6-inch vertical clearance

2. A water supply for firefighting must be provided (either fire hydrants or water tanks of sufficient capacity shall be available onsite).

3. **Access to fire hydrants:** Fire Department inlet connections or fire protection system control valves shall not be hampered. A minimum 3-foot clearance must be maintained

around fire hydrants. Storage, vehicles, trash, or other materials or objects shall not be placed or kept near fire hydrants, Fire Department inlet connections, or fire protection system control valves. Any temporary fencing installed near fire hydrants or fire protection equipment shall be provided with a gate to allow emergency access.

4. **Housekeeping:** All construction debris and trash shall be removed at least once per day at the end of the shift or more frequently if necessary.
5. Flammable and combustible materials shall be stored in accordance with the IFC. These materials may not be stored near existing facilities, egress routes, emergency vehicle access points, or fire protection equipment.
6. **Fire Protection Impairment Permit (FPIP):** Notify the SCI if work will impair or inadvertently activate a fire protection detection or suppression system already in service. The Contractor shall submit an FPIP for any fire protection system impairments. Reference standard construction specification 28 31 11, "Fire Alarm Systems," for temporary signage requirements. Reference standard construction specification Section 21 13 13, "Automatic Sprinklers and Water-Based Fire Protection Systems," for fire suppression system impairments.
7. Protective clothing for welding, cutting, and allied process shall be selected to minimize the potential for ignition, burning, trapping hot sparks, or electrical shock.

F. Hot Work Permit

Prior to cutting, welding, open-flame burning, or use of tar kettles and roof solvents, obtain a Hot Work Permit from SNL Fire Protection Engineering. Display the issued permits in a prominent location at the work site.

1. If welding, brazing, or thermal cutting is performed, submit a completed "Contractor Welding, Cutting, Brazing Exposure Assessment Form" to the Industrial Hygienist supporting Facilities construction operations.
2. Prior to receiving a site-specific Hot Work Permit, operators responsible for performing the hot work and personnel responsible for performing fire-watch duties annually shall view the training videos and read the accompanying literature provided by Fire Protection Engineering. These videos are approximately 1 hour in combined length.
3. The operators responsible for performing the hot work and the personnel responsible for performing the fire-watch duties shall be trained in the use of portable fire extinguishers annually and shall have demonstrated proficiency through certification.
4. Hot-work operations shall be suspended if in an area where a fire suppression system is impaired.
5. A Fire Watch shall be provided during hot-work operations and shall continue for a minimum of 30 minutes after the conclusion of the work. Fire Protection Engineering or the SDR is authorized to extend the time required for the Fire Watch based on the hazards or work being performed (such as tar-kettle roofing operations).

6. The Fire Watch shall include the entire hot-work area. Hot work conducted in areas with vertical or horizontal fire exposures that are not observable by a single individual shall have additional personnel assigned to Fire Watches to ensure that exposed areas are monitored.
7. Individuals assigned to Fire-Watch duty shall be responsible for the safety of the welders in addition to that of the property, extinguishing spot fires, and communicating an alarm. Individuals assigned Fire-Watch duties must remain in the hot work area until hot work is completed and for 30 minutes afterwards and shall not have any other duties (e.g., not a runner).
8. The Operator shall ensure that his/her Fire Watch is present prior to beginning hot-work activities. If the operator is found to be performing hot-work activities without his/her Fire Watch present, the Operator forfeits the active Hot Work Permit, and his/her supervisor must apply for a new permit.
9. The Operator (if no Fire Watch is required) shall perform a final area inspection, sign the Hot Work Permit, and return the permit to Fire Protection Engineering (MS 0909).
10. The Fire Watch shall be present while the Operator is performing hot-work activities at all times. The Fire Watch shall not perform any additional tasks while on duty. If the Fire Watch is found delinquent in his/her duties, he/she forfeits the active Hot Work Permit, and his/her supervisor must apply for a new permit.
11. The Fire Watch shall perform a final area inspection, sign the Hot Work Permit, and return the permit to Fire Protection Engineering (MS 0909).

G. Fire Protection System Impairments

When performing any work activity or task that affects the operation or functioning of a fire protection system (fire alarm and fire suppression systems), either directly or indirectly, the following actions shall be taken:

1. **Fire Protection Impairment Permit:** Prior to performing any work that will generate heat, smoke, fumes, or dust (e.g., welding or cutting drywall) or when modifying or disrupting a fire protection system, complete and submit an FPIP to the SCI to request an impairment.

    a. Obtain the FPIP form from the SCI.

    b. Upon receipt of the FPIP form by the SNL Maintenance Planner, allow a minimum of 5 working days for approval. Each FPIP is valid only for five working days. If the impairment extends beyond five days, submit another FPIP form.

    c. Impairment requests will be canceled if the person performing work is not present at the building fire alarm control panel within 15 minutes of the impairment scheduled start time.

2. **Putting a Building Fire Alarm System on "NO ACTION":** A fire alarm system put on "NO ACTION" operates in a standalone mode and will not transmit fire alarm signals to emergency responder workstations. Listed below are the requirements for placing a building on "NO ACTION" status:

a. Submit the FPIP form to the SCI requesting impairment.

b. The FPIP requestor or designee shall remain in the impaired building for the duration of the “NO ACTION” to function as a Fire Watch to call 911 in an actual fire.

c. If the “NO ACTION” extends into non-standard work hours, post signs at each ground-level building exit door informing building occupants that the fire alarm system is not in operation and to call 911 in a fire. The Fire Watch will be required during non-standard work hours.

3. **Disabling Fire Alarm Devices and Zones:** Fire alarm devices and zones are frequently disabled (blocked out) to prevent accidental activation while performing work or to allow modification to occur on a fire alarm system. Listed below are the requirements for disabling fire alarm system devices or zones:

a. Submit the FPIP form to the SCI requesting impairment.

b. The FPIP requestor or designee shall remain at the fire alarm control panel whenever notification appliance circuits (NACs) are disabled to restore operation of the NACs if an actual alarm occurs that requires building occupants to be evacuated. In Building 858, TA-V, and the Radioactive and Mixed Waste Management Facility (RMWMF), Sandia personnel will be required to stay at the panel while the NACs are disabled.

c. For manual pull stations that are non-operational because they are disabled or part of new construction, place a sign over the pull station stating, “OUT OF SERVICE.”

d. If the fire alarm control panel will be non-operational during non-standard work hours, post signs at each ground-level building exit door informing building occupants that the fire alarm system is not in operation and to call 911 in a fire. The Fire Watch will be required during non-standard work hours.

H. Fugitive Dust Control Permit

For surface-disturbance operations affecting land area greater than ¾-acre, sandblasting, and other surface preparation or demolition of any building containing over 75,000 cubic feet of total volume, comply with the requirements of Division 1, Section 1563, *Dust Control*, and the Fugitive Dust Control Permit issued by the City of Albuquerque.

I. Storm Water Control

For construction sites greater than 1 acre, develop and submit a Pollution Prevention Plan to the SDR for review prior to construction operations. The Pollution Prevention Plan shall follow the EPA’s National Pollution Discharge Elimination System (NPDES). This system addresses silt control and other possible storm-water effects. The NPDES requires inspections at least every 14 calendar days, and within 24 hours of the end of a storm event of 0.5 inches or greater. Inspections shall continue through the duration of the project. Contractors shall report spills and accidental releases to the storm sewer system immediately to the SDR. All documents associated with the Pollution Prevention Plan, including inspection documents and reports, shall be submitted to the SDR upon request of final payment.

J. Earth Fill and Borrow Areas

Project-specific fill and borrow areas shall not be near or on underground or aboveground utilities. If the Contractor has written authorization from the SNL Project Manager or contract documents to use a designated borrow or fill area in a location other than the project site, the Contractor shall do the following:

1. Ensure that the CSSP adequately addresses the hazards identified in the designated area. If the designated area is located within the boundaries of a project site controlled by another Contractor, the visiting Contractor shall coordinate access with the controlling project site Contractor and comply with all requirements for that site.
2. Obtain the required Fugitive Dust Control Permit prior to disturbing the soil.

K. Bird Nesting Sites

Bird nesting sites are not to be disturbed. If nesting sites are discovered during the course of operations, contact the SCI for further direction.

L. Paved and Graded Roads

Contractors shall keep vehicles on paved or graded roads at all times unless prior approval has been obtained to travel into previously undisturbed areas.

M. Sanitary Sewer Discharge

Notify the SDR of planned discharges to the sanitary sewer system, other than routine sewage, prior to discharge. The SDR will review the planned discharge and coordinate authorization from the Sandia Water Quality organization. Report spills and accidental releases to the sanitary sewer system immediately to your SDR.

N. Surface Discharge

Notify the SDR of planned surface discharges prior to discharge. The SDR will review the planned discharge and coordinate authorization from the Sandia Water Quality organization. Report spills and accidental releases immediately to the SDR.

O. Underground Storage Tanks

Underground storage tank (UST) installation and maintenance operations shall comply with New Mexico Environment Department (NMED), UST Bureau requirements. The NMED UST Bureau-Certified Contractor shall perform work activities/tasks on USTs. If an unanticipated UST is discovered during construction operations, contact the SCO for notification to SNL's FESH team.

P. Contractor's Staging Area

The SDR shall approve staging area locations prior to use. Stored vehicles and equipment, intended for use on SNL property, shall be in serviceable and safe operating condition. Immediately repair or remove defective or unsafe equipment from SNL property until proper repairs are completed. The staging area shall not be used for storage of hazardous materials not intended for timely use (within 30 days) for work activity. Remove or dispose of excess hazardous material in accordance with the "Waste Management and Disposal" article.

Q. Temporary Buildings/Storage Areas

Obtain approval from the SDR for location of temporary buildings and storage areas prior to scheduled delivery of building or material.

R. Hoisting, Rigging, and Load Handling

This section applies to all hoisting and rigging lifting operations involving but not limited to chain falls, bridge cranes, mobile cranes, forklifts, and all-terrain lifts. Adhere to DOE-STD-1090-2015 during hoisting and rigging operations. Perform a proper hazard analysis for all hoisting activities on a graded approach and in concurrence with the SNL construction team.

1. **Mobile Cranes: All crane lifts require documented review and approval.** Notify the SPM 48 hours in advance of the scheduled mobile crane site arrival time and arrange for a Facilities crane inspection. The inspection shall include but not be limited to verification of license or training; load charts; inspection reports; and physical verification of ropes, slings, undercarriage, outriggers, and boom. Additionally, the SCI shall document the review of crane placement and lifting plan or sequence with the Contractor and Contractor's crane operator, as appropriate. Review the site for underground utility vaults. Buildings or affected parts of the buildings shall be evacuated prior to lifts; this shall be conducted in conjunction with the SNL construction team. All crane lifts shall be submitted for review and approval.

   a. Provide proof of inspection and load tests in accordance with 29 CFR 1926 and ASME B30 series.

   b. Crane operators shall be properly trained and experienced in operation of the crane or hoisting device. The Crane operator shall have one of the following in possession during crane inspection and operation: valid State of New Mexico Crane Operator's License or certification that indicates completion of a State of New Mexico recognized, in-house training course based on ASME B30 standards for hoisting operators and who is employed by the entity that taught the training course or contracted to have the training course taught.

2. **Ordinary/Documented Lift Plan:**

   a. Lift planning shall comply with ASME P30.1, "Planning for Load Handling Activities" and 48 CFR 970.5223-1 "Integration of environment, safety, and health into work planning and execution"—a.k.a. Integrated Safety Management System (ISMS). The following additions and exceptions to the above cited standard should also be implemented.

   b. A written lift plan beyond normal site work planning and control documents is not required for ordinary lifts, other than crane operations. However, the Designated Leader may determine that a written plan is prudent.

c. The Designated Leader shall ensure that in addition to the P30.1 "Standard Lift Plan" considerations, the following pre-lift planning issues are addressed, as applicable, prior to the lift.

   1) Identify the item to be moved, its intrinsic characteristics (e.g., load integrity, loose materials, liquids), weight, dimensions, center of gravity, ability to support imposed lifting forces (both the load and any lift points), and whether it contains any hazardous or toxic materials.
   2) Validate the loads path and clearances.
   3) Identify lifting equipment and rigging to be used by type and rated capacity.
   4) Prepare rigging sketches, as necessary.
   5) Evaluate the work area for conditions impacting crane setup operations (e.g., weather, soil bearing capacity, underground utilities, clearances to power lines and other structures).
   6) Identify any special or site-specific operating procedures and special instructions.

3. **Critical Lift:**

a. A designated person shall classify each lift/load handling activities (LHA) into one of the DOE categories (ordinary, special critical, personnel, or pre-engineered production) prior to planning the lift. A lift shall be classified critical if any of the following conditions are met:

   1) If loss of control of the item being lifted would likely result in the declaration of an emergency as defined by the facility's emergency plan or construction site emergency plan (such as release of radioactive or hazardous material into the environment exceeding the established permissible environmental limits).
   2) The load item is unique and, if damaged, would be irreplaceable or not repairable and is vital to a system, facility, or project operation.
   3) The cost to replace or repair the load item, or the delay in operations of having the load item damaged, would have a negative impact on facility, organizational, or DOE budgets to the extent that it would affect program commitments.
   4) If mishandling or dropping of the load would cause any of the above noted consequences to nearby installations or facilities.
   5) For steel erection, a lift shall be designated as a critical lift if:
      a) The lift exceeds 75 percent of the rated capacity of the crane or derrick, ***or***
      b) The lift requires the use of more than one crane or derrick (refer to 29 CFR 1926.751).
         i. Further site-specific criteria may be developed to supplement

those cited above and may include criteria imposed by site or project safety basis requirements as well as lifting loads which require exceptional care in handling because of size, weight, close-tolerance installation, or high susceptibility to damage, as well as lifts using multiple pieces of lifting equipment.

ii. The critical lift plan must be followed in sequence as written unless noted otherwise.

iii. Though lifting personnel may meet the above criteria, personnel lifts shall not be considered critical lifts and shall be conducted in accordance with 29 CFR 1926.1431 and ASME B30.23.

b. **Critical Lift Requirements**

1) Ensure that the requirements are met for lifts specified in each section of this standard for each particular equipment category.

2) The operating organization shall appoint a person who meets the criteria for both a competent person and a qualified person, or by a competent person who is assisted by one or more qualified persons (Lift Director). The Competent/Qualified person/Lift Director shall be present at the lift site during the entire lifting operation.

3) The Lift Director shall:

a) Have the necessary knowledge and experience of the specific type of equipment and assigned lifting operations.

b) Understand the site rules and procedures addressing:

i. Administrative requirements for lifting operations.

ii. Personnel assignments and responsibilities commensurate with job requirements.

iii. Selection of proper slings, rigging hardware, and lifting equipment.

iv. Recognition and control of hazardous or unsafe conditions.

v. Job efficiency and safety.

vi. Critical-lift determination and documentation.

4) The Competent/Qualified person shall ensure that a documented pre-job plan or procedure is prepared by qualified person(s) that defines the operation and includes the following:

a) Identify the item to be moved, its intrinsic characteristics (e.g., load integrity, loose materials, liquids), weight, dimensions, its center of gravity, its ability to support imposed lifting forces (both the load and any lift points), and whether it contains any hazardous or toxic materials.

b) Identification of operating equipment to be used by type and rated capacity (e.g., mobile crane, overhead crane, forklift).

c) Rigging sketches and/or descriptions that include (as applicable):

i. Identification and rated capacity of slings, lifting bars, rigging accessories, and below-the-hook lifting devices. Calculate and provide the rated capacity of equipment in the configuration in which it will be used.

ii. Load-indicating devices.

iii. Load vectors.

iv. Lifting points.

v. Sling angles.

vi. Required lifting equipment movement (e.g., boom and swing angles, trolley and bridge motions).

vii. Methods of attachment.

viii. Crane orientations.

ix. Other factors affecting equipment capacity (e.g., load path sketch, key point heights, floor or soil bearing capacity).

5) Operating procedures and special instructions to operators including rigging precautions and safety measures to be followed as applicable.

a) All rigging equipment used in critical lifts (i.e., slings, below-the-hook lifting devices, and rigging hardware) shall be proof load tested in accordance with applicable ASME standards.

b) Experienced operators who have been trained and qualified to operate the specific equipment to be used shall be assigned to make the lift.

c) Only designated, qualified signalers shall give signals to the operator. However, the operator shall obey a STOP signal at all times, no matter who gives the signal.

d) The procedure and rigging sketches shall be reviewed and approved by a qualified person (technical authority), the responsible manager (or designee), and the responsible oversight, which could include a competent safety person and qualified rigging engineer before the lift is made. Subsequent revisions shall be approved per site-specific procedures.

e) A pre-lift meeting involving participating personnel shall be conducted prior to making a critical lift. The critical lift plan/procedure shall be reviewed and questions shall be resolved.

f) Prior to executing a critical lift, a qualified person shall verify that the as-installed rigging matches the configuration in the approved lifting plan.

g) If required by the critical lift procedure, a practice lift shall be done before the critical lift. Conditions for a practice lift should closely simulate actual conditions involving weight, rigging selection and configuration, load movement path, and other relevant factors. Practice lifts should be performed by the same crew using the same lifting equipment that will be used in the lift. The crane/equipment should be operated through the full range of motion prior to performing the lift.

h) Although individual plans are generally prepared for critical lifts, multi-use plans may be employed to accomplish recurrent critical lifts. For example, a multi-use plan may be used to lift an item or series of similar items that are handled repeatedly in the same manner. However, if the lifting equipment or rigging must change to accomplish the lift, the critical lift plan must be revised and approved accordingly.

4. **Millwright/Moving:** The contractor shall use properly rated equipment for millwright and industrial moving operations. Considerations shall be made for floor loading, building considerations, knowledge of the weight being moved, unstable loads, anchor points, tie-downs, chocks, struck-by, caught-between hazards, and training.

5. **Digger-Derricks:**

a. The digger derrick is a multi-use piece of equipment. Generally, the 1910.269 standard applies to the use of a Digger-Derrick by a qualified electrical worker and operator.

b. For nonqualified electrical workers refer to **1926.1408**.

1) Determine if any part of the equipment, load line, or load (including rigging and lifting accessories), if operated up to the equipment's maximum working radius in the work zone, could get closer than 20 feet to a power line. If so, the employer must meet the requirements in Option (1), Option (2), or Option (3) of this section, as follows:

a) **1926.1408(a)(2)(i)** *Option (1) – Deenergize and ground*. Confirm from the utility owner/operator that the power line has been deenergized and visibly grounded at the worksite.

b) **1926.1408(a)(2)(ii)** *Option (2) – 20-foot clearance*. Ensure that no part of the equipment, load line, or load (including rigging and lifting accessories), gets closer than 20 feet to the power line by implementing the measures specified in paragraph (b) of this section.

c) **1926.1408(a)(2)(iii)** *Option (3) – Table A clearance*.

d) **1926.1408(a)(2)(iii)(A)** Determine the line's voltage and the minimum approach distance permitted under Table A (*see* § 1926.1408).

e) **1926.1408(b)(5)** The requirements of paragraph (b)(4) of this section do not apply to work covered by subpart V of this part.

c. Qualified High Voltage Worker working on transmission and distribution systems.

1) 1926.960 – Electric Power T&D – Working on or near exposed energized parts

Note: Most of this section deals with Qualified Workers doing live-line barehand type work from aerial lifts on energized conductors. The only part that applies to the Digger Derrick crews is the 2-man rule, if lines are potentially energized. Approach distances are calculated for live line work, not mechanical equipment.

S. Confined-Space Entry

Contractor work practices and procedures shall incorporate all applicable regulatory requirements and SNL specifications, and knowledge of the content of applicable regulatory standards should be considered fundamental for any Contractor who proposes to engage in confined space operations at SNL.

1. **Types:** There are three types of construction confined space entry operations recognized at SNL/NM—permit-required, non-permit, and telecommunications. The Contractor is responsible for developing confined-space entry programs and issuing confined space permits.
2. **Signage:** In areas that appear to qualify as a confined space, absence of appropriate signage shall not be interpreted to mean that the area is not a confined space.

   a. Permit-Required Confined Space signs state DANGER – CONFINED SPACE – ENTER BY PERMIT ONLY or other similar language.

   b. Non-Permit Confined Space signs state CAUTION – CONFINED SPACE – CONTACT SPACE OWNER FOR PERMISSION TO ENTER or other similar language.

3. **Written Confined Space Program:** The Contractor is responsible for developing confined space entry programs and issuing confined space permits.

   Note: Telecommunication-confined space requirements are covered under number 6 of this section. The Contractor's written confined space program shall comply with 29 CFR 1926 Subpart AA and include at a minimum the following requirements:

   a. Define how spaces are classified:

      1) Permit-required confined space (PRCS)

      2) Non-permit confined space (NPCS)

   b. Define alternate procedure/reclassification of PRCS (optional)

      1) C5 alternate procedure (atmospheric hazard only)

      2) C7 reclassification (non-atmospheric hazards)

c. State training objectives/requirements for:

    1) Supervisor authorizing entry (SAE)
    2) Authorized entrant
    3) Attendant

d. Implement measures that prevent unauthorized entry into permit-required confined space

e. Identify and evaluate the hazards of permit spaces

f. Develop and implement procedures for safe permit space entry operations, including but not limited to the following:

    1) Define atmospheric monitoring requirements:

        a) Instrument used for calibration and bump testing, hazards monitored, and documentation of results
        b) Acceptable entry conditions specifying OSHA PEL or ACGIH TLV, whichever is most protective.

    2) Identify control measures including:

        a) Communication: radio, voice, visual, etc.
        b) Isolation
        c) Cleaning
        d) Purging
        e) Inerting
        f) Flushing
        g) Ventilation
        h) Protective equipment
        i) Rescue equipment
        j) LOTO of equipment

    3) State pre-entry briefing requirements:

        a) Frequency
        b) Items/safety issues covered
        c) Attendance requirement and documentation

    4) Address requirement for entrant protection from outside hazards as necessary via pedestrian, vehicle, or other barriers.

5) Address verification procedures of conditions in the permit space as being acceptable for entry throughout the duration of an authorized entry.
6) Provide provision for authorized entrant or his/her authorized representative to have the opportunity to observe any monitoring or testing of permit spaces.
7) If C5 alternate procedures are incorporated into written plan, develop and implement requirements set forth in 1910.146(c)(5).
8) If C7 reclassification is incorporated into the written plan, develop and implement requirements set forth in 1910.146(c)(7).

g. Identify non-entry rescue methods

1) Non-entry retrieval equipment
2) Extraction procedures

h. Develop and implement an Emergency Response Plan that has appropriate elements of the following:

1) "Rescue of Personnel in Confined Spaces at SNL/NM"
2) SNL Incident Commander (IC) notification methods:

a) Just prior to entry
b) After entry is terminated
c) If any emergency situation occurs

i. Includes forms for permit-required confined space entry

1) SF 2001-CSS, *Confined Space Permit Sign-In/Sign-Out Sheet for Emergency Response*
2) Contractor's permit
3) Contractor's C5 alternate procedure form, if implemented into written Confined Space Program
4) Contractor's C7 reclassification form, if implemented into Contractor's written Confined Space Program

j. Address method used to inform SDR of hazard(s) confronted or created in permit spaces through a debriefing or during entry operations.

4. **Permit Required Confined Space:** The Contractor must meet with representatives from the SNL Confined Space Program prior to entry to ensure that all hazards are adequately identified and that all entry requirements comply with applicable standards:

a. 29 CFR 1910.146 and approved written Confined Space Program
b. SAE, attendant, and authorized entrant(s) shall be current with training requirements

c. Conduct a pre-entry briefing

d. Fill out permit

1) Implement all controls noted on permit

2) Wear all PPE required for entry noted on permit

e. Personnel making a confined space entry shall follow the procedures in Attachment A, "Rescue of Personnel in Confined Spaces at SNL/NM," to establish their confined entry plan.

f. Notification requirements include the following:

1) Communication must be established with the IC at the jobsite prior to entry. This can be accomplished via cell phone, if working outside of Limited Areas, or two-way radio. SOCs have radios that can be loaned to the Contractor for a confined space entry.

a) The Contractor shall identify the specific location of the confined space (building, room, space type; if the space is outside, indicate the direction [NW, SE, etc.] from the closest building).

b) The Contractor shall identify the individual serving as the SAE (for purposes of overseeing the entry), the company name, and number of entrants and attendants.

c) The Contractor shall identify the communication equipment used to contact emergency personnel (IC) and the means used to communicate between the attendant and entrants.

g. SF 2001-CSS, *Confined Space Permit Sign-In/Sign-Out Sheet*: This form is used to maintain accurate, real-time tracking of entrants for emergency response. Use of this form only becomes necessary when the permit extends beyond a single day, or different entrants other than those initially identified on the permit are involved in the entry.

h. Atmospheric Monitoring: Perform atmospheric monitoring on a continuous basis for the duration of the entry. If monitoring indicates the presence of atmospheric contaminants above acceptable concentrations, NO ENTRY IS ALLOWED. If entry has already occurred when contaminants are detected, exit the space immediately and contact the SCO, SDR, and IC.

1) If C5 alternate procedures are allowed under the Contractor's written Confined Space Program and are used, the IC does not need to be notified.

2) If C7 reclassification is allowed under the Contractor's written Confined Space Program and is used to enter the PRCS, then the following apply:

a) The IC does not need to be notified.

b) Atmospheric monitoring is not done (no actual or potential hazardous atmosphere exists).

c) Non-atmospheric hazards are eliminated during entry.

3) Completion/termination of permit entry:

a) Notify IC that PRCS entry is terminated.

b) Debrief SDR of hazard(s) confronted or created in permit spaces.

5. **Non-Permit Confined Space:** This refers to a space that fits the definition of a confined space but lacks any inherent or introduced hazards. Entry into this type of space includes:

   a. Pre-entry briefing.

   b. If operations performed within and/or in close proximity to the confined space will create additional hazards that will impact safeguards and entry procedures, space shall be treated as a permit-required confined space and follow the requirements of 29 CFR 1910.146 and the Contractor's written Confined Space Program.

6. **Commissioned Telecommunication Manholes and Vaults:** These must comply with the following:

   a. 29 CFR 1910.268

   b. Telecommunication manholes and vaults that have been newly constructed or are part of an ongoing construction project are not considered commissioned and shall comply with 29 CFR 1926 Subpart AA.

T. Electrical Safe Work Practices

Ensure that electrical work, equipment, and installations are in compliance with the National Electric Code (NEC); National Electric Safety Code (NESC); NFPA 70E, *Standard for Electrical Safety in the Workplace*; and OSHA standards. When conflicts exist between OSHA and NFPA 70E, the contractor shall review the affected work with the SNL team prior to operations. Subcontractor and manufacturers' representatives shall be managed to the above standards.

1. **Training:** Employees who face a risk of electrical hazard that is not reduced to a safe level by the applicable electrical-installation requirements shall be trained to understand the specific hazards of electrical energy and identify and understand the relationship between electrical hazards and possible injury. Retraining is required for qualified workers every three years.
2. **Documentation:** The Contractor shall document that each employee has received the training on electrical hazards and controls necessary for his/her safety. Records shall be maintained for the duration of the employee's employment and shall contain each employee's name and dates of training.
3. **Lockout/Tagout:** Lockout/tagout procedures shall be documented in the Contractor's CSSP. The procedures shall be appropriate for the experience and training of the employees and the conditions that exist in the workplace. The procedure shall address employee and management responsibilities associated with LOTO, training, system/hazard

communication, and energy control methods (e.g., types of locking devices, authorized testing equipment, and PPE). A lock must always be applied (Article 120) NFPA 70E.

4. **Arc-Flash Protection:** Arc-flash-protection procedures shall be documented in the Contractor's CSSP. At a minimum, documentation shall include requirements for (1) developing arc-flash boundaries; (2) requirements for protective clothing, hard hats, eye protection, face shields, hand and foot protection, and hearing protection based on hazard/risk category classifications; and (3) care and maintenance of arc-rated (AR) clothing, AR flash suits, and other PPE.

   If the SNL electrical equipment/system to be worked on has an arc-flash hazard (AFH) warning label, contract employees will wear PPE and establish flash boundaries specified in their employer's CSSP for the hazard level/category identified on the label. If the electrical equipment is not provided with an AFH warning label, contract employees will implement controls, wear PPE, and establish flash boundaries as identified in their employer's CSSP for the hazard/risk categories specified below.

5. **Shock Protection:** Procedures shall be documented in the Contractor's CSSP. At a minimum, documentation shall include requirements for the following: (1) developing limited shock approach boundaries, (2) requirements for voltage-rated gloves and insulated tools, and (3) maintenance and testing of PPE.

6. **Electrical Outage Requests:** Prior to performing work on any live parts that are not placed in an electrically safe work condition (i.e., prior to performing energized work), the Contractor shall contact the Electrical SCI and request an electrical outage. Exemptions to this requirement include tasks such as testing, troubleshooting, and voltage measuring, assuming appropriate safe work practices and PPE are provided and used in accordance with NFPA 70E.

7. **GFCI Protection:** Provide listed ground-fault circuit interrupter (GFCI) protection for 120-volt, single-phase, 15- and 20-ampere receptacle outlets on work sites that are not part of the permanent wiring of a building or structure and that are in use by employees.

U. Energized Electrical Work

This includes work performed on live parts that are not placed in an electrically safe work condition.

1. Energized work shall not proceed without written justification/authorization from the SNL Project Manager and Contractor's written permit. Permit and authorization shall be available onsite during the energized work task. The Contractor's written permit shall include, at a minimum, all items required by NFPA 70E.
2. When working on or near energized parts in hallways, corridors, or other areas used for passage, maintain a working space barrier with caution tape and signage. The working space boundary for barriers shall be defined at the "limited-approach boundary."
3. Do not leave exposed energized parts unattended in areas occupied by those other than construction personnel. Do not leave exposed energized parts without providing working space barrier at the "limited-approach boundary."

4. Comply with the following when working on energized electrical parts:

   a. Notify the SCI before proceeding with work.

   b. Electrical work on energized electrical parts shall be performed by a qualified individual with a second qualified person available.

   c. Individual shall be knowledgeable and experienced in working with the specific type of electrical circuits on which energized electrical work is to be performed. See Division 16, Section 16475, “Primary Systems Safety Requirements,” for additional requirements.

V. Steel Erection Work

This includes any steel erection operations involved in construction, alteration, and/or repair of single- and multiple-story buildings, bridges, and other structures where steel erection occurs.

1. Each employee engaged in steel erection tasks that are on a walking working surface with an unprotected side or edge more than 6 feet above a lower level shall be protected from fall hazards.

W. Fall Protection

Control the methods used to protect employees from fall hazards, which may include administrative controls, PPE, and other controls necessary for fall restraint or fall arrest.

1. The CSSP shall identify administrative controls, fall-protection methods, or both to be used for all work within 15 feet of an unprotected side or edge that is more than six feet above a lower level for all construction trades, excluding roofers. The requirement is within six feet for roofers.

2. Anchor points to be connected by drilling, welding, or attaching to SNL structures/buildings used for fall-protection purposes must be reported to the SDR/SCO for SNL approval prior to installation and use.

X. **Asbestos Safety**

Asbestos might be present in existing building materials, finishes, and mechanical systems.

1. Asbestos-containing building materials will be identified as part of the JSHE. An Asbestos Work Release Permit will be attached to the JSHE report.

   Work may proceed only if the Contractor’s work activities do not damage or disturb the asbestos-containing materials. If worksite conditions or the scope of work changes, or if the Contractor is unsure if work activities will damage or disturb potential asbestos-containing building materials, the Contractor must stop work and contact the SNL Construction Observer or the SDR for further instructions.

   If construction activities uncover hidden finishes or building systems that are suspected to contain asbestos, the Contractor must stop work and contact the SCO or the SDR for further instructions.

2. **Asbestos Work Release Permit:** This permit documents existing asbestos hazards and provides recommendations to control or eliminate the hazards. The Contractor must conduct a pre-work safety meeting with workers to review the Asbestos Work Release Permit guidance and follow the guidance exactly when performing the work.

Appendix A: Occupational Medicine Services

A.1 Purpose

All Contractors and their lower-tier Subcontractors must comply with the DOE's Worker Safety and Health Program regulation, 10 CFR 851, *Worker Safety and Health Program* (WSHP). The WSHP enforces worker safety and health requirements, including but not limited to existing standards of OSHA, ANSI, and Workers Compensation Laws, as incorporated in the SNL WSHP.

To assist in ensuring Contractors meet the worker safety and health provisions of 10 CFR 851 in the occupational medicine functional area, SNL requires Contractors to provide a written declaration identifying their Occupational Medicine Providers (OMP), as applicable, prior to performing work.

A.2 Applicability

Contractors at all tiers who meet the applicability criteria below must establish and provide comprehensive occupational medicine services to workers employed at DOE-controlled premises. Occupational health personnel providing services must maintain current license, registration, or certifications as required.

A.3 Criteria

- Work on a DOE site for more than 30 days in a 12-month period

  or

- Are enrolled for any length of time in a medical- or exposure-monitoring program required by this rule and/or any other applicable federal, state, or local regulation or other obligation.

A.4 General Requirements Summary Information

In accordance with New Mexico Workers Compensation Laws, OSHA, and DOE Regulation (10 CFR 851, *Worker Safety and Health Program*), Contractors at all tiers must have an OMP for performing hazard-based medical monitoring and surveillance; qualification-based fitness for duty medical evaluations; and injury and illness case management. The Contractor is responsible for maintaining the appropriate documentation to demonstrate compliance with the administration of necessary medical and health care programs and may be subject to assessments and audits.

Hazard-based medical monitoring and surveillance programs include but are not limited to the following:

- OSHA specifically regulated substances ("Expanded Health Standards"), including but not limited to the following: asbestos, arsenic, cadmium, chromium, lead, and methylene chloride
- OSHA occupational noise exposure

Qualification-based fitness-for-duty evaluations include but are not limited to the following:

- OSHA/ANSI respiratory protection
- Department of Transportation (FMCSA) commercial driver's license

Injury and illness case management includes but is not limited to the following:

- Determination of work-relatedness
- Work restrictions
- Rehabilitation
- Return to work

A.5 Occupational Medicine Program Requirements

Occupational medicine services must be under the direction of a graduate of a school of medicine or osteopathy. OMPs, such as physicians, nurses, physician assistants, nurse practitioners, psychologists, and employee-assistance counselors, must be licensed, registered, or certified as required.

Contractors shall make available to their OMP current activity-level hazard information, such as that listed in the CSSP and addenda. This information must include the following:

- Actual or potential work-related hazards (chemical, radiological, physical, biological, or ergonomic)
- Actual or potential work-site exposures
- Job functions
- Update information when a change to job functions, hazards, or exposures occurs

The following health evaluations shall be conducted when determined necessary by the OMP. The results of evaluations performed by the OMP must be communicated, as appropriate, to facilitate activity work controls and mitigation of hazards.

- Medical placement evaluation at the time of employment entrance or transfer to a job with new functions and hazards
- Hazard-based medical monitoring or qualification-based fitness for duty medical evaluations required by regulations and standards
- Medical diagnostic examinations to evaluate an employee's injuries and/or illnesses for work-relatedness, applicability of medical restrictions, and referral for definitive care, as appropriate
- After a work-related injury or illness or an absence because of any injury or illness lasting 5 or more consecutive workdays, inform the OMP provider to determine if an evaluation is necessary
- General health evaluation at the time of separation from employment
- The purpose, nature, and results of evaluations and tests must be clearly communicated verbally and in writing to each worker provided with testing, and the results must be documented in the medical record of the worker.

Afford the OMP an opportunity to participate in worker safety and health meetings and committees, as well as an opportunity to conduct worksite visits. Worksite visits are conducted for an evaluation of job conditions and issues relating to the health of their workers. All site visits by the OMP to Sandia-controlled premises must be coordinated with the SNL Inspector. The Inspector will notify a representative from Health, Benefits, and Employee Services (HBE) of the visit request.

The Contractor shall ensure the OMP establishes a record, including any medical, health history, exposure history, and demographic data collected for occupational medicine purposes, which is maintained for each worker receiving occupational medicine services. Documents shall be stored in a manner that will ensure their long-term preservation and retrieval. Records must remain confidential and protected from unauthorized access. Any psychological records shall be maintained separately from medical records and in the custody of the designated psychologist. Access to the records shall be granted in accordance with DOE regulations implementing the Privacy Act and the Energy Employees Occupational Illness Compensation Program Act.

Contractors at all tiers are responsible for workers' compensation administration and case management. The OMP shall monitor ill and injured workers to determine work-relatedness, facilitate their rehabilitation and safe return to work, and issue and/or remove restrictions as necessary. Ensure the OMP notifies the worker and the SDR for any issued and/or removed work restrictions and communicates results of health evaluations to management and safety and health protection specialists to facilitate the mitigation of worksite hazards.

The OMP must include measures to identify and manage the principal preventable causes of premature morbidity and mortality affecting worker health and productivity. The Contractor must include programs to prevent and manage these causes of morbidity when evaluations demonstrate their cost-effectiveness. If programs are implemented, Contractors must make available to the OMP appropriate access to information from health, disability, and other insurance plans (de-identified as necessary).

Submit Employee Assistance Programs to the OMP (EAP: Substance Abuse Rehabilitation Programs and Wellness Programs) for review and approval of the medical and behavioral aspects of these counseling and health promotional programs.

The Contractor shall ensure the OMP reviews the medical aspects of immunization as well as bloodborne pathogen and biohazardous waste programs to evaluate their conformance with applicable guidelines. The Contractor must determine the applicability and need for the specific programs based on work activities and actual or potential worksite exposures of each employee.

Sandia shall provide the OMP the opportunity to review medical emergency response procedures in site emergency and disaster preparedness plans. Contact the SDR for assistance.

Appendix B: Facilities Superintendent – Job Aid

Date: ___________ Location: _____________________Name___________________________________

The superintendent role is critical to the facilities construction success. It is also a requirement under 10 CFR 851. Below are some requirements and reminders to support superintendent interaction and discussion with the work team. Promoting hazard awareness, understanding, and a questioning attitude at the work site will lower the number and severity of incidents as work site conditions change.

- ☐ **Pre-work Planning**: Read the safety plan/CSSP and understand the specific elements that pertain to the project Scope of Work. Evaluate procedures to assure that adequate precautions exist.
- ☐ **Train/communicate the crew** on the CSSP, JSHEs, permits and possible hold points. Facilitate a "what if" discussion.
- ☐ **Increase awareness** of "High risk activities"; working near high-voltage lines or gas lines, working at heights/ladders, excavations, struck-by equipment, etc.
- ☐ **Pre-Task Plan:** The pre-task plan is completed and all workers understand the hazards, steps, and controls for the job at this time. They know that they must re-evaluate for changes.
- ☐ **Anticipate changes**: Take time to closely examine the project-specific hazards throughout the day and allow the project team to implement proper controls in advance to avoid or mitigate them.
- ☐ **Lead by example**: Abide by safety rules and make time to be visible and challenge workers at the site to think about emerging and potential hazards.
- ☐ **Understand interaction with all contractors**: Communicate between crafts, within facilities, with SNL personnel and scheduling.
- ☐ **Empower workers** to stop/pause work to address operational safety issues before an incident occurs. Reward such behavior.
- ☐ **Barricading: Is proper barricading for pedestrian, vehicle and overhead work in place?**
- ☐ **Awareness of "scope creep":** Identify when work transitions from an area of well-understood hazards to tasks exposing workers to unplanned-for hazards that have "crept" into the activity.
- ☐ **Identify span of control issues**: Are work crews properly supervised, and is there always a person with stop-work authority?
- ☐ **Identify the "critical thinkers":** Empower critical thinkers to challenge the team, stop/pause work, rethink, and seek technical help when necessary.
- ☐ **Reward safe actions:** Provide small awards for team members who identify, report, or work to avoid a safety issue or concern, and actively support site safety awareness.

END OF SECTION

Exceptional service in the national interest

Sandia National Laboratories

Section 01 06 5A – Attachment A: Rescue of Personnel in Confined Spaces at SNL/NM

April 2016

Effective Date: 04/18/2016
Review Date: 04/18/2019

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 01 06 5A – Attachment A: Rescue of Personnel in Confined Spaces at SNL/NM

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.

Rescue of Personnel in Confined Spaces at SNL/NM

General Requirements and Advance Notification

The Contractor Entry Supervisor (also known as the Supervisor Authorizing Entry) is responsible for the following:

- Providing advance notification of the confined space entry activity to SNL On Duty Incident Commander (IC) **PHONE: 844-4189 (24-hour duty phone)** to verify that rescue services are available. Advance notification must occur by phone on a daily basis for the duration of the entry activity. If additional written information is requested by the SNL/IC, it may be faxed to 844-7474 (preferred) or 844-6533. **NOTE:** Do not fax entry notification, phone contact must be established with the IC prior to work.
- Ensuring that the means for summoning emergency response/rescue personnel is operable and readily available.
- Notifying the IC when the entry activity is terminated. As with notification, termination must occur on a daily basis for the duration of the activity.
- Selecting the retrieval equipment and determining if the use of the equipment would increase the overall risk of entry and would not contribute to the rescue.
- Identify alternate means for the Rescue Service to contact the Entry Supervisor (cellular, pager, radio, etc.) in the event emergency services become unavailable during the entry period.
- Ensuring all equipment and instrumentation is inspected prior to use to ensure proper working condition. Equipment shall be maintained in accordance with manufacturer's requirements.
- Posting the entry permit at the entry site.
- If chemical materials are used in the confined space, the manufacturer's Material Safety Data Sheet (MSDS) must be attached to the permit.

Non-Entry Extraction of Confined Space Entrant(s)

Should it become necessary to extract personnel from a confined space, it is essential that all personnel involved know exactly what to do and what not to do. There have been several instances where persons who were trying to rescue an individual in a confined space also became victims, because of failure to follow the proper procedures. The Attendant may retrieve a victim wearing a retrieval line from a confined space if this is possible without additional help **and does not require entry by the Attendant.** Typical retrieval/extraction equipment includes tripod, wincher (mechanical lifting device), retrieval line, and body harness. Retrieval equipment is not required for Non-Permit Confined Spaces; however, strong consideration should be given to spaces which present unique rescue difficulty due to location (such as remote areas), space configuration, or other elements.

The hazards associated with work in confined spaces include possible exposure to the following:

1. Oxygen deficient atmospheres (Less than 19.5%)
2. Oxygen enriched atmospheres (Greater than 23.5%)
3. Atmospheres containing flammable gas or dust
4. Atmospheres containing toxic substances or biological hazards
5. Mechanical or physical hazards

II. CONFINED SPACE EMERGENCY: ENTRY RESCUE: The SNL/Emergency Management Dept. and KAFB Fire Dept. provide entry rescue/responder service for confined spaces at SNL/NM.

- **PRIMARY: Contact: SNL/On Duty Incident Commander** (service during standard working hours, Monday-Friday) **PHONE: 844-4189; or 844-0911 from a cellular phone; or 911 from an SNL phone**
- **The On-Duty Incident Commander prefers SNL personnel contact them 7 days/24 hours first. If necessary, the IC will contact Kirtland Air Forces Base. SECONDARY: Contact: Kirtland Air Force Base** (service after standard hours and weekends) **PHONE: 846-8069;** FAX: **846-6569.** Also notify the SNL/IC.

NOTE: In Technical Areas or "limited access" areas where the use of cellular phones is prohibited, communication radios suitable for contacting emergency response services, are available from the Construction Inspection and Acceptance Group. Instructions for radio use are also available from the Construction Group.

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Sandia National Laboratories

Section 01065-S – Environment, Safety, and Health for Service Contracts

April 2016

Effective Date: 04/18/2016
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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

Sandia National Laboratories

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Section 01065-S – Environment, Safety, and Health for Service Contracts

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.

Part 1 – Part 1 – General

1.01 Summary

Section Includes: Requirements and guidelines in performance of work concerning protection of environment and property, and the safety and health of Contractors, Sandia National Laboratories (SNL) and Department of Energy (DOE) employees, visitors to SNL, and members of the public. **This Section is applicable only to Service Contracts that do not involve construction or construction-like activities.** Construction and construction-like activities are covered by Section 01065, *Environment, Safety and Health* (*ES&H) for Construction Contracts*. The entire ES&H program shall focus on safe-by-design intent, understanding the technical basis for the work, identifying and controlling energy sources, unacceptable consequences, risk assessments, and positive verification.

1.02 References

A. American Conference of Governmental Industrial Hygienists (ACGIH®)

Threshold Limit Values (TLVs) for Chemical Substances

Physical Agents and Biological Exposure Indices (BEIs)

B. American National Standards Institute (ANSI)

Z41 Personal Protection - Protective Footwear

Z49.1 Sections 4.3 and E4.3 Welding, Cutting, and Allied Processes

Z88.2 Practices for Respiratory Protection

Z89.1 Industrial Head Protection

Z136.1 Safe Use of Lasers

C. American Society of Mechanical Engineers (ASME)

B30.5 Mobile and Locomotive Cranes

D. Code of Federal Regulations (CFR)

29 CFR 1910 Title 29-Labor, Part 1910-Occupational Safety and Health Standards

10CFR 851 Worker Safety and Health Program

E. National Fire Protection Association (NFPA®)

70 National Electrical Code

70-E Standard for Electrical Safety Requirements for Employee Workplaces

1.03 Definitions

Activity Hazard Analysis (AHA)	A documented plan that identifies and plans for the mitigation of hazards associated with activities. Activities are general classes of separately definable construction work (for example excavation, foundations, structural steel, and roofing). Activities are not time- or location-specific. An AHA is a required section of the Contract-Specific Safety Plan (CSSP).
Sandia Contracting Representative (SCR)	Person authorized to act as official representative of SNL for specific purpose of administering Contract, including payment authorization and approval for change orders. The SCR is the only person who may legally obligate SNL for expenditure of funds, change scope, change level of effort, change terms and conditions, negotiate, and sign documents legally binding SNL commitment. Obligations or promises, implied or expressed, by SNL personnel other than the SCR do not bind SNL in any manner.
Inspector	The Sandia Delegated Representative's (SDR) contract field representative to monitor, document, and report on the progress, quality, and safety of construction work in accordance with contract specifications and plans, and applicable codes. The Inspector assists in coordinating outages for construction operations. The Inspector shall not exercise supervision over Contractor's employees.
Sandia-Delegated Representative (SDR)	Person authorized in the Contract who is authorized to act as delegated Sandia representative for the specific purpose of review, inspection, and acceptance of work, and to interpret plans, specifications, codes, and standards. The SDR shall not exercise supervision over Contractor's employees.
Sandia Facilities Environmental, Safety & Health Support Team	Persons authorized to act as official representative of SNL for the specific purpose of supporting SCRs, SDRs, and Inspectors with ES&H observations and resolution of issues/concerns associated with Contractor safety performance. The team has representation from Sandia's Safety Engineering, Industrial Hygiene, Environmental, Radiological Protection, and Asbestos programs.
Sandia Delegated Representative (SDR)	Person responsible for the review and acceptance of the Contract-Specific Safety Plan, coordinating the Preconstruction Meeting, and providing written justification/authorization for energized electrical work. The SDR shall not exercise supervision over Contractor's employees.
Task Hazard Analysis (THA)	A process that may include dialog (such as a pretask plan or tailgate meeting), document (such as checklist or permit), or knowledge (such as training) that identifies and plans for the mitigation of hazards associated with a task. A task is a specific segment of a particular scope of construction work that is time-, condition-, worker- and/or location-dependent. Documented Task Hazard analysis is required on a graded approach, for example, permits. Critical thinking shall be utilized during this part of the analysis. A focus on what could go wrong, weather, and changes to the process and personnel need to be evaluated regularly.

1.04 Submittals

A. Contract-Specific Safety Plan (CSSP): Submit in accordance with Quality Assurance requirements for review and approval by the Sandia Delegated Representative (SDR) prior to commencement of onsite work.

B. Safety Plan Addendum: Submit modification to CSSP if required to address activity hazards not previously identified in the CSSP.

C. Pollution Prevention Plan: Submit in accordance with requirements of the Quality Assurance article when required.

D. Fugitive Dust Control Permit: Submit an application for a Fugitive Dust Control Permit when required.

1.05 Quality Assurance

A. Regulatory Requirements: Comply with applicable environmental, safety, and health laws, rules, and regulations (as amended) of the federal, state and local governments, the Department of Energy (DOE), and SNL. Adhere to safety rules and regulations, access restrictions, and emergency egress procedures unique to the Contractor's work at SNL-controlled premises, as defined in the following sections of this specification and Contract documents, and as determined through consultation with the SDR.

B. Flow-Down of Requirements (as applicable): Service Contractor shall flow down the requirements identified in this specification to subcontracts for all tiers. Sandia has the right to validate the work is being performed in accordance with a documented safety plan, and to stop work and resolve any noncompliance with applicable ES&H requirements for this contract and subcontracts for all tiers associated with this contract.

C. Worker Hazard Awareness and Training: The Service Contractor is responsible for ensuring its employees, subcontractors, and suppliers are informed of foreseeable hazards and protective measures associated with the worksite/project.

D. Service Contractor shall certify on the *Sandia National Laboratories/NM Facilities Contractor Badge/Clearance Request* form that employees have read and understand the CSSP.

1.06 Contract-Specific Safety Plan

A. General

The CSSP shall state the nature of the work, potential hazards anticipated, and how these hazards will be mitigated or how workers, including Subcontractors, service providers, area/building occupants, site visitors, and/or pedestrians in the vicinity of hazardous activities will be protected from hazards.

1. **CSSP:** Address the Occupational Safety and Health Administration (OSHA) 29 CFR 1910, DOE 10 CFR 851, ACGIH, and SNL-specific requirements. SNL requirements are identified in Section I and Section II (Standard Terms and Conditions) of the Contract, the *Jobsite Hazard Evaluation*, and this Specification. All requirements and recommendations identified in the *Jobsite Hazard Evaluation* shall be considered part of the CSSP unless an alternate hazard control/mitigation for the identified hazard has been submitted by the Contractor and accepted by the SDR.

2. The Prime Contractor may incorporate Subcontractors' CSSPs into a single CSSP package and submit for review and approval (any differences between the Prime Contractor's safety plan and

the subcontractors' safety plans shall be addressed prior to submitting package for review). Example: Contractor may want to include electrical Subcontractors' safety plan sections involving NFPA 70E arc flash and lockout/tagout (LOTO) for electrical hazards.

3. The Contractor shall submit a completed 01065S-A, *Service Contract Safety Plan Checklist* along with the CSSP. NOTE: A guidance document for completing the form is available (01065S-B). These documents are available on the external Engineering Standards Webpage (http://www.sandia.gov/engstds/spec_index.html).

B. Hazard Identification and Assessment: Establish procedures to identify existing and potential workplace hazards and assess the risk of associated workers' injuries and illness. Assess worker exposure to chemical, physical biological, and safety workplace hazards using recognized exposure assessment methodologies.

1. Address hazards introduced by service contract work and any known SNL-introduced hazards as communicated in Sandia's *Job Hazard Evaluation.* Additional hazards introduced by SNL for a specific task will be listed in the work orders/releases to the service contractor. It is incumbent upon the service contractor to compare the task hazards with those addressed in the safety plan, and, if the hazard is not addressed, see 1.06B.
2. Contractors performing work at SNL facilities shall identify carcinogens that may be introduced by the service work. Carcinogens may be identified in the CSSP by including a listing of products or their Material Safety Data Sheets (MSDSs) that contain carcinogens.
3. Contractors shall provide an inventory of all chemicals or chemical products anticipated for use on the project. The contractor shall describe how the chemical or chemical product will be used and the controls that will be established to ensure they do not present an exposure hazard to construction workers or collocated SNL Members of the Workforce. An exemption to this requirement is consumer products used in the same form, quantity, and concentration as a product packaged for distribution and use by the general public (such as Windex®, Simple Green®, and WD-40® in packages sold for use by the general public).
4. A daily pre-task plan is required prior to any work activity. Task-specific hazard analyses shall be performed and documented for high-hazard activities. High-hazard activities include, but are not limited to confined space entry, critical lifts, hot work, excavation, penetration, energized work, or activities that require respiratory protection.

C. Hazard Prevention and Abatement:

1. Establish and implement a hazard prevention and abatement process to ensure all identified and potential hazards are prevented or abated in a timely manner. Hazard controls must be selected based on the following hierarchy:

   a. Elimination or substitution of the hazards where feasible and appropriate
   b. Engineering controls where feasible and appropriate
   c. Work practices and administrative controls that limit worker exposures
   d. Personal protective equipment (PPE)

2. Identify methods (including safety meetings) to inform and periodically remind workers of the nature of work, potential hazards anticipated, how these hazards will be mitigated, and how workers will be protected from hazards (focusing on Contract-Specific as well as Task-Specific) prior to commencement of work activities. Documentation shall be maintained which identifies workers' names, date of communication, activities, hazards, and identified controls.

D. Site Control:

Service Contractor is responsible for safety of personnel at the act work site and shall ensure that persons visiting the service contract work site comply with safety requirements identified in the CSSP. Ensure contractor, any subcontractor employees, and visitors on the service contract work site wear the necessary PPE. The contractor has responsibility and authority to deny access to any person entering a service contract work site without appropriate PPE.

E. Address emergency action.

Contractor shall be responsible for transporting personnel with non-life-threatening injuries that require medical attention to local medical facilities identified in the plan.

F. Accident Scene Preservation:

Personnel on the site shall make every effort to preserve the accident scene until a Sandia Incident Commander, Safety Engineer, or SDR arrives on site to assume control of the area.

G. CSSP Documentation:

Keep an office copy of the approved CSSP and documentation demonstrating personnel have received training on the CSSP to ensure all personnel are informed of foreseeable hazards and the requirement to follow protective measures. The CSSP shall be available to any subcontractors, SNL project managers, and SNL safety personnel.

H. Safety Plan Addendum:

Before performing any work activity that involves hazards not addressed in the original CSSP, submit an addendum to the CSSP (in the form of a new Task-Specific Safety Plan) for acceptance. New hazards may result from changes to the scope of work or unexpected site conditions. The addendum shall identify mitigation or control for new hazard as described in "Contract-Specific Safety Plan" Article above.

1.07 Jobsite Hazard Evaluation

A. General: The general nature of this service contract work has been evaluated by SNL for nonstandard industrial, environmental, safety, and health concerns or conditions that exist and may impact normal Contractor methods and procedures in performance of the work.

1. A documented *Jobsite Hazard Evaluation* will be included with contract documents for work activities when existing, nonstandard industrial, environmental, safety, and health concerns have been identified. The documented *Jobsite Hazard Evaluation* does not include hazards that may be introduced during execution of work or by the location of the work necessary to meet the contract "Statement of Work."

2. Hazards introduced in performance of work shall be evaluated and mitigated in accordance with existing federal, state, and local regulations, including10 CFR 851 and 29 CFR 1910, and applicable provisions of this specification.

B. Identified Existing Conditions: Take precautions for existing conditions identified per the *Jobsite Hazard Evaluation* and work orders/releases. Comply with restrictions or conditions specified for each identified hazard. Do not proceed without full knowledge and understanding of these conditions. If corresponding description or identified paperwork or permit is not attached for an identified hazard, contact the SCR immediately. These existing conditions should be addressed initially in the CSSP or in an addendum to the CSSP.

C. Unidentified Hazard: If an unidentified hazard is encountered during performance of Work contact the SDR for specific requirements before performing work which may impact condition or concern.

1.08 Event Notification

A. General: When the contractor becomes aware of an event that could adversely impact workers, the public, or the environment, or unplanned disruptions of normal operations, report it to the SDR. If in doubt, report the event.

B. Emergency: If the event is an emergency, call 911 on an SNL telephone, or (505) 844-0911 on an outside/cellular telephone. After calling for emergency support, Contractor shall contact the SDR, SCR, or Project Manager as soon as possible.

C. Nonemergency: If the event is not an emergency, Contractor shall contact the SDR, SCR, or Project Manager as soon as possible.

1.09 Suspension of Work

A. General: All employees, contractors, and visitors at SNL have the responsibility and authority to suspend inappropriate or unsafe work activities when those activities present clear and imminent danger to employees, contractors, visitors, the public, or the environment. Personnel may suspend activities they observe or in which they are a participant if they believe the activity presents an imminent danger. To conduct this properly, we must understand the design intent and technical basis for the activity and controls. Each contractor shall communicate the unacceptable consequences for work at this site.

B. Upon receiving suspension of a work request (oral or written), immediately cease activity and notify the SDR. Obtain the name and telephone number of person requesting the suspension and the reason for suspension of work. Work shall not continue on that activity until the issue has been resolved. The SDR may restart activity only after review and approval of oral or written response submitted by Contractor.

C. Stop Work Order: A Stop Work Order that affects a crew for period greater than one (1) hour shall be followed by issuance of a formal written Stop Work Order. Work may be restarted only with written work release from the SCR. A Stop Work Order shall include the following information:

1. Date and time when work was stopped

2. Reason for stopping work
3. Requirements for Contractor to resume work
4. Date and time when SNL expects corrective actions to be completed, if required

D. Work Release: The SCR shall provide written work release that includes the following:
   1. Reference Stop Work Order
   2. Reason for work stoppage
   3. Conditions for restart of activity
   4. Specified date and time when work may resume

1.10 Integrated Safety Management System (ISMS)

A. General: SNL is committed to performing work safely and ensuring the protection of employees, the public, and the environment. To support these commitments, SNL employs an integrated safety management system (ISMS), which provides the framework for this specification and the requirements established for contracted service work at SNL.

B. ISMS Guiding Principles: The following guiding principles are the cornerstone of an effective safety management program.

   1. Contractor Responsibility for Safety: The Service Contractor management is accountable for the protection of the public, workers, and environment.

   2. Clear Roles and Responsibilities: Clear and unambiguous lines of authority and responsibility for ensuring safety are established and maintained at all organizational levels within the company and any subcontractors.

   3. Competence Commensurate with Responsibilities: Personnel possess the experience, knowledge, skills, and abilities necessary to discharge their responsibilities.

   4. Balanced Priorities: Resources are effectively allocated to address safety considerations. Protecting the public, workers, and environment is a priority whenever activities are planned and performed.

   5. Identification of Safety Standards and Requirements: Before work is performed, associated hazards are evaluated and an agreed-upon set of safety standards and requirements are established, which, if properly implemented, provide adequate assurance that the public, workers, and environment are protected from adverse consequences.

   6. Hazard Controls Tailored to Work being Performed: Administrative and engineering controls to prevent and mitigate hazards are tailored to the work and associated hazards.

   7. Operations Authorization: Conditions and requirements to be satisfied for work to be initiated and conducted are established and agreed upon.

C. Apply the ISMS work cycle shown in Figure 1 at task or activity level for service assignments. Depending on size and complexity of the work activity, some elements of work-planning phase may not formally be used.

- **Plan Work:** Contract requirements are translated into work, expectations are set, tasks are identified and prioritized, and resources are allocated.
- **Analyze Hazards:** Hazards associated with the work are identified, analyzed, and categorized.
- **Control Hazards:** Applicable standards and requirements are identified. Controls to prevent/mitigate hazards are identified; contract-specific safety plans are developed, and controls are implemented.
- **Perform Work:** Contractor's readiness to perform contract work is confirmed and work is performed safely.
- **Feedback and Improve:** Feedback information on the adequacy of controls is gathered, opportunities for improving the definition of planning of work are identified and implemented, oversight is conducted, and when necessary, controls are modified to ensure a safe work environment.

Figure 1 Integrated Safety Management System

Table 1 provides requirements for demonstrating effective safety management during execution phase of this Contract.

Table 1. Engineered Safety and ISMS Contractor Requirements

Work Cycle Phase	Contractor Requirements	Expectations
Plan Work		
Review of SNL Jobsite Hazard Evaluation Checklist	Understand pre-existing conditions which may affect worker safety and health	Contractor will review JSHE, work order, or release and incorporate pre-existing site hazards into their CSSP or in an Addendum.
Proposal Submission	Commit adequate level of resources for job conditions.	Contractor will ensure adequate competency and level of resources is available and provided as submitted in bid.
Analyze Hazards		
Job Safety Analysis and Risk Assessment Approach	Evaluate job-specific and site-specific work requirements and work hazards.	Contractor will review work requirements and hazard controls. Ensure estimates of low probability of occurrence do not dominate early decision-making since human nature and external pressures tend to minimize the use of what would otherwise be sensible controls based on the severity of accident consequences.
SNL Hazard Information	Request and incorporate hazard identification and hazard control information supplied by SNL.	Contractor will ensure that information from JSHE, work order, or release is incorporated into their CSSP.
Job Task Analysis and Understanding the Technical Basis	Resolve job assignment and personnel fitness issues.	Contractor will ensure that workers have the appropriate training and skills for the assigned tasks. The technical basis of an existing hazardous activity must be reconstructed sufficiently to ensure continued safe operations. The effort will be prioritized according to the severity of potential accident consequences.
Control Hazards		
Safety Program and Define Unacceptable Consequences	Identify company safety management policies, processes, and procedures. Ensure there are clear responsibilities for accepting and suspending work.	Contractor's Safety Program will be complete and contain the company- specific safety information.
CSSP – Identify and Control Hazards	Address all contract-specific safety requirements and protective measures, including combined requirements and combined controls.	• CSSP will incorporate company specific information from their safety program as well as contract-specific requirements. • CSSP will document how the combination of company-specific hazards and contract-specific hazards will be controlled. • Subcontractor's addendums will be incorporated into the Contract CSSP.

Work Cycle Phase	Contractor Requirements	Expectations
Hazard Awareness and Identifying and Controlling Energy Sources	Discuss work hazards and controls with employees and any subcontractors as appropriate prior to initiating new work, and at work site meetings focusing on CSSP and daily work activities.	• The Service Contractor will be responsible for ensuring that responsibilities, hazards and work controls flow down to the workers through documented safety meetings, toolbox talks, and pre-task meetings. • Any subcontractors and their workers will be knowledgeable of the Service Contractor's CSSP. • Workers attend documented safety meetings and pre-job meetings as required; positive verification is required. • Workers are familiar with the responsibilities hazards and work controls that result in safe working conditions. Stored energy must be identified and controlled with appropriate engineered and administrative controls designed to prevent or mitigate the consequences of accidental release. Kinetic, potential, electrical, electro-mechanical, thermal, pressure, and chemical are examples of energy sources that can be released directly or in another form as the result of an accident.
Work Authorization	Ensure that safety plans/corrective action plans are reviewed and work is authorized prior to initiating work or corrective actions.	• Contractor will obtain and follow all permits as required by SNL. Permit information will be flowed down to subcontractors and affected workers during documented pre-job meetings and safety meetings. • Corrective actions will be completed as required.
Perform Work		
Job Supervision and Positive Verification	Ensure that all workers have appropriate safety supervision by contractor management at all times.	Supervisors assume responsibility for the safety of the worksite and workers. Positive verification requires that each team member affirm to the person in charge that his/her part of the system is in the state intended for safe operation. This can be done during pre-task analysis for less complex operations. If the team does not have concurrence, it should be assumed by the person in charge that it is not safe to proceed.
Emergency Response	Ensure that all personnel at work site can recognize off-normal or unsafe conditions, and know how to respond (e.g., "what-if scenarios").	Train workers to recognize off-normal, unsafe conditions, and understand how to respond to the conditions. Every worker understands worker has the responsibility and authority to suspend an activity if worker believes it presents an imminent danger.
Corrective Actions	Implement interim controls for unsafe or off-normal conditions, including notification to workers and the SDR.	Contractor has controls in place to immediately address unsafe or off-normal conditions.
Feedback and Improve		
Self-Assessment	Identify opportunities for safety process and work performance improvements.	Contractor will review any lessons learned and injury/illness reports to identify areas that require improvement.
Performance Reviews	Discuss performance strengths and weaknesses with employees and subcontractors.	Information on strengths and weaknesses will flow down to subcontractors and workers.
SNL Feedback	Communicate suggestions for SNL improvements to the SDR.	Contractor will provide updated information and/or suggestions that will add value to ongoing improvement programs to the SDR.

1.11 Work Site Identification

A. Hazard Identification Signage and Barricades: Provide appropriate hazard identification and barricades in accordance with 29 CFR 1910, to warn Contractor personnel and visitors of specific work hazards. Prior to start of work, ensure personnel on site know and understand SNL signage that may be present on site during performance of work.

1. Use flagging and tape barricades only for temporary (less than 24 hour) protection, unless otherwise accepted by the SDR. Use orange safety fencing or snow fencing around excavations and trenching. Fencing shall be minimum 4 feet- (1.2 m-) high and secured vertically every 10 feet (3 m).

2. Provide signage in compliance with 29 CFR 1910. Protect unattended sites with applicable signs and barricades at all times.

B. Documentation: The following documents shall be available for review at each work area:

1. Project plans, specifications, and/or work orders/releases
2. All required permits, if applicable
3. Material safety data sheets for onsite chemicals or hazardous materials

Part 2 – Products (Not Used)

Part 3 – Execution

3.01 Coordination of Work Impacting Ongoing SNL Operations

A. Overhead Work: Schedule work required to be performed above occupied areas for nonstandard hours, unless specific and approved precautions including signage, barricades, occupant consent, and any other precaution deemed necessary by SNL is provided in advance of operation.

B. Utility or System Outages: Submit an *Outage Request Worksheet* to the SDR in advance of an activity requiring utility or equipment shutdowns that will impact ongoing SNL operations, observing the advance notice requirements thereon.

C. Removal of Administrative Tags: SNL personnel may utilize locks and/or tags to prevent unauthorized use of or access to equipment or systems. These locks and/or tags are not used for lockout/tagout purposes (protection during the maintenance and servicing of equipment). Contractor shall obtain permission from the SDR before removing any SNL administrative lock and/or tag.

3.02 Medical/Health Protection

A. Emergency Action: For life-threatening injuries or illnesses, immediately call for medical assistance by dialing 911 on an SNL telephone, or (505) 844-0911 on an outside/cellular telephone.

1. Transport personnel with non life-threatening injuries or illnesses that require medical attention to Contractor’s identified medical facility.

2. Electrical Shock: Accompany any employee who receives an electrical shock for immediate medical attention to the SNL Medical facility during standard working hours, no matter how minor the shock appears. For nonstandard hours, seek medical attention in an off-site facility. Notify the SDR immediately after transporting the individual to SNL Medical.

3. Notification of Accidents, Injuries, or Illnesses: Verbal notification to the SDR shall be performed as soon as possible. Submit a SF 2050P "Report of Occupational Injury/Illness" to SDR within three days.

    a. Nonemergency Medical Incident: Notify the SDR within 24 hours.

    b. Serious or Life-Threatening Accident or Illness: Notify the SDR immediately after taking emergency action.

B. Contractor's Industrial Hygiene Program: Contractor's shall implement an Industrial Hygiene Program that meets the requirements of the *SNL Worker Safety and Health Program Plan* and 10 CFR 851 Appendix A, Section 6. Conduct exposure assessment surveys of all work areas or operations to identify, evaluate, and control potential worker health risks. Exposure assessments shall be documented through written reports, activity hazard analysis, or exposure monitoring reports.

1. Require that workers acknowledge being informed of the hazards and protective measures associated with assigned work activities. Those workers failing to utilize appropriate protective measures must be subject to the service contractor's disciplinary process.

2. A personal protective equipment hazard analysis, in accordance with 29 CFR 1910.132, shall be completed for each activity. If respiratory protection is determined to be the required control measure for inhalation hazards, comply with 29 CFR 1910.134 Respiratory Protection and ANSI Z88.2, Practices for Respiratory Protection.

3. Comply with the current edition of the ACGIH Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs) when the ACGIH TLVs and BEIs are lower (more protective) than OSHA Permissible Exposure Limits (PELs).

    a. Comply with applicable OSHA expanded health standards even when ACGIH TVLs are used.

4. Gases, Vapors, Fumes, Dusts, and Mists: Use the hierarchy of controls: substitution, isolation, engineering, and administrative or PPE to help prevent employee exposures.

    a. Controls must be evaluated to ensure the appropriate level of protection to worker.

    b. Professionally and technically qualified industrial hygienists shall be responsible to determine appropriate air monitoring requirements, methods, equipment, and analytical methods to evaluate employee exposures to airborne contaminants. Use American Industrial Hygiene Accredited Laboratories for exposure assessment sample analysis.

c. Welding, cutting and brazing operations require an approved *Welding, Cutting and Brazing (WCB) Control Permit* from the Industrial Hygienist supporting FMOC service work in addition to the required *Hot Work Permit.*

i) Display the approved *WCB Control Permit* in a prominent location near the welding, cutting, or brazing operations.

ii) If a permit is approved for more than one day, Contractor shall ensure, and document on the permit that all permit conditions are maintained during those days when welding, cutting, or brazing is performed.

iii) Contractor or contractor's qualified health and safety representative shall identify hazards and select and implement effective controls to ensure worker safety and health. Control measures (e.g. full face air-purifying respirators or local exhaust ventilation) may be required.

5. Physical Hazards: Includes noise (sound pressure levels), ergonomics, lasers, nonionizing radiation, and thermal stress.

a. Noise: Comply with ACGIH TLVs.

b. Lasers: Comply with ANSI Z136.1, Safe Use of Lasers.

i) Class 1, 2 and 3a lasers may be used.

ii) Do not use Class 3b or Class 4 lasers without the written approval of the SNL/NM site Laser Safety Officer.

iii) When used for activities such as leveling floors, roads, and sidewalks, a laser beam shall not be directed above the horizon, through navigable airspace, or towards aircraft ground operations. Laser beams shall be backstopped with a nonreflective surface opaque (nontransparent) to the beam.

C. Substance Abuse Prevention and Testing: Use of drugs (including misuse of prescribed substances) or alcohol on the site shall be grounds for removal of an individual from the work site, and may include other corrective action, including contract termination.

D. Radiological Safety: Employees may not enter an area that contains posted radiological sign, signified by radiation symbol on yellow background with black or magenta markings, without prior authorization and SNL-provided training appropriate for radiological hazard.

1. If work is required in posted area, and specific written instructions have not been issued, do not enter area. Contact the SDR for instructions.

2. For performance of work in posted radiological areas, ensure the following:

a. Obtain a Jobsite Hazard Evaluation for work activity performed in radiological areas.

b. Employees understand and follow Jobsite Hazard Evaluation requirements.

c. Obtain Radiological Work Permit (RWP), when required by Sandia Radiation Protection Department, and understand and follow provisions and requirements.

d. Employees shall be current on radiological training required for site or activity (e.g. General Employee Radiation Training - GERT, RAD Worker I, RAD Worker II).

e. Employee shall be 18 years of age or older.

f. Comply with Contract requirements for work in radiological areas.

g. Comply with CSSP for work as reviewed by SNL.

3. Dosimetry: Workers who have appropriate training and have elected to work in radiological areas may be required to participate in SNL's external and internal dosimetry monitoring program. Contractors participating in the Dosimetry Monitoring Program shall ensure that their Thermoluminescent Dosimeters (TLDs) are current. TLDs must be returned to the SDR for exchange by last day of quarterly expiration date. Failure to accomplish the exchange in a timely manner may result in loss of the TLD.

4. Each project involving the use of accountable radioactive source or radiation generating device (RGD) requires prior approval by the SDR and SNL's Radiation Protection Department. Examples of such devices include, but are not limited to soil testing densitometers and XRF analytical devices for lead detection.

3.03 Waste Management and Disposal

A. General Requirements: Waste generated during work activities is considered solid waste and may be regulated as hazardous waste. Property items and equipment that may be reused for their intended purpose are not considered waste and shall be managed as U.S. Government Property and coordinated with the SDR.

B. Service Contract Work Debris: Lumber, wallboard, nonasbestos insulation, clean concrete, and similar debris shall be transported to a landfill authorized to receive such waste. Personnel trash such as papers and food containers should be bagged, removed from the site, and properly disposed of by the Contractor.

C. Residue Material and Equipment: Intact and dismantled equipment and material removed during the work activity shall remain the property of the U. S. Government. If the equipment and material is not reused in the performance of the project, the Contractor shall manage it as residue material and equipment. All residue material and equipment shall be staged by the contractor and evaluated for hazardous and radioactive contamination by SNL personnel before being coordinated with the SDR and delivered to the reapplication yard.

D. Empty Containers: A container that held any chemical (including cleaning products) or hazardous material, except a substance identified as an acute hazardous waste, is defined as an empty container if both following criteria are met:

1. All material that can be removed has been removed using the practices commonly employed to remove material from that type of container, such as pumping, pouring, or aspirating, and

2. No more than 3% by weight of the total capacity of the container remains in the container.

3. Containers with capacity of five gallons or less that meet the above criteria may be thrown in trash. Empty containers with capacity of greater than five gallons shall be managed as chemical waste. Those containers shall be marked with the words "Empty Container" and disposal shall be coordinated with the SDR.

E. Fluorescent Lamps: Fluorescent, sodium, and incandescent lamps shall be removed from light fixtures and managed as chemical waste. These items shall be boxed and labeled to identify the contents.

F. Light Ballasts: Remove ballasts from all light fixtures and submit a residue material form for characterization by the Facilities ES&H Team.

1. Ballast clearly labeled “No-PCBs” shall be placed in a container for disposal.
2. Ballasts that are NOT clearly marked “No-PCB” shall be managed as PCB Chemical Waste.
3. Light fixtures installed prior to 1980 and that have evidence of ballasts leaks shall be removed and treated as PCB Chemical Waste.
4. All PCB Chemical Waste must be double-bagged or double-wrapped with the words “Removed From Service _______ (date)”.

G. Oil-Containing Equipment: Equipment containing oil or other petroleum products shall be drained of oil and managed as residue material. Drained oil shall be managed as chemical waste by the Contractor.

H. Chemical Waste/Hazardous Waste: SNL manages chemical wastes as regulated wastes. This designation applies to all chemical wastes, used oil, asbestos- containing wastes, and PCB-containing wastes as examples. Due to regulatory liability, SNL assumes responsibility for management and disposal of chemical wastes. Chemical wastes shall be managed as hazardous waste unless specific guidance is provided in Contract. If applicable, Contractor will coordinate hazardous chemical waste disposal through SNL’s Facilities ES&H Team and the SDR. The following procedure describes coordinated disposal of chemical/hazardous waste:

1. Inventory all items.
2. Label all containers (labels shall include contents, project number or name, and contact phone number).
3. Notify SNL Project Manager that waste is ready for pick-up as soon as possible.
4. SNL personnel will pick-up the waste and determine the appropriate disposal method.

I. NORM Materials: Naturally-occurring radioactive materials (NORM) used in commercial products that have measurable radioactivity above SNL established policy (which includes State of New Mexico established limits), shall be managed as radioactive waste when declared waste, and is not deemed for Reapplication. Some examples are:

1. Chemicals with naturally-occurring radioactive material
2. Ceramic insulators (with some exceptions)
3. Glass-containing thorium or uranium for coloring purposes

4. Smoke detectors

J. Radioactive Waste: Material found to have detectable radioactivity above SNL free-release limits shall be managed as radioactive waste. Store and dispose of radioactive waste in accordance with applicable federal, state, and local regulations to minimize impact of waste on personnel, public, and environment. Before removal from the work location, SNL radiation protection technicians shall survey waste generated from Radiological Management Areas.

K. Mixed Waste: Residue or waste found to be both hazardous and radioactive shall be managed as mixed waste through Sandia Radioactive and Mixed Waste Management Organization. Mixed waste can only be generated with written SNL approval.

L. Transportation of Hazardous Waste: Facilities contractors are prohibited from transporting hazardous waste. Disposal of Hazardous Waste should be coordinated with the SDR.

M. Bird Nesting Sites: Bird nesting sites are not to be disturbed. If nesting sites are discovered during the course of operations, contact the SNL Project Manager for further direction.

N. Paved and Graded Roads: Contractors shall keep vehicles on paved or graded roads at all times unless prior approval has been obtained to travel into previously undisturbed areas.

3.04 General Project Work Practices

A. Significant Hazards: A focus on the potential consequence and severity for work is required. Oftentimes, significant risk is overlooked because personnel are frequently around the hazards and become familiar with the activity, which can give a false sense of safety. Attention to potential and kinetic energy is required for proper hazard analysis.

B. Hidden Hazards Penetration

1. General: SNL has adopted a five-step approach in an effort to minimize impact to hidden hazards when performing penetration or excavation activities. This process includes: (1) drawing review, (2) site investigation, (3) detection using instrumentation (as appropriate), (4) use of appropriate tools and (5) use of appropriate PPE.

2. Workers engaging in excavation or penetration activities shall use tools that are in good working condition, and use PPE, electrically-rated gloves, GFCI protection, and double-insulated tools as appropriate.

3. To mitigate risk the contractor shall ensure that adequate site investigation, using methods that would not penetrate hidden hazards (e.g. visual inspection, detection using instrumentation) is performed prior to any excavation or penetration activity. If hidden hazards cannot be identified through site investigation the SDR shall be notified prior to excavation or penetration activities and appropriate PPE shall be worn during the work activity.

C. Excavation Permit: Obtain a permit from the SNL SDR.

1. Obtain an excavation permit prior to start of the following activities:

a. Digging, saw-cutting, drilling, coring, or trenching into soil or concrete sidewalks, or asphalt to a depth greater than 12 inches.

b. Excavation of soil beneath concrete sidewalks, slabs, or asphalt to a depth greater than two inches.

c. Excavation into subsurface soil beneath the slab under buildings.

d. Scraping, blading, or excavation of any area previously undisturbed or that appears to be undisturbed, such as areas covered by native vegetation, and blading or improvements to previously-unimproved roads or paths.

2. Area to be excavated shall be shown on the Drawing and identified in the field using white paint. Submit permit requests to the SDR no more than 14 days and no less than six days before excavation.

3. The excavation permit process involves environmental, cultural, and ecological site review to determine whether environmental site impacts will occur due to activities related to performance of work.

4. The permit is task-specific. Confine excavation activities to those areas identified on permit.

D. Penetration Permit: Obtain a permit from the SNL SDR.

1. Obtain a penetration permit prior to start of the following activities:

a. Penetration into concrete slabs, floors, ceilings, roofs, or walls greater than 2 inches (50mm) in depth (does not include precast concrete).

b. Penetration into underground concrete duct banks. All duct bank penetrations shall be reviewed by FMOC for high voltage hazards. If high voltage hazards are identified on the penetration permit, Supervisor authorizing the duct bank penetration shall ensure that 1) a task-specific (each duct bank penetration is considered a task) procedure is written and submitted to the SDR for review and acceptance, and 2) Supervisor authorizing the duct bank penetration shall attend and ensure attendance of the Penetrator at the pretask meeting, which will be scheduled by the Project Manager. The task-specific procedure shall be reviewed at the meeting.

c. Penetrations where a site investigation cannot identify possible hidden hazards.

2. Area to be penetrated shall be shown on Drawing. Submit permit requests to the Project Manager no more than 14 days and no less than 6 days prior to start of penetration.

3. Permit is task-specific. Confine penetration to those areas identified on the permit.

E. Fire Safety: All service contract work activities shall, at a minimum, follow the requirements set forth in the International Fire Code (IFC) and ANSI Z49.1, Sections 4.3 and E4.3, including:

1. Emergency vehicle access shall be provided as follows:

a. Minimum 20-foot-wide vehicle pathway

   b. Must support the weight of fire apparatus (75,000 lbs)
   c. Minimum 13-foot, 6-inch vertical clearance

2. Access to fire hydrants: Fire department inlet connections or fire protection system control valves shall not be hampered. A minimum 3-foot clearance must be maintained around fire hydrants. Storage, vehicles, trash, or other materials or objects shall not be placed or kept near fire hydrants, fire department inlet connections, or fire protection system control valves. Any temporary fencing installed near fire hydrants or fire protection equipment shall be provided with a gate to allow emergency access.

3. Smoking shall be prohibited.

4. Housekeeping: All debris and trash shall be removed at least once per day at the end of a shift, or more frequently if necessary.

5. Flammable and combustible materials shall be stored in accordance with the IFC. These materials may not be stored near existing facilities, egress routes, emergency vehicle access points or fire protection equipment.

6. Fire Protection Impairment Permit (FPIP): Notify the SDR if work will impair or inadvertently activate a fire protection detection or suppression system already in service. Contractor shall submit a FPIP for any fire protection system impairments.

F. Hot Work Permit: Prior to cutting, welding, open-flame burning, or use of tar kettles and roof solvents, obtain a Hot Work Permit from SNL Fire Protection Engineering. Display the issued permits in a prominent location at the work site.

1. If welding, brazing, or thermal cutting is performed, obtain a *Welding, Cutting, and Brazing Control Permit* from the Industrial Hygienist supporting FMOC construction and service operations prior to obtaining a *Hot Work Permit.*

2. Prior to receiving a site-specific *Hot Work Permit*, operator(s) responsible for performing the hot work and personnel responsible for performing the fire watch duties shall view the training videos and read the accompanying literature provided by Fire Protection Engineering annually. These videos are approximately one (1) hour in combined length.

3. The operator(s) responsible for performing the hot work and the personnel responsible for performing the fire watch duties shall be trained in the use of portable fire extinguishers annually and shall have demonstrated proficiency (through certification).

4. Hot work operations shall be suspended if in an area where a fire suppression system is impaired.

5. A fire watch shall be provided during hot work operations and shall continue for a minimum of 30 minutes after the conclusion of the work. Fire Protection Engineering or the SDR is authorized to extend the time required for the fire watch based on the hazards or work being performed (i.e., tar kettle roofing operations).

6. The fire watch shall include the entire hot work area. Hot work conducted in areas with vertical or horizontal fire exposures that are not observable by a single individual shall have additional personnel assigned to fire watches to ensure that exposed areas are monitored.

7. Individuals assigned to fire watch duty shall be responsible for the safety of the welder(s) in addition to that of the property, extinguishing spot fires, and communicating an alarm. Individuals assigned fire watch duties must remain in the hot work area until hot work is completed and for thirty (30) minutes afterwards, and shall not have any other duties (e.g., not a runner).

G. Fugitive Dust Control Permit: Obtain from the SNL SDR for surface disturbance activities affecting land area greater than ¾ acre, sandblasting and other surface preparation.

H. Storm Water Control: For work areas greater than one (1) acre, develop and submit Pollution Prevention Plan to the SDR for review prior to service contract work activities. The Pollution Prevention Plan shall follow the EPA National Pollution Discharge Elimination System (NPDES). This system addresses silt control and other possible storm water impacts. EPS's NPDES requires inspections at least every fourteen (14) calendar days and within 24 hours of the end of a storm event of 0.5 inches or greater. Inspections shall continue through the duration of the project. Contractors shall report spills and accidental releases to storm sewer system immediately to SDR. All documents associated with the Pollution Prevention Plan, including inspection documents and reports, shall be submitted to the SDR upon request of final payment.

I. Earth Fill and Borrow Areas: If the contractor has written authorization from the SNL Project Manager or contract documents to utilize a designated borrow or fill area in a location other than the project site, Contractor shall:

1. Ensure that Contract-Specific Safety Plan adequately addresses hazards identified in the designated area. If the designated area is located within the boundaries of a project site controlled by another contractor, visiting Contractor shall coordinate access with the controlling project site contractor and comply with all requirements for that site.
2. Obtain required fugitive dust control permit prior to disturbing the soil.

J. Sanitary Sewer Discharge: Notify the SDR of planned discharges to sanitary sewer system, other than routine sewage, prior to discharge. SDR will review planned discharge, and coordinate authorization from the Sandia Water Quality organization. Report spills and accidental releases to sanitary sewer system to SDR immediately.

K. Surface Discharge: Notify SDR of planned surface discharges, prior to discharge. SDR will review planned discharge and coordinate authorization from Sandia Water Quality organization. Report spills and accidental releases immediately to SDR.

L. Hoisting & Rigging: This section applies to all hoisting and rigging lifting operations involving but not limited to chain falls, bridge cranes, mobile cranes, forklifts, and all-terrain lifts. A hazard analysis shall be conducted to ensure compliance to OSHA, ASME and the DOE 1090 specification.

Crane lifts are not anticipated in service work. If the need arises the Contractor shall notify the SDR and the Facilities ES&H organization and work will be conducted in accordance with the above requirements.

M. Confined Space Entry: Contractor work practices and procedures shall incorporate all applicable regulatory requirements and SNL specifications, and knowledge of the content of applicable regulatory standards should be considered fundamental for any contractor who proposes to engage in confined space operations at SNL.

1. Three types of service contract work involving confined-space entry are recognized at SNL/NM: Permit-required, non-permit, and telecommunications. Contractors are responsible for developing confined space entry programs and issuing confined space permits.

2. Signage: In areas that appear to qualify as a confined space absence of appropriate signage shall not be interpreted to mean that the area is not a confined space.

   a. Permit Required Confined Space signs state, "**DANGER – CONFINED SPACE - ENTER BY PERMIT ONLY**" or other similar language.

   b. Non-Permit confined space signs state, "**DANGER - CONFINED SPACE ENTRY BY AUTHORIZED PERSONNEL ONLY**" or other similar language.

3. Permit Required Confined Space: Entry shall comply with:

   a. 29 CFR 1910.146

   b. Personnel making a confined space entry shall follow SNL procedures contained in "Rescue of Personnel in Confined Spaces at SNL/NM" in order to establish their confined entry plan. Please contact the SDR for the latest version.

   c. Notification requirements include the following:

      i) Communication must be established with the Incident Commander (IC) at the jobsite prior to entry. This can be accomplished via cell phone, if working outside of Limited Areas, or two-way radio. SNL Project Managers have radios that can be loaned to the contractor for a confined space entry.

      ii) Contractor shall identify the specific location of the confined space (for example, building, room, or space type; if the space is outside, indicate the direction [NW, SE, etc.] from the closest building).

      iii) Contractor shall identify the individual serving as the Entry Supervisor (for purposes of overseeing the entry activity), the company name, and number of entrants and attendants.

      iv) Contractor shall identify the communication equipment used to contact emergency personnel (IC) and means used to communicate between the attendant and entrants.

   d. SNL *Confined Space Permit Sign In/Sign Out Sheet* is used to maintain an accurate, real-time tracking of entrants for emergency response. Use of this sheet only becomes necessary when the permit extends beyond a single day, or different entrants other than those initially identified on the permit are involved in the entry activity. Contact the SDR for the latest version of this sheet.

e. Atmospheric Monitoring: Perform atmospheric monitoring on a continuous basis for the duration of the entry activity. If monitoring indicates the presence of atmospheric contaminants above acceptable concentrations, NO ENTRY IS ALLOWED**.** If entry has already occurred when contaminants are detected, exit the space immediately and contact the SDR and Incident Commander.

4. Non-permit Confined Space: Fits the definition of a confined space, but lacks any inherent or introduced hazards. Entry into this type of space includes:

   a. Atmospheric Monitoring: Perform atmospheric monitoring on a continuous basis for the duration of the entry activity. If monitoring indicates the presence of atmospheric contaminants above acceptable concentrations, NO ENTRY IS ALLOWED. If entry has already occurred when contaminants are detected, exit the space immediately and contact the SDR and Incident Commander.

   b. If activities performed within and/or in close proximity to the confined space will create additional hazards that will impact safeguards and entry procedures, space shall be treated as a Permit-Required Confined Space.

5. Commissioned Telecommunication manholes and vaults shall comply with:

   a. 29 CFR 1910.268

   b. Telecommunication manholes and vaults that have been newly constructed and are part of an ongoing construction project are not considered commissioned, and shall comply with 29 CFR 1910.146.

N. Electrical Safe Work Practices: Ensure that electrical work, equipment, and installations are in compliance with the National Electric Code (NEC), National Electric Safety Code (NESC), NFPA 70E, *Standard for Electrical Safety in the Workplace*, and OSHA standards. When conflicts exist between OSHA and NFPA 70E, the contractor shall review the affected work with the Sandia team prior to operations.

1. Training: Employees who face a risk of electrical hazard that is not reduced to a safe level by the applicable electrical-installation requirements shall be trained to understand the specific hazards of electrical energy and to identify and understand the relationship between electrical hazards and possible injury. Retraining is required for qualified workers every three years [110.2(D)(3)].

2. Documentation: The Contractor shall document that each employee has received the training on electrical hazards and controls necessary for his/her safety. Records shall be maintained for the duration of the employee's employment and shall contain each employee's name and dates of training.

3. Lockout/Tagout: Lockout/tagout procedures shall be documented in Contractor's CSSP. The procedures shall be appropriate for the experience and training of the employees and

conditions as they exist in the workplace. The procedure shall address employee and management responsibilities associated with LOTO, training, system/hazard communication, and energy control methods (for example, types of locking devices, authorized testing equipment, and PPE). A lock must always be applied (article 120) NFPA70E.

4. Arc Flash Protection: Arc flash protection procedures shall be documented in Contractor's CSSP. At a minimum, documentation shall include requirements for: 1) developing arc flash boundaries, 2) requirements for protective clothing, hard hats, eye protection, face shields, hand and foot protection, and hearing protection based on hazard/risk category classifications, and 3) care and maintenance of ARC-Rated, (AR)-Rated (AR) clothing, AR flash suits, and other PPE.

   If the SNL electrical equipment/system to be worked on has an Arc-Flash Hazard (AFH) warning label, contract employees will wear PPE and establish flash boundaries specified in their employer's CSSP for the hazard level/category identified on the label. If the electrical equipment is not provided with an AFH warning label, contract employees will implement controls, wear PPE, and establish flash boundaries as identified in their employer's CSSP for the hazard/risk categories specified below.

   a. **Hazard Risk Category Zero**: Circuits operating between 50 and 208 volts single-phase. A 4-foot arc-flash boundary will be established.

   b. **Hazard Risk Category One and Two:** Circuits operating between 120 and 600 volts, excluding circuits operating at 50 and 208 volts single-phase (see above), Category Three and Four (see below), three-phase service entrance equipment and switchgear (see below), and equipment identified with a Level V AFH label (see below).

   c. **Hazard Risk Categories Three and Four:** Three-phase service entrance equipment and switchgear operating between 120 and 600 volts, excluding those systems with a RED, Level V Arc Flash Hazard label (see below). Only persons identified as Qualified Electrical Craftspersons may perform work activity on switchgear or service entrance equipment/systems.

   d. **Hazard Risk above Forty Calories:** All three-phase equipment operating between 208 and 600 volts and identified with a Level V (red) Arc-Flash Hazard label, reflecting an Incident Energy level in excess of forty cal/cm^2, shall be deenergized prior to performing any work. Contractor personnel shall contact their SDR, CO, or SDR to obtain documented location-specific arc-flash hazard information, PPE requirements, and instructions for verifying electrical safe work controls.

   e. **Hazard Risk Category for High Voltage Electrical Work (over 600 volts):** Contractors shall obtain an arc-flash hazard analysis for all work performed on systems operating above 600 volts, excluding work in 15 kV power manholes. - 15 kV Power Manholes: Category 2 PPE shall be worn for work performed in 15 kV power manholes excluding cable terminations. Category 2 head, face, and glove protection may be removed during cable terminations if no other work is being performed in the manhole.

5. Shock Protection: Procedures shall be documented in Contractor's CSSP. At a minimum, documentation shall include requirements for: 1) developing limited shock approach

boundaries, 2) requirements for voltage-rated gloves and insulated tools, and 3) maintenance and testing of PPE.

6. Electrical Outage Requests: Prior to performing work on any live parts that are not placed in an electrically safe work condition (that is, prior to performing energized work), Contractor shall contact the Electrical Inspector, and request an electrical outage. Exemptions to this requirement include tasks such as testing, troubleshooting, and voltage measuring, provided appropriate safe work practices and PPE are provided and used in accordance with NFPA 70E.

7. GFCI Protection: Provide listed ground-fault circuit interrupter (GFCI) protection for 120-volt, single-phase, 15- and 20-ampere receptacle outlets on work sites which are not part of permanent wiring of building or structure, and which are in use by employees.

8. Energized Electrical Work: Work performed on live parts that are not placed in an electrically-safe work condition.

   a. Energized work shall not proceed without written justification/authorization from the SNL Project Manager, and Contractor's written permit. Permit and authorization shall be available on site during energized work activity. Contractor's written permit shall include at a minimum all items required by NFPA 70 E.

   b. When working on or near energized parts in hallway, corridors, or other area used for passage, maintain working space barrier with caution tape and signage. Working space boundary for barriers shall be as defined at the "limited approach boundary."

   c. Do not leave exposed energized parts unattended in area occupied by other than service personnel. Do not leave exposed energized parts without providing working space barrier at the "limited approach boundary."

   d. Comply with the following when working on energized electrical parts:

      i) Notify the SDR before proceeding with work.

      ii) Electrical work on energized electrical parts shall be performed by qualified individual with second qualified person available.

      iii) Individual shall be knowledgeable and experienced in working with specific type of electrical circuits on which energized electrical work is to be performed. See Division 16 Section 16475, "Primary Systems Safety Requirements" for additional requirements.

O. Fall Protection: Control the methods used to protect employees from fall hazards, which may include administrative controls, PPE, and other controls necessary for fall restraint or fall arrest.

1. The CSSP shall identify administrative controls, fall-protection methods, or both to be used for all work within 15 feet of an unprotected side or edge that is more than 6 feet above a lower level for all construction trades, excluding roofers. The requirement is within 6 feet for roofers.

2. Anchor points to be connected by drilling, welding, or attaching to SNL structures/buildings used for fall-protection purposes must be reported to the SDR/CO for SNL approval prior to installation and use.

END OF SECTION

Section 01453 – Construction Inspection Report Requirements

April 2016

Effective Date: 04/18/2016
Review Date: 04/18/2019

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 01453 – Construction Inspection Report Requirements

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
7/27/17	John Harding	Subst	Added a bullet on fire sprinkler system
8/3/17	John Harding	Subst	Added sub-bullets under “Special Projects“

Section 01453 – Construction Inspection Report Requirements

PART 1 - General

1.01 Summary

A. Application: All work requiring inspection will be in accordance with the International I-Codes, National Electrical Codes (NEC), and Sandia National Laboratories (SNL) Standard Specifications.

B. Code Compliance/SNL Specifications: The inspections necessary to ensure that the work complies with the applicable code and/or specification and other contract documents shall be performed by the appropriate inspector under the direction of the building official.

C. Notification: It is the responsibility of the prime contractor to notify the appropriate inspector and request inspection within approximately 24 hours when work is ready for inspection/reinspection, and provide access to and means to perform inspection of the work. Reference Section 3.01 B, *Documentation*.

D. Inspection Deficiencies: Inspections found not to be in full compliance with the code and/or the specifications shall be required to be corrected. The contractor is responsible for notifying the inspector when corrections have been made and the work is ready for reinspection. Notification of corrected work shall be within five working days unless determined otherwise by the project team.

E. Covered and Unapproved Work: Work must be visible and accessible to be inspected and shall not be covered or used before approval is given by the inspector. Work that is covered before it is inspected or tested, if applicable and approved, may be ordered uncovered by the inspector or the building official at no cost to SNL. Work shall not be performed beyond what is required for the next inspection without approval of the inspector.

1.02 References

A. International I-Codes, NEC, and SNL Standard Specifications.

PART 2 - Products (not used)

PART 3 - Execution

3.01 Performance Requirements

A. Inspections: The following inspections are required and are deemed as "hold points." Hold points are defined in the items listed below. In addition to the required inspections specified below, the Building Official may make or require other inspections of any construction work in order to ascertain compliance with the code and other laws enforced by SNL.

1. Footings and foundation (soils, line, and grade)
2. Concrete slab and under-floor inspections
3. Lowest floor elevation
4. Frame inspections
5. Roof systems, components, and cladding
6. Special inspections
    a. Equipment Pre-delivery/Fit-up complete (all trades)
    b. Underfloor inspection
    c. System inspection prior to concealment
    d. Third party testing
    e. Substantial Completion (Hook-up Complete)
7. Energy efficiency inspections (insulation, fenestration, building envelope, duct systems, heating, ventilation, and air conditioning, and water heating equipment)
8. Lath and gypsum board inspections (interior/exterior)
9. Weather-resistant barrier inspection
10. Underground and under-slab inspection (infrastructure)
11. Flushing underground sprinkler piping water supply to riser and lead-in connection to the system riser, witnessed by Inspector.
12. Rough-in electrical
13. Rough-in of all mechanical work
14. Water distribution including all water piping inside and/or under building
15. Rough-in of all plumbing
16. Inspection of system/systems before pressure testing
17. Water service piping from service and connection outside of building. Includes fire sprinkler system flushing and cleaning, witnessed by Inspector.
18. Above ceiling inspections, and systems seismic bracing
19. Process gasses
20. Fire and smoke-resistant penetrations
21. Top-out inspection of all vented piping above floor and all extensions through the roof and/or walls
22. Top-out testing procedures to ensure system/systems are free of leaks and defects
23. Required other inspections deemed necessary to ascertain compliance with applicable building code and/or specification and all other contract documents

24. Site and infrastructure
25. Water quality testing
26. Inspection of electrical equipment prior to energizing
27. Final inspections for architectural, mechanical, plumbing, electrical, fuel gas, fire sprinklers, and fire alarm systems, and Americans with Disabilities Act and Architectural Barriers Act accessibility requirements

B. Documentation: All inspections and requests for inspection shall be documented using the Construction Inspection Report (CIR), specifically FRM-019A_CIR PDF. For high formality/life safety projects, use FRM-306, *Sandia Construction Inspection Log Sheet* (Blue Card), and FRM-013, *Code Compliance Traveler*, with signoff from the appropriate inspector. The Sandia Labs Construction Inspection Log Sheet (Blue Card) shall be maintained by the contractor at the jobsite. All work shall be complete and inspected before occupancy of the building. (**Note:** The forms are available either on the Facilities webpage for internal SNL users or the Sandia Labs External Collaborative Network [ECN] for external users.)

C. Inspection Requests: Contractors shall submit all inspection requests electronically using FRM-019A_CIR PDF, following the guidance provided in the guide entitled "Guide for Filling Out FRM-019A CIR PDF_03-12-15." This guide provides detailed information on how to open and fill out FRM-019A_*CIR PDF* (a PDF editable form) in Adobe Acrobat Reader. It also provides directions on how to submit this form to the Sandia Labs Inspection Group to request an inspection via email. Both forms are found on the ECN under the "Forms" section. The contractor is responsible for completing the sections identified in the CIR/guide and emailing the request to the Sandia Labs inspection email entity account (cir-cont@sandia.gov) prior to 12:00 pm the day prior to a requested inspection. The request will be routed to the appropriate inspector to schedule the inspection.

Required third party special inspections will require 48 hours advanced notice. Special inspections are required for materials, installation, and fabrication, erection or placement of components, and connections requiring special expertise to ensure compliance with the approved construction documents and referenced standards.

Completed inspection reports shall be returned to the contractor and technical assistant within 48 hours of a completed inspection.

D. Construction Documents: Construction documents shall be made available to the inspector at the time of inspection. Documents include but are not limited to the following:

1. Manufacturer's installation guidelines
2. Shop drawings
3. Approved construction drawings
4. Redlines, Requests for Information, and Directed Change Orders
5. SNL specifications

PART 4 - END OF SECTION

Exceptional service in the national interest

Sandia National Laboratories

Section 01505 – Construction Waste Management

November 2018

Release Date: 11/19/2018
Next Review Date: 11/19/2021

U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

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Section 01505 – Construction Waste Management

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
8/9/18	Tim Peterson	Admin	Added clarification to content, e.g. definition of non-routine; added non-routine disposal to different areas of document
11/19/18	Tim Peterson	Subst	Moved a lot of information to different parts of the document (reorganization); added “P” under Section 1.3; added new information to 3.2-3.4.
12/17/19	–	Admin	Updated NNSA logo, removed disclaimer

Section 01505 – Construction Waste Management

Part 1 – General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 Summary

A. Section includes construction waste management requirements for all construction, renovation, demolition, repair, and land clearing project activities. This section defines the construction waste management requirements for work conducted at Sandia National Laboratories (SNL), based on waste minimization and diverting construction waste from landfill disposal to the extent practical.

1. Small construction projects (defined in 1.3) shall segregate construction materials and debris as appropriate for disposition at the SNL Construction and Demolition (C&D) Recycle Center located on the west side of Building 967, Solid Waste Collection and Recycling Center (SWCRC) (see Section 01505-A, "SWCRC Guidance"). If larger quantities of material will be generated, then alternative staging and disposition should be arranged through the Construction Managers and support team.

2. Infrastructure projects (defined in 1.3) shall, as appropriate, segregate scrap metal for recycling and deliver concrete and asphalt to the SNL Concrete and Asphalt Recycle Area (see Section 01505-A, "SWCRC Guidance").

3. Large building construction projects (defined in 1.3) shall implement waste management practices herein and in addition follow the specifications set forth in the Construction Master Specification – Section 01350, "LEED® Requirements."

B. Related Sections

1. Division 1, Section 01065, "Environmental, Safety, and Health for Construction and Service Contracts"

1.3 Definitions

A. Construction and Demolition (C&D) Waste (per 20 NMAC 9.1, Solid Waste Management): "'Construction and demolition debris' means materials generally considered to be not water soluble and nonhazardous in nature, including, but not limited to, steel, glass, brick, concrete, asphalt roofing materials, pipe, gypsum wallboard and lumber from the construction or destruction of a structure project, and includes rocks, soil, tree remains, trees and other vegetative matter that normally results from land clearing. If construction and demolition debris is mixed with any other types of solid waste, it loses its classification as construction and demolition debris. Construction and demolition debris does not include asbestos or liquids including, but not limited to, waste paints, solvents, sealers, adhesives or potentially hazardous materials."

B. Clean: Untreated and unpainted; uncontaminated with adhesives, oils, solvents, tapes, textures, mastics, and like products.

C. Disposal: Acceptance of solid wastes at a legally operating facility for the purpose of landfilling.

D. Green Waste: Biodegradable waste generally consisting of leaves, grass clippings, weeds, branches, and stumps. Such waste may be generated through activities such as clearing, grubbing, tree removal, and trimming.

E. Infrastructure Project: Construction projects involving utility supply and distribution systems, central utility plants, roadways, site development, parking lots, and walkways.

F. Large Building Construction Project: New building projects including Line Item Projects and General Plant Projects (GPP).

G. Non-Construction Waste: Personal and/or office-type waste such as paper, food containers, beverage containers, and other items not resulting from construction activities.

H. Material Sustainability and Pollution Prevention (MSP2) Program: Administers, manages, and performs activities to reduce waste in SNL/New Mexico (SNL/NM) operations, including construction and demolition projects.

I. Recycling: The process of sorting, cleansing, and reconstituting materials for the purpose of using the materials in the manufacture of a new product.

J. Reuse: Materials that are recovered for use in the same form, on- or off-site.

K. Salvage: To remove waste materials from the site for resale or reuse by a third party.

L. Sandia Delegated Representative (SDR): Person authorized in the Contract to act as a delegated SNL representative for the specific purpose of review, inspection, and acceptance of work, and to interpret plans, specifications, codes, and standards.

M. Sandia Construction Observer (SCO): SDR's contract field representative to monitor, document, and report on the progress, quality, and safety of construction work in accordance with contract specifications and plans and applicable codes.

The SCO is responsible for coordinating outages associated with construction activities. The SCO does not exercise supervision over Contractor's employees.

N. Small Construction Projects: Construction projects other than those defined as a Large Building Construction Project or an Infrastructure Project. All projects with funding lower than the GPP and including Firm Fixed Price (FFP) and Time and Materials (T&M). Such projects typically include Facilities Express projects, routine maintenance projects, minor walkway or parking lot repair projects, etc.

O. Waste Minimization: Any practice that reduces the amount of waste generated prior to recycling or disposal.

P. Waste Flyaways: Lightweight items that could be carried off by the wind (e.g., foam, cardboard, paper, packing materials, and other non-construction waste).

Q. Non-Routine: Any underground or above ground existing infrastructure or equipment that is to be relocated during the course of a construction project that is not typical, such as underground tanks, power poles, or equipment that would require additional planning for removal/disposals.

1.4 Submittals

A. Small Construction Projects

1. No formal submittals are required for small construction projects, only adherence to the applicable practices and procedures defined herein. If commercial waste haulers are used to support a project, then a waste load report shall be submitted in close-out and subsequently turned over to MSP2 by the end of that quarter.

B. Infrastructure Projects

1. No formal submittals are required for Infrastructure Construction Projects, only adherence to the applicable practices and procedures defined herein.

C. Large Building Construction Projects

1. All submittals associated with Large Building Construction Projects shall follow the requirements set forth in the Construction Master Specification – Section 01350, "LEED Requirements."

1.5 Quality Assurance

A. General

1. Comply with applicable environmental, safety, and health laws, rules, and regulations, as amended, of the federal, state, and local governments, the Department of Energy, and SNL disposal site criteria concerning

management and disposition of construction, renovation, alterations, repair, demolition, and land clearing waste.
2. Use only on-site collection centers or containers or facilities properly permitted or registered with the State of New Mexico, and by local authorities as applicable.
3. Do not perform work until applicable environmental permits are obtained and notifications given for construction activities.
4. Contractor shall bear costs for project delays due to noncompliance with required permits or failure to provide required notifications.
5. Contractor shall contact SDR prior to construction start to coordinate disposal methods of large and small non-routine waste and salvage materials.

B. Construction Waste Characterization

1. Construction waste resulting from execution of this contract shall be evaluated for the potential to contain or be contaminated with regulated hazardous and/or radiological substances in accordance with Section 01065, "ES&H for Construction and Service Contracts."

2. Construction waste determined to contain or be contaminated with regulated hazardous, and/or radiological substances shall be managed in accordance with Section 01065, "ES&H for Construction and Service Contracts."

3. Construction waste determined to be non-routine (large or small) shall be evaluated for disposal methods by the contractor and coordinated with the SDR prior to construction start.

C. Construction Material Ownership

1. Property items and equipment that may be reused for their intended purpose are not considered waste and shall be managed as U.S. Government Property. Intact and dismantled equipment and material originating from SNL premises and removed during the work activity shall remain the property of the U.S. Government and shall be managed as Residue Material and Equipment as defined in Section 01065, "ES&H for Construction and Service Contracts."

2. All construction waste materials and debris originating from SNL premises, regardless of the temporary or permanent nature of the materials and debris, are the property of the U.S. Government.

3. No construction waste materials or debris originating from SNL premises shall be removed from SNL property for the purpose of salvage, reuse, recycle, or resale unless specifically stated in contract documents.

D. Regulatory Requirements

1. Comply with applicable waste management laws, rules, and regulations, as amended, of the federal, state and local governments, the Department of Energy (DOE), and SNL.

2. According to the Federal Pollution Prevention Act of 1990 waste shall be managed according to the following hierarchy: prevention, reuse, recycling, treatment, and compliant disposal.

1.6 Delivery, Storage, and Handling

A. On-site Waste Management and Disposal Resources: The following list identifies recycling and disposal resources on site at SNL/NM. Use of on-site SNL resources shall be coordinated through the Waste Management and Pollution Prevention Department and/or the SDR (or as further delegated).

1. Construction & Demolition Recycle Center: Located on the west side of Building 967 (Solid Waste Collection and Recycling Center). Accepts construction materials and debris to include carpet tile and ceiling tile from small construction projects for recycling and disposal.
2. Concrete/Asphalt Recycle Area: Located at the south end of Tech Area III (map to be provided as needed). Accepts concrete and asphalt materials from all SNL/NM construction projects for recycling. Stores crushed asphalt, crushed concrete base course (CCBC), rip-rap, and other clean fill for Facilities projects.
3. MSP2 STENT11: Located southeast of Building 967 on Ordnance Road, provides a resource to store and handle palletized construction waste items such as carpet tile and ceiling tile.
4. Green Waste: Currently accepted at strategic areas throughout SNL/NM.
5. Kirtland Landfill: Accepts general construction & demolition waste and green waste for disposal.
6. Miscellaneous: Other on-site SNL/NM infrastructure resources exist, such as clean soil reuse and reusable wood pallets. Coordinate utilization of "other" on-site SNL/NM Waste Management and Pollution Prevention Department resources and/or the SDR.
7. Non-Routine Construction Waste: Coordinate disposal methods with SDR prior to construction start.

Part 2 – Products (Not Used)

Part 3 – Execution

3.1 General Requirements

A. General: Every reasonable effort shall be made to minimize waste generation, as well as recycle, reuse, and salvage generated waste.

B. Source Separation, Handling, and Storage: Separate, store, protect, and handle at the project site all identified recyclable, reusable, and salvageable waste materials to maximize waste material diversion from landfill. Waste material separation, handling, and storage areas shall be clearly marked and kept neat and clean to avoid prohibited content, e.g., plastics, foam, cardboard, or trash in metals roll-off, or mixing of materials. Obtain waste collection containers from the Waste Management and Pollution Prevention Department in sizes adequate to handle C&D waste or recyclables from construction activities.

C. Hazardous and Other Regulated Construction Waste Types: All hazardous and other regulated construction waste types generated shall be managed in accordance with Section 01065, "ES&H for Construction and Service Contracts." Where classification of any given waste material is unclear, verify the appropriate disposition with the SDR.

D. Non-Construction Waste: All non-construction waste shall be segregated from construction waste and recyclable materials, removed from SNL property, and properly disposed of by the Contractor. No waste or recyclable items shall be placed in the brown, blue, or yellow dumpsters located on SNL property.

E. Training: Provide on-site instruction of appropriate collection, segregation, handling and recycling, salvage, reuse, return methods, and disposal to be used by all parties at the appropriate stages of the project.

3.2 Waste Minimization Requirements

A. The following measures shall be implemented for proactive waste management by all parties involved in construction-related project activities at SNL:

1. Waste generation shall be minimized to the maximum extent possible.

2. Waste generation shall be avoided by implementing the following measures:

   a. Purchase products with minimal packaging to reduce waste from packaging.

   b. Ensure proper storage of products and materials to prevent deterioration and damage from weather.

   c. Utilize proper material handling techniques to eliminate breakage.

   d. Plan and sequence work to efficiently utilize products and materials.

   e. Enforce just-in-time ordering to eliminate extended storage, over ordering, and ordering error.

3. All diligent means shall be employed to pursue practical and economically feasible reuse, salvage, and recycling options for the inevitable waste generated during project activities.

4. Waste disposal in landfills shall be minimized to the greatest extent possible.

3.3 Small Construction Projects

A. The following procedure shall be implemented for planning and use of the SNL C&D Recycle Center:

   1. Review the C&D Recycle Center Disposition Form (see Section 01505-A, “SWCRC Guidance”) for a current list of recyclable construction waste materials and debris, facility hours of operation, facility location, and other general information, instructions, and requirements.

   2. Segregate recyclable construction waste materials and debris and nonrecyclable waste materials and debris.

   3. Transport construction recyclable materials to the SNL C&D Recycle Center.

   4. Segregate the recyclable material and place it into the appropriate collection container. C&D Recycle Center personnel will provide assistance for unloading into the appropriate containers.

   5. Small amounts of non-recyclable C&D material can be added to the C&D waste roll-off. **NOTE**: Do not add non-C&D waste in this roll-off. A trash dumpster is located onsite for disposition of trash.

   6. **NOTE**: If there are no recyclable construction materials within a specific load or shipment, that load or shipment shall be transported directly to the appropriate landfill for disposal. Waste taken directly to the Kirtland Air Force Base landfill has to be weighed at the SWCRC truck scale, including an initial tare weight.

B. Small construction projects that anticipate a large quantity of C&D waste or recyclables may obtain large containers from the Waste Management and Pollution Prevention Department for management and disposition and shall be coordinated with the Construction Manager and support team.

3.4 Infrastructure Projects

A. Recyclable Materials: Depending on scope of work may include concrete, asphalt, scrap metal, wood (pallets, crates, scraps, dimensional lumber, etc.), and cardboard. Contact MSP2 for assistance with recycling any other materials associated with Infrastructure Projects.

B. Various types of concrete and asphalt waste are generated during C&D projects and site operations that are suitable for recycling.

   1. "Washout" from trucks that deliver concrete to project site.

   2. Asphalt debris is generated when disturbing roadways and parking lots and concrete debris when removing curb and gutter.

   3. Reinforced concrete from building foundations and slabs.

   4. Non-reinforced concrete from sidewalks.

C. Contaminants are unacceptable. The following items must be separated from concrete and asphalt debris before delivery:

   1. Asphalt or concrete that is contaminated with hazardous or radioactive material.

   2. Concrete-like products that are composed of low grade concrete mix designs such as pavers and bricks.

   3. General construction waste, such as wood, wallboard, pipe, cardboard, insulation, fixtures, glass, sandbags, plastic etc.

   4. All expansion joint materials in curb and gutter, slabs, and foundations.

   5. Plastic sheeting of any kind, such as caution tape, washout pit liner material, and landscape underlayment.

   6. Landscaping materials such as weed fabric.

   7. General non-construction waste (beverage cans or plastic bottles, food waste, paper or foam products, rags, opaque (non-see-through) garbage bags, etc.).

D. For projects that generate less than 20 tons of asphalt or concrete, the following procedure shall be implemented for planning and use of the SNL Concrete and Asphalt Recycling Area (CARA):

   1. Concrete should be broken into smaller (~1 to 2 cf) pieces prior to loading.

   2. Transport acceptable concrete and asphalt materials to the CARA. Contact the Project Manager for directions and location of CARA.

      a. The CARA has three specific drop-off zones for asphalt, un-reinforced concrete, and reinforced concrete. Drop off concrete and asphalt materials separated according to these three categories.

1) In the event a mixed load concrete and/or concrete and asphalt is unavoidable, the mixed load shall be placed in the location of material constituting the largest quantity of material.

2) For example, a mixed load of predominantly asphalt and a lesser amount of un-reinforced concrete shall be delivered to the asphalt material pile.

3) Any mixed amount containing reinforced concrete shall be placed in the reinforced concrete pile.

E. If a project will generate 20 tons of acceptable (see C, above) asphalt or concrete (with or without rebar), and mixtures of both, they shall be direct hauled to a local asphalt and concrete vendor.

1. The contractor can choose a local asphalt and concrete vendor that will take the material for free.

2. A net weight shall be obtained at the SWCRC truck sale.

   a. Leave a copy of the weight ticket in the designated C&D collection box.

   b. Write on the weight ticket where the material will be delivered to.

3. A net weight shall also be obtained from the concrete and asphalt vendor's scale. The vendor will provide Sandia Waste Management copies of the scale tickets.

F. In the event prohibited content cannot be separated from a load of concrete and/or asphalt material, the entire load must be disposed as general construction waste to the KAFB landfill. This is strongly discouraged.

G. Other recyclable materials such as metals, cardboard, and scrap wood may be generated during Infrastructure Projects. Please refer to the C&D Recycle Center Guidance Document (see Section 01505-A, "SWCRC Guidance") for a current list of recyclable construction debris. The Guidance Document provides facility hours of operation, facility location, and other general information, instructions, and requirements for recycling of these items.

3.5 Large Building Construction Projects

A. Follow guidelines set forth in the Construction Master Specification – Section 01350, "LEED Requirements."

B. Implement waste management practices and procedures in accordance with the approved Construction Waste Management Plan. Maintain such practices and procedures throughout the life of the project. **Note:** If asphalt or concrete removal is performed as part of a large building construction project, the material should be managed as stated in Section 3.4 above.

C. Transportation: Arrange for regular collection, transport from the site, and delivery of recyclable waste materials to approved recycling centers to keep construction site clear.

D. On-Site Recordkeeping: Maintain record keeping procedures with provisions for:

1. Tracking collections of waste materials at the site and deliveries to recycle, reuse, salvage, and landfill facilities.

2. Maintaining on-site logs that are included for each load of materials removed from the site: type of material, load weight, recycling/hauling service, and date accepted by recycling service or landfill.

3. Use of the Waste Diversion/Landfill Log provided as an attachment to the generic Plan template.

4. Accessibility to the SCO for verification of construction waste recycling. Legible copies of on-site logs, bills of lading, weight tickets, and receipts. Bills of lading shall be from recycling and disposal site operators that can legally accept the materials for the purpose of recycling, reuse, salvage, or disposal.

E. Prohibited Contents: Prevent prohibited contents from being included in recyclable materials. Remove any prohibited contents inadvertently deposited in recyclable material containers. Provide cleanup of excessive prohibited contents at recycling vendor locations when such prohibited contents are not controlled at the project site.

END OF SECTION

Section 01505A – SNL Solid Waste Collection and Recycling Center (SWCRC)

April 2016

Effective Date: 04/18/2016
Review Date: 04/18/2019

Section 01505A – SNL Solid Waste Collection and Recycling Center (SWCRC)

Attachment A

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.

SNL Solid Waste Collection and Recycling Center (SWCRC)

Construction and Demolition (C&D) Recycle Center

Guidance Document

Important Notes: *Hazardous and radiological materials are prohibited. Liquids are prohibited. Construction and Demolition (C&D) waste containing liquids and/or contaminated with hazardous and/or radiological materials are prohibited. Only C&D waste originating from onsite Sandia Labs project work is acceptable.

*Observe the same Health and Safety requirements applicable to your work site.

1	**ALUMINUM (NOT CANS)**: Any and all aluminum items, other than beverage cans. Aluminum sheet, plate, foil, or other items. NO sealed aluminum containers, devices, or items containing residues.
2	**BRASS:** Any and all brass items. Brass tubing, piping, fittings, valves, hardware, fasteners, etc. NO sealed brass containers, devices, or items containing residues.
3	**CARDBOARD:** Clean, corrugated cardboard. Remove any packing material. Knock down and fold flat. NO chip paper or chipboard is allowed, such as cereal boxes and file folders.
4	**COPPER WIRE:** Insulated or bare copper cords, wire, etc. NO electronic devices.
5	**COPPER (NOT WIRE):** Any and all copper items, other than copper wire. Copper tubing, piping, fittings, etc. NO sealed copper containers, devices, or items containing residues.
6	**OTHER METAL:** Any and all metal items (ferrous or non-ferrous), other than those identified above. NO sealed metal containers, devices, or items containing residues. NO pressurized cylinders or aerosol cans.
7	**REUSABLE SHIPPING PALLETS:** Reusable shipping pallets in good condition. Stack neatly at location indicated by signage.
8	**PLASTIC BOTTLES:** Used beverage bottles, emptied.
9	**WOOD:** Unpainted, untreated lumber, all dimensional lumber, and unusable wood shipping pallets. NO railroad ties, telephone poles, plywood, OSB, or particle board. NO metal fasteners (such as nails) larger than 1/4-inch in diameter.
10	**C&D WASTE:** Glass, brick, plastic wrap, insulation, non-recyclable roofing material etc., from construction/demolition Projects.
11	**NON-C&D WASTE:** Household-type waste items, including food containers, paper cups, etc.

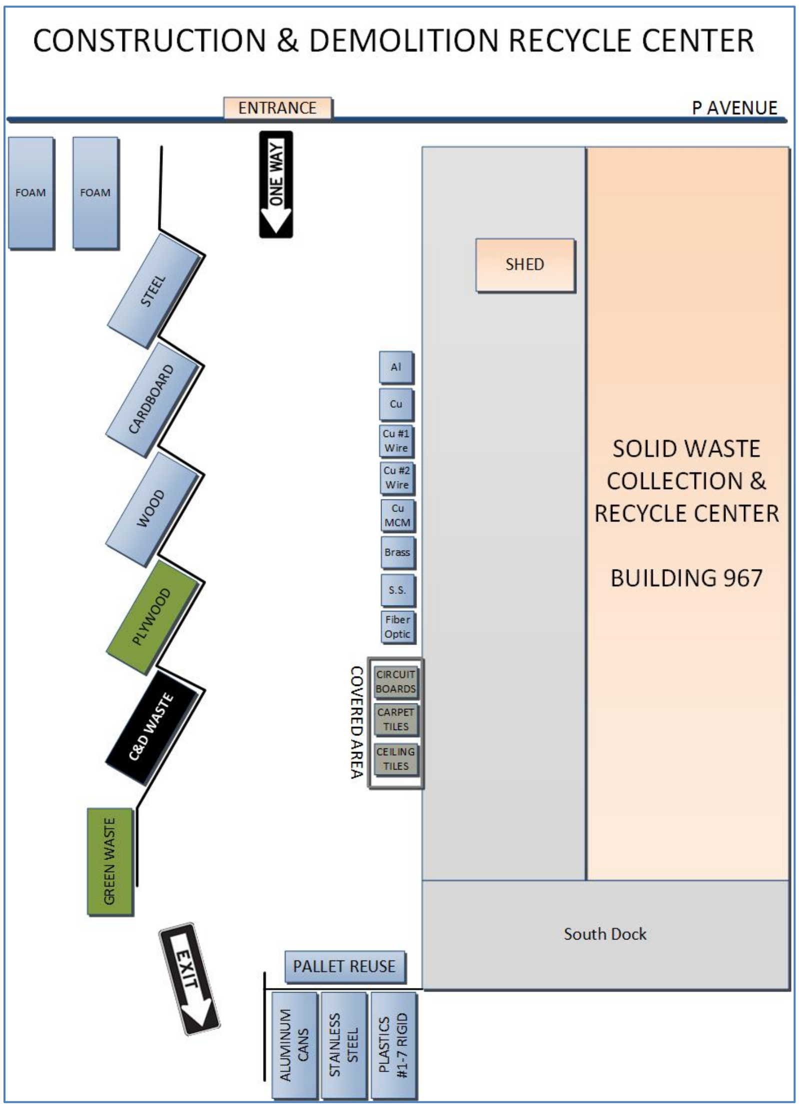
SWCRC C&D Recycle Center Hours of Operation are Monday through Friday from 7:30 a.m. to 3:30 p.m.

For additional information contact

Ralph Wrons,
SWCRC Site Coordinator
844-0601
rjwrons@sandia.gov

General Instructions:

1. Access the C&D Recycle Center from P-Avenue. Always follow one-way traffic flow through the C&D Recycle Center and adhere to the requirements of signage.
2. Place recyclable materials in the container(s) labeled for such materials. If it is uncertain as to which container a waste material should be deposited, ask SWCRC staff. In the event that the uncertainty cannot be resolved, place the waste material in the roll-off container marked for "C&D Waste."



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Sandia National Laboratories

Section 01505B – Waste Management Plan (Generic Template)

April 2016

Effective Date: 04/18/2016
Review Date: 04/18/2019

U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 01505B – Waste Management Plan (Generic Template)

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.

Company X Project Y Contract Z

Sandia National Laboratories, Albuquerque, New Mexico

Waste Management Plan (Generic Template)

1.0 General

This Waste Management Plan specifies the procedure for the management, control and disposition of items designated as waste material for the **Y Project, Contract Z.** The following is a list of the different categories of materials that will be generated during the project:

- Recyclable Materials
- Waste/Refuse Materials
- Reusable Materials

The procedures for the management, control and disposition of these items are described in subsequent sections of this plan. **Company X** and all of its subcontractors are required to identify, maintain proper control, and provide documentation for the disposition of materials described in this plan. Sandia National Laboratories is also responsible for the disposition of some waste as described below. The intent of this plan is to minimize the amount of waste generated on this project to the extent practicable. The goal for this project is to ensure that at least 75% of all waste material generated will be recycled, re-used, or otherwise diverted from direct landfill disposal. Each subcontractor is required to follow this plan for the disposition of the waste generated by the subcontractor’s activity. Waste Management will be an agenda item at the weekly construction meeting that **Company X** conducts. The waste management activities described in this plan will be maintained until substantial completion has been agreed upon by Sandia Labs.

2.0 Waste Minimization

Company X is dedicated to maintaining a stringent set of guidelines to control the amount of construction waste and debris disposed in a landfill. **Company X** will be responsible for communication between field personnel and subcontractors regarding minimization requirements during internal weekly construction meetings.

2.1 Packaging

All vendors and their suppliers are encouraged to minimize the packaging for materials and equipment. Packing materials should be selected based on whether they can be recycled on this project. This request will be communicated through project meetings, weekly subcontractor meetings, written correspondence and through the project Waste Management Team that is made up of contractor representatives.

2.2 Housekeeping

Housekeeping activities must minimize the amount of waste and maximize the amount of recyclable material that can be efficiently gathered at the local collection points and minimize the amount of refuse materials. **Company X** will assign housekeeping responsibility to an on-site **Company X** employee who will oversee and manage the field operations with regards to housekeeping and waste management. Discuss any issues identified by this person during weekly construction meetings.

2.3 Maximizing Product Use

Layout and cutting procedures should be used to minimize the amount of waste materials. Cut-offs and other scrap materials should be applied on this project to the extent practicable. Emphasize this procedure to all subcontractors during weekly construction meetings.

2.4 Materials Management

All material should be stored in weatherproof containers or otherwise protected from contamination and deterioration prior to use. Containers should be opened as needed and work should be sequenced to use materials efficiently and in a timely fashion. This ensures that the material meets the specified requirements and that unused or off-spec product will not become a waste. Emphasize this procedure to all subcontractors during weekly construction meetings.

3.0 Licenses, Permits, Fees, and Taxes

3.1 All subcontractors working on the Y Project will be required to maintain and be responsible for all fees, licenses, permits, and taxes needed to comply with Federal, State, and Local Regulations and requirements.

3.2 Each subcontractor will identify haulers or trucking firms they will be using on this project.

4.0 Material Disposition

Attachment A provides an estimation of the waste material types and quantities to be generated during the construction of **Project Y**. Attachment B identifies the disposition pathway for each waste material type to be generated during the construction of **Project Y**.

4.1 Recyclable Material

All material for recycling will be placed in designated containers furnished by Sandia National Laboratories and **Company X**. These containers will be labeled clearly and according to types of material. Material must be stored and handled to avoid contamination so it is acceptable to the recycler.

4.1.1 Sandia Labs Furnished Dumpsters

Sandia Labs will provide individual appropriate containers at the job site for local collection of material as indicated in the Material Disposition worksheet in Attachment B. The location of the containers and pickup/delivery will be coordinated between Company X and P2 personnel. Sandia Labs will haul the Sandia Labs furnished containers and will provide Company X with weight information for each load. Refer to Sections 4.4 and for 4.5 for specific documentation and measurement requirements.

4.1.2 Company X Furnished Dumpsters

Company X will provide individual appropriate containers at the job site for local collection of material as indicated in the Material Disposition worksheet in Attachment B. The location of the containers and pickup/delivery will be coordinated by **Company X**.

Company X will haul the containers to the location designated in the Material Disposition Table and will maintain the weight information for each load. **Company X** will be responsible for obtaining weight information for non-

Sandia Labs hauled materials through use of the truck scale located at Sandia Labs' Solid Waste Collection & Recycling Center (Building 967). Refer to Sections 4.4 and for 4.5 for documentation and measurement requirements.

4.1.3 Pick-up Frequency

Recycled material containers will be hauled on an as needed basis, with coordination required between Company X field staff and Sandia Labs project inspectors.

4.2 Empty Containers

A container that held any chemical or hazardous material, except a substance identified as an acute hazardous waste, is defined as an empty container if both of following criteria are met:

- All material has been removed that can be removed using the practices commonly employed to remove material from that type of container, such as pumping, pouring, or aspirating, and
- No more than 3% by weight of the total capacity of the container remains in the container.

Containers with capacity of 25 gallons or less that meet above criteria may be placed in the appropriate recycling container (i.e., roll-off, hopper, basket). Empty containers with capacity of greater than 25 gallons shall be managed separate from the recycle material collection containers. Those containers shall be marked with words “Empty Container” and staged separate from the recycling collection containers until they have been inspected by an SNL Hazardous Materials Inspector (HMI). Following inspection and acceptance they shall be managed according to the HMI's guidance.

Any containers that hold an acutely hazardous substance shall be regarded and managed as a hazardous waste.

4.3 Non-Recyclable or Refuse Materials

All materials not identified in the material disposition table categories will be considered refuse material. It will be the responsibility of each **Company X** subcontractor to load and transport all material identified as refuse to a landfill designated by Sandia Labs. This material may either be demolition debris or construction waste. Any permits required by the designated landfill site, will be the responsibility of each subcontractor. **Company X** will ensure that all procedures are followed. Permits will be valid throughout the duration of the project. These items will be tracked with the same requirements outlined in section 4.4.

***Personal trash such as papers, food containers, beverage cups, etc., shall be bagged, removed from the site, and properly disposed of by each subcontractor.**

4.4 Documentation

A record of each disposition activity (permits, landfill receipts, weights, weight tickets, and any other receipts) will be maintained at the **Company X** Site Office by the Construction Superintendent. A waste diversion/landfill log (refer to Attachment C) will be maintained and a waste management progress report worksheet (refer to Attachment D) will be completed bi-annually and at end of project to track and summarize the quantities of waste generated by the project. This documentation will be used to calculate the percent of material diversion achieved. It is the responsibility of **Company X** to collect and maintain documentation.

4.5 Weighing Waste Material

Haulers of refuse and recyclable/reusable materials must provide weight documentation for all shipments from the project site. Truck scales are available at Sandia Labs' Solid Waste Collection & Recycling Center (SWCRC) (Building 967), although other scales may be used. **Company X** will make arrangements to have non-Sandia Labs-provided containers weighed. If the empty weight of a vehicle is known, only its full weight must be determined. If methods other than weighing are used, the proposed method of generating the weight must be approved (for example: density, times, volume estimation). Refer to Section 4.4 for documentation requirements.

4.6 SNL Truck Scale Location and Use

Truck scale available from 7:30 a.m. to 3:30 p.m. Monday – Friday.

Directions to SNL Truck Scale:

- From Hardin Blvd, travel south on 9th Street.
- After approximately 3/10 of a mile, turn east on East Ordinance Rd.
- After approximately 1/10 of a mile, turn north into the rear entrance for Bldg. 967, Sandia Labs' SWCRC.
- The truck scale is located along the southeast fence-line of the SWCRC.

Procedure to obtain documentation of vehicle weight:

- Upon passing through the rear entrance to the SWCRC, proceed slowly onto the truck scale platform.
- Gently bring the vehicle to a stop once all tires are on the truck scale platform.
- Upon securing the vehicle, exit the vehicle and proceed to the truck scale house.
- Observe the reading on the "Fairbanks" scale read-out for credibility of weight indicated. If a negative number or otherwise non-practical weight value is displayed,

return to the vehicle and proceed forward off the truck scale platform. Again secure the vehicle and return to the truck scale house. If a numerical value other than “0” is displayed, press the key labeled “ZERO.” The scale read-out should now be “0.”

- Return the vehicle to the truck scale platform and again observe the reading on the scale read-out located within the truck scale house.
- Place a blank weight ticket (located on counter top in truck scale house) onto the “Fairbanks” printer. Slide the blank weight ticket into the printer against the paper guide and move it upward until resistance is encountered.
- Press the “print” key on the “Fairbanks” scale readout.
- Remove weight ticket from the back of the scale printer and maintain for project records.
- Leave the Truck Scale by proceeding north and exiting the SWCRC yard onto P Avenue.

Procedure for reporting and/or tracking actual load weights.

An “empty” weight as well as a “full” weight must be known for the vehicle in order to determine the quantity of material being transported. An “empty” weight can be determined using the SNL truck scale as described above, and need only be determined one time. Although slight variations in “empty” vehicle weight may occur due to fuel levels and individual drivers, these variations are considered minimal when determining the load weight. An “empty” vehicle weight (if known) may be hand written on weight tickets obtained for “full” vehicle weights to aid in computing individual load weights on a single weight ticket.

Attachment A: Waste Material Estimating Worksheet

Instructions:

1 Edit material/item list in left hand column as appropriate.

2 Include all waste material types to be generated.

3 Fill in columns with relevant recycling/disposal data.

Material/Item	Total Amount Generated (tons)	Amount Diverted from Landfill by Reuse, Salvage, or Recycle (tons)	Amount Sent to Landfill (tons)	Percent Diverted from Landfill (%)
Mixed Metals/Steel				
Wood				
Concrete				
Asphalt				
Ceiling Tile				
Carpet Tile				
Wall Board				
Clean fill Dirt				
Paper				
Cardboard				
Aluminum				
Non-recyclable Construction Waste				

Attachment B: Waste Material Disposition Worksheet

Instructions:

1. Edit material/item list in left hand column to match Waste Material Estimating worksheet.
2. Include all waste material types to be generated.
3. Edit remaining worksheet contents with relevant collection, transportation, disposition, and contact information as appropriate to suit project-specific requirements.

Material/Item	**Local Collection Point**	**Hauler**	**Disposition**	**Disposition Location**	**Contact Name / Phone #**
Mixed Metals/ Steel	Sandia Labs Provided Container	Sandia Labs	Recycle	Sandia Labs local Scrap Metals Recycling Contractor	Rick Dotson 845-8751
Concrete/Asphalt	Job site	Company X	Recycle	Sandia Labs Concrete/Asphalt Recycle Area (CARA)	Rick Dotson 845-8751
Wood (Reuse)	On site	Company X	Re-use	C&D Recycle Center	Rick Dotson 845-8751
Wood (Engineered Lumber)	On site Container	Company X	Recycle	Wood You Recycle	Rick Dotson 845-8751
Ceiling Tile	On site Container	Company X	Recycle	Sandia Labs P2 Tent	Rick Dotson 845-8751
Carpet Tile	On site Container	Company X	Recycle	Sandia Labs P2 Tent	Rick Dotson 845-8751
Clean Fill (Dirt)	On site	Company X	Recycle	Sandia Labs Soil Borrow Area	Sandia Delegated Representative
Paper	Sandia Labs Provided Container	Sandia Labs	Recycle	Sandia Labs Solid Waste Collection & Recycling Center (SWCRC)	Sam McCord 844-8916
Cardboard	Sandia Labs Provided Container	Sandia Labs	Recycle	Sandia Labs SWCRC	Sam McCord 844-8916
Aluminum	Sandia Labs Provided Container	Sandia Labs	Recycle	Sandia Labs SWCRC	Rick Dotson 845-8751
General Construction Waste	On Site Container	Company X	Disposal	Kirtland Air Force Base Landfill	Sandia Delegated Representative

Attachment C: Waste Diversion/Landfill Log

Project: Project Y

Period: _____ to _____

Instructions: Complete and maintain Log at **Company X** site office.

Material/Item	Quantity (tons)	Disposed, Reused, Salvaged, or Recycled	Destination	Date
List materials and items as appropriate	*Fill in as appropriate for each load or shipment of materials/items.*			

Attachment D: Waste Management Progress Report Worksheet

Project: Project Y

Reporting Company: Company X

Report Period: _____ to _____

Instructions: Complete and submit bi-annually and at end of project.

Material/Item	Land filled (tons)	Recycled (tons)	Reused (tons)	Salvaged (tons)
List materials and items as appropriate	*Fill in material/item amounts (in tons) under applicable disposition columns.*			

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Section 01701 – Subgrade Utilities and As-Built Requirements

May 2016

Effective Date: 05/31/2016
Review Date: 05/31/2019

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Section 01701 – Subgrade Utilities and As-Built Requirements

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
5/31/16	Tim Peterson	Subst	Small edits throughout; updated Part 3: 3.01.A.3.d and Part 3: 3.01. D.

Section 01701 – Subgrade Utilities As-Built Requirements

PART 1 - General

1.01 Description of Work

A. Section Includes: Administrative and procedural requirements for the Construction Contractor to perform the as-built redline process and coordinate the Sandia National Laboratories (SNL) Utility Position Survey.

1.02 Reference Documents

1.03 Section 01330, "Submittal Requirements"

1.04 Section 01700, "Contract Closeout"

PART 2 - Products (Not Used)

PART 3 - Execution

3.01 Record Documents

A. Record As-Built Drawings: Maintain as-built records of all construction elements on the project. These records shall be maintained as bound set red-lined contract drawings in the Contractor's field office, and shall be updated as necessary to ensure that no record of variations from clarification to the construction drawings are absent from the final markups transferred to SNL. If the contract does not require a field office, the Contractor shall maintain the set of as-built Contract Drawings in an accessible location and make them available to SNL for review upon request.

1. Mark whichever drawing is most capable of showing "field" condition fully and record a cross-reference at corresponding location on this set of contract drawings. Include changes on all detail sheets associated with the change.

2. Changes to Contract Drawings, including those that involve only narrative, shall be clearly and neatly marked in red pen or pencil, and shall be noted on the appropriate drawings. Applicable changes to the Contract Drawings include:

    a. Changes to material or equipment for substitutions approved through the SNL submittal process (Section 01330).

    b. Shop Drawing information.

    c. RFIs and Change Order information.

    d. All construction changes made to accommodate field conditions.

3. Contractor shall note each entry with a notation referencing the source of information (Example: RFI #94, CO #3, or field notes of name).

   a. As-built record drawings shall be updated no less frequently than once per week. As-builts will be reviewed for verification of updates by the construction observer on a regular basis, depending on the length of the contract.

   b. Verification of current as-built record drawing status will be included in the monthly payment approval process that will be noted in the Sandia Construction Observer's (SCO) log notes. Final payment in accordance with Section 01700 will be withheld until final as-built record drawings have been submitted and approved.

   c. Identify the contractor's representative(s) responsible for coordinating the verification of the as-built process with SNL to the Sandia Delegated Representative (SDR).

   d. As-built record drawings shall be made on no less than full-size issued for construction drawings (24" x 36").

4. Submit current as-built red-lined drawings for the work completed since the last pay request and submit as an attachment to each new pay request, but in any event, no less than once a month. Alternatively, the SDR and the contractor's representative may establish a process which allows SNL to scan the as-built red line drawings no less than once a month.

B. Record Specifications: Maintain one bound copy of specifications, including addenda, change orders and similar modifications as issued. Give particular attention to identify substitutions, selection of options, and similar information on work, which is concealed or cannot otherwise be readily discerned later by direct observation. Note related record drawing information and product data, where applicable. Upon completion of mark up, submit to SDR for records and future reference. **All marking shall be neatly shown in red ink.**

C. Operation and Maintenance Manuals: Organize operation and maintenance manual information into suitable sets of manageable size, and bind into individual binders properly identified and indexed as per Section 01330. Include emergency instructions, spare parts listing, warranties, wiring diagrams, recommended "turn-around" cycles, inspection procedures, shop drawings, product data, and similar applicable information. Bind and label each manual of each set in a heavy-duty three-ring vinyl-covered binder, and include pocket folders for folded sheet information.

D. If furnished in the Contract Documents, complete the Master Equipment List (MEL) for all equipment that has been removed or installed. This includes Sandia Furnished Equipment (SFE).

E. Utility Position Survey Requirements: Coordinate a Utility Position Survey for all new infrastructure and utility service installations with SNL prior to backfilling any utility.

1. Coordination responsibilities shall include:

   a. Initiate GPS Support Requests during normal working hours a minimum of two hours prior to the planned backfill activities, which may be initiated through a variety of methods. Establish the primary coordination method with SNL once the a notice to proceed on the contract is received. The preferred method is the GPS Support pager (505)530-4477 during normal working hours. Coordinate GPS Support Requests for work during non-standard hours a minimum of two working days in advance. GPS Support Requests may be scheduled in advance of these minima.

   b. The SNL GPS Technician will be responsible for responding to all GPS Support Pages or requests. SNL GPS Technician will respond to each pager request by contacting the telephone number received on the pager system to coordinate the Utility Position Survey with the contractor's representative.

   c. Include backfilling actives in the project schedule to allow SNL to anticipate workload with respect to supporting the Utility Position Survey.

   d. Maintain an active GPS Support Request Log to document all GPS Support Requests. This log shall be reviewed at regular intervals and no less than once each pay period. The status of the log shall be reviewed during construction meetings to assure that the appropriate coordination between SNL and the Contractor is occurring. A sample GPS Support Request Log is shown as Attachment A to this Section.

   e. The SNL Project Manager and the General Contractor may agree to modify the support process, as may be acceptable to both parties, to improve coordination for the overall benefit of the project.

2. The consequences for backfilling prior to coordination of the Utility Position Survey in advance shall be:

   a. Excavate all or portions of the utility system that was backfilled prior to coordination of the Utility Position Survey at Contractor's expense. The backfilled utility shall be sufficiently exposed allowing SNL to obtain utility position measurements safely. Install shoring, sheeting, or trench boxes as required. This shall include, but not be limited to, fittings, other appurtenances, changes in direction, changes in elevations, and points of connection.

   b. Further coordination of the Utility Position Survey for a particular utility in a specific location is not required, if SNL is "non-responsive" to the support request for that specific utility and location. However, SNL may issue a change order directing that the backfilled utility be uncovered, or portions of the utility be exposed by traditional excavation or vacuum excavation technology. "Non-responsive" shall be defined to be:

(1) No response received by the Contractor to GPS Support Pagers within the allotted 2-hour time period during normal hours.

(2) Support request was not completed by the GPS Technician within the allotted time period, or within the period agreed-upon in advance (such as support requests during non-standard hours), or support activities that have been arranged in advance.

(3) Document that coordination efforts were made by:

i. Completing the GPS Support Request Log, documenting the location of the utility where SNL was non-responsive. SNL will cross-reference the GPS Support Request Pager Log to verify all "non-responsive" claims.

ii. Notify the SNL Project Manager of each non-responsive occurrence in a timely manner.

3. Work performed by the SNL GPS Technician will be in accordance with the Contractors' approved safety plan.

F. Document, on the as-built drawings, existing known utilities exposed during trenching and/or excavation operations that vary from the construction drawings. Approximate the position and depth of burial below existing surface of such utilities, and mark the information on the as-built drawings. Contact SNL GPS personnel as above to ensure that the utility location is captured electronically prior to backfilling the excavation.

END OF SECTION

<u>ATTACHMENT A</u>

Sample GPS Support – Request Log

GPS SUPPORT—REQUEST LOG

Project Title: ______________________________________ **Project Number:**

Contractor: ________________________________ **Superintendent:**

USE THE GPS SUPPORT PAGER (505)530-4477 FOR ALL SUPPORT REQUESTS PRIOR TO BACKFILLING ALL UTILITIES

Contractor shall allow for the appropriate response time per SNL Construction Standard Specification Section 01701 prior to backfilling any exposed utility. Contractor is responsible for keeping this log updated. The Construction Observer will verify that this log is current and may cross-reference with the SNL GPS Support Request Log prior to project invoicing.

Identify the following for each GPS Request:

Date/Time Pager was Called	Utility (Indicate if New or Existing)	Construction Drawing and Sequence #s	Station -to- Station	Date/Time GPS Completed	Contractor's Representative's Signature	GPS Technician's Signature

A copy of completed logs shall be submitted with the as-built red-lined drawings per Specification 01701 paragraph 3.02 D. Copies of in-progress logs shall be submitted to the SNL Project Team no less than monthly at a progress meeting. Submit copies of all logs in a binder at Project Closeout.

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Special Specification Section 01810S – Facility Commissioning Requirements

April 2016

Effective Date: 04/18/2016
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Gen 3 LP Date: 12/15/20

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Special Specification Section 01810S –

Facility Commissioning Requirements

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.

Special Specification Section 01810 –

Facility Commissioning Requirements

PART 1 - GENERAL

1.01 Summary

A. This Section specifies the administrative and procedural requirements for Sandia National Laboratories (SNL) Facility Commissioning.

B. SNL Facility Commissioning is a quality-focused process for enhancing the delivery of a project. This systematic process of verification and documentation ensures components, equipment, and systems perform interactively in compliance with SNL project requirements, basis of design, contract documentation, and operational needs. This systematic process also ensures that those design features included for safety meet their design intent.

C. SNL Facility Commissioning is intended to be a working partnership between SNL the General Contractor (GC) and its Subcontractors (Subs).

D. SNL Facility Commissioning activities and milestones shall be identified in the GC's Construction Schedule.

E. The GC shall include line items for the commissioning activities and milestones, as identified in the Commissioning Plan, in the schedule of values with the Contract Pay Application. Approval of construction progress payments will be evaluated on meeting scheduled commissioning milestones, as applicable.

F. The intent of this section is to define the requirements for management, coordination, and execution of commissioning activities so a logical and trackable commissioning process is achieved.

G. The purpose of the commissioning process for this project is to provide SNL assurance that equipment/systems have been provided as required, installed in the prescribed manner and operate in compliance with SNL project requirements, basis of design, contract documentation, and operational needs. In addition, commissioning provides SNL assurance that any special safety engineered features to prevent or control the accidental release of hazardous energy operate appropriately. Commissioning is intended to enhance the quality of system startup, operation and aid in the orderly and timely transfer of fully functioning systems.

H. The Contractor (or appropriate Subs, suppliers, and manufacturer's representatives) verifies installation, provides scheduling and coordination of equipment startups and prescribed tests, performs training, corrects deficiencies, performs retests, and provides documentation of the process.

I. The Commissioning Authority (CxA), as one of the SNL-designated Owner Representatives, shall observe commissioning activities (e.g., installation, field testing, equipment startup, prefunctional checklists, and functional performance testing). Other SNL Owners Representatives/Commissioning team members may participate as test witness and active Commissioning team members as coordinated by the Project Lead and CxA. Positive verification of final acceptance of any commissioning activities is done by the CxA only through submittal of the Cx Report. The Contractor is expected to verify the functional readiness of systems to be tested prior to performing the tests in the presence of the Owner Representatives. The approved Cx Report should be submitted to the Commissioning Team, including Maintenance, Planning personnel to be used for preventive maintenance, and Maintenance Planning.

1.02 Related Work Specified Elsewhere

A. Divisions 02 through 33 specification sections requiring documentation, training, adjustment, testing, and verification including but not limited to the following:

1. 221513, *General Service Compressed Air Piping*
2. 226313S, *Gas Piping Systems – Special Specification*
3. 230050, *Basic Mechanical Materials and Methods*
4. 230533S, *Heat Trace Piping Systems – Special Specification*
5. 230594, *System Component Checkout and Balance*
6. 230595S, *Mechanical Systems Demonstration – Special Specification*
7. 230923S, *Molten Salt Valves – Special Specification*
8. 230993S, *Process Control System – Special Specification*
9. 232113, *Hydronic Piping*
10. 232124S, *Molten Salt Pumps – Special Specification*
11. 232125S, *Molten Salt Piping Systems – Special Specification*
12. 233113, Metal *Ducts*
13. *233119, HVAC Casings*
14. 233300*, Air Duct Accessories*
15. Project-specific special specifications if required to be commissioned

1.03 Definitions And Abbreviations

A. CxA: The CxA is the SNL point of contact that will lead the overall implementation of the commissioning process and verify all of SNL's performance requirements are achieved.

B. Construction Commissioning Lead (CCL): The person designated by the General or Contractor to act as a single point of contact and to coordinate the testing and verification requirements of the Subs, manufacturers, suppliers, vendors, and training staff involved with installation of the commissioned systems and equipment as outlined in the contract documents and Commissioning Plan. The CCL role may be filled by GC or Subs as long as they satisfactorily perform duties as specified herein to commission the systems. The CCL will plan, coordinate, schedule, and facilitate the execution of the commissioning activities (i.e., field quality testing, startup, prefunctional checks and testing/functional performance required by contract documents and the Commissioning Plan).

C. Engineer of Record (EOR): The team responsible for the design and development of the contract drawings and specifications. The EOR shall be responsible for all changes to the contract documents. The EOR shall also be involved throughout the construction process to include construction observations and inspections, the witnessing of tests, answering request for information, and supporting SNL in the development and design of all change orders affecting the design.

D. Owner: The owner for this project will be SNL.

E. Owners Representative: All persons authorized by SNL to interface with the Contractor in various capacities on SNL's behalf.

F. SNL: Sandia National Laboratories

G. SNL Site Mechanic/Electrician (SM/E): The SM/E provides mechanical and electrical commissioning performance criteria input, receives training, and ultimately operates the commissioned systems for the life of the facility.

H. SNL Project Associate (PA): Assists the Project Lead in managing the overall performance, cost, and schedule for the project.

I. SNL Contract Representative (SCR): The SNL purchasing agent in charge of the project contracts.

J. SNL Delegated Representative (SDR): The SDR, on behalf of the SNL Construction Procurement Agent, reviews, inspects, and accepts the work in accordance with the applicable codes, specifications, and drawings.

K. Sandia-Furnished Equipment (SFE): Equipment provided to the Contractor by SNL.

L. SNL Project Technologist/Inspectors: The persons authorized by SNL to witness construction activities to ensure construction is accomplished in a safe manner according to the contract documents. They are to ensure safety procedures are followed, witness field quality control tests required by specifications, conduct independent tests as deemed necessary, review and monitor contractor certifications, and stop work if required to ensure the safety of personnel and the compliance of the Contractor to the contract documents. Project Technologists/Inspectors may witness commissioning activities as part of the commissioning team, but acceptance of commissioning activities is only by the CxA.

M. SNL Project Lead (PL): The PL manages overall performance, cost, and schedule for a project. The PL authorizes the CxA and any other CxA delegates.

N. SNL Operations Engineer (OE): The OE manages the commissioning performance criteria for the mechanical, electrical, civil, architectural, or structural systems for a project. The OE is responsible for the performance of these systems for the life of the facility.

O. Test, Adjust, Balance (TAB): The work performed by a certified Test and Balance Contractor, directly under contract to SNL, which tests and balances the air and water side of the building systems as well as the vibration and balance requirements.

P. X-Ray Firm: The work performed by a certified firm, directly under contract to SNL, which performs the x-ray tests required by the piping system contract documents.

1.04 Commissioning Team

A. The SNL commissioning process is based on developing partnership cooperation between SNL, the Contractor, and the Subs by forming a Commissioning Team. The principle points of contact are the Commissioning Authority and the Construction Commissioning Lead.

1. Commissioning Authority (CxA)
2. Construction Commissioning Lead (CCL)

B. The SNL CxA will be supported by the following SNL Commissioning Team members, as applicable:

1. Project Lead (PL)
2. Project Associate (PA)
3. Operations Engineer (OE)
4. Building Mechanic/Electrician (BM/E)
5. Sandia Delegated Representative (SDR)
6. Project Technologist/Inspector
7. Facilities Control System (FCS)
8. Test, Adjust, Balance (TAB)

9. Engineer of Record (EOR)

C. The CCL will be supported by the following contracted Commissioning Team members, as applicable:

1. Subs: The Subs are contractually responsible to the Contractor for delivering, installing, testing, and starting up in operating mode specified in contract documents specific equipment and/or systems.

2. Manufacturer's Representatives (MR): MR are responsible to the Contractor or Sub for the correct installation, operation, and training of specific equipment and/or systems.

3. Others: Specialty Contractors are responsible for performing special testing as required by the Contract Documents.

1.05 Facility Systems AND Components to be Commissioned

A. The following energy-related systems, equipment, and their components shall be included in the scope of the commissioning activities and shall be considered to be commissioned systems and equipment.

1. Compressed Air System

2. Ullage Gas Piping System (Nitrogen & Argon)

3. Ullage Gas Acid / Salt Particulate Scrubber System

4. Hot & Cold Salt Vertical Turbine Pumps including associated bearing cooling and ullage gas barrier systems.

5. Hot & Cold Salt Storage Tank Immersion Heaters, and Salt Tank Foundation Cooling System

6. Salt Flow Control Valves and Valve Ullage Gas Barrier System

7. Supercritical CO2 Brayton Cycle Loop

8. Solar Receiver Sodium Loop System

9. Salt Melter System

10. Salt Expansion Surge Tank Gas Barrier System at Sodium-to-Salt Heat Exchanger and Tanks at the Inlet and Outlet of the Salt to s-CO2 Heat Exchanger

11. Liquid Nitrogen System

12. Each of the Operating Sequence Diagrams (Logic Diagrams)

1.06 CCL Qualifications and Responsibilities

A. The CCL shall meet the following minimum qualifications:

1. Excellent communication and writing skills, organizational skills, and ability to work well with management, trades contractors, manufacturers, suppliers, vendors, and training staff.

2. A good working understanding of contracting, general, mechanical, and electrical construction methodology.

3. Competent with email, online collaboration, revision tracking, and use of schedules.

B. The CCL shall execute the following responsibilities as specified in this document and include, but are not limited to, the following:

1. Coordinate and manage the Contractor's documentation, training, adjustment, testing, startup, and verification activities for the commissioned systems as defined in Parts 1.05 and 3.0 of this specification section.

2. Coordinate directly with each Sub, supplier/vendor and manufacturer's representative with respect to responsibilities and contractual obligations and ensure that equipment startup/prefunctional checklists/functional performance tests have been completed and accepted.

3. Obtain, assemble, and submit commissioning verification documentation.

4. Attend on-site meetings associated with the commissioning efforts.

5. Coordinate Owner's Representative (CxA, EOR, Inspectors, etc.) test witnessing, after verifying that pretests and startups have been satisfactorily conducted and final tests are ready to be performed.

6. Track deficiencies identified during startup, inspections, training, point verification testing, and functional performance testing until correction and retesting are successfully completed.

7. The identity of the CCL shall be submitted with the GC's Contract Proposal.

1.07 Commissioning Authority (information only)

A. This section is provided for the Contractor's information only. The Contractor is not responsible for the hiring of the CxA, and the CxA has no control over the construction activities.

B. The Owner will appoint a CxA.

C. The duties of the CxA may include, but are not limited to, the following:

DESIGN PHASE

1. If Enhanced Commissioning is required, develop a “design phase” Commissioning Plan that provides a framework for the commissioning and quality assurance process. The plan outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process during this phase. Include the following information.
   a. Include an organizational chart showing lines of communication between the commissioning team members.
2. Conduct, at a minimum, one commissioning design review of the Owner’s project requirements, basis of design, and design documents prior to the midconstruction documents (at SNL, this generally refers to midway during Title II Design Development or between 30–100% design). If additional design submittals are required by SNL (i.e., at Conceptual Design, or Title I (Schematic Design 0–30% design), or Title II 90–100% final design) the CxA will review at each phase required and should be involved in design milestone meetings.
3. Report deficiencies and resolutions process during the “design phase” to SNL and commissioning team members.

CONSTRUCTION PHASE

4. Develop a “construction phase” Commissioning Plan for the project. The intent of this plan is to, along with this specification, provide a framework for the commissioning and quality assurance process. The Commissioning Plan will identify how commissioning responsibilities are distributed. This plan will include the following information.
   a. Include an organizational chart showing lines of communication between the commissioning team members. See attachments.
   b. Coordinate and identify who will be responsible for producing the various procedures, reports, owner notifications, and forms required for the commissioning process.
   c. Coordinate and identify which subcontractors, suppliers, and manufacturer’s representatives will participate in each of the tests.
   d. Coordinate and identify instrumentation required for each test.
   e. Coordinate and identify who will provide instrumentation for each test.
   f. Include prefunctional checklists for applicable equipment and systems. See attachments.
   g. Determine the scope of and include functional performance test procedures for applicable equipment and systems.

5. Commissioned equipment Issues Log (incorporate Issues Log within SNL's "punchlist" process).

6. If Enhanced Commissioning is required, review contractor submittals applicable to systems being commissioned concurrent with the EOR.

7. Appropriate amount of Site Observations through the construction phase.

8. To archive all Contractor-submitted test reports, startup reports, startup checklists, FCS point and functional performance test reports, operating and maintenance manuals, etc. using IBM Lotus® QuickPlace® or otherwise approved document retrieval system that provides easy future document identification and retrieval; for example, provide all operations and maintenance (O&M) documentation on a searchable CD.

9. Oversight and reporting on installation verification, field testing, startup, prefunctional checklist, and functional performance testing issues.

10. Acceptance of equipment/systems installation and operation through successful completion of functional performance testing.

11. Develop Systems Manual that provides future operating staff the information needed to understand and optimally operate the commissioned systems.

12. Verify the requirements for training of the operating personnel and building occupants have been completed.

13. Compile the Cx Report, which documents all commissioning activities.

D. The CxA is expected to communicate as follows:

1. The CxA will formally communicate with the Contractor via approved project channels. It is expected, however, that informal communication and coordination will be conducted directly with the CCL.

2. The CxA will keep SNL PL, SDR, and CCL advised regarding commissioning activities, progress, and problems that may develop.

PART 2 - Products

2.01 Test Equipment

A. Provide industry-standard test equipment required for performing the tests specified herein.

B. Instrumentation shall meet the following standards:

1. Be of sufficient quality and accuracy to test and measure system performance within the tolerances required to determine adequate performance.

2. Be calibrated on the manufacturers' recommended intervals with calibration tags permanently affixed to the instrument being used.

3. Be maintained in good repair and operating condition throughout the duration of use on this project.

4. Be recalibrated/repaired if dropped or damaged in any way since last calibrated.

2.02 Means of Access

A. The Contractor shall provide means for the CxA and Owner Representatives to access, observe, and visually confirm proper operation of all equipment and systems. These means shall be in compliance with all OSHA and DOE regulations and the project specific Safety Plan.

B. The Contractor shall also take appropriate precautions per the specific Safety Plan during testing as required by the nature of hazard (i.e., high-voltage electrical, high pressure/temperature).

PART 3 - EXECUTION

3.01 Communication response times

A. Timeliness in delivering information or providing responses to the CxA is essential to providing the construction product on time, as well as facilitating the commissioning process.

B. The Contractor shall adhere to the following guidelines to meet this objective:

1. Delivery of draft O&M manuals: Ninety days prior to the scheduled training

2. Delivery of proposed training material: Sixty days prior to the scheduled training

3. Delivery of startup plan for each piece of equipment: Six weeks after approved submittals

4. Delivery of final approved checklist: One week from actual completion of the checklist

5. Written response to a site observation comment: Two weeks or less from receipt of comment

6. Written response regarding the acceptability of the functional testing procedures: Four weeks from receipt of the testing procedures

7. Time to correct discrepancies noted in Record Drawings during construction phase: Two weeks from the date the discrepancy was noted

3.02 Commissioning Meetings

A. Commissioning shall be an agenda item in the regularly scheduled project progress meetings. The CCL shall update the installation, startup, operation, and status of all Commissioned systems. The CCL shall update the status of prefunctional checklist completion. The CCL shall update and track the status of any commissioning equipment issues to resolution. The CxA assisted by the CCL shall determine the need for specific commissioning meetings as necessary to plan for the required commissioning activities.

B. The CxA assisted by the CCL shall determine who should attend the meetings. The CCL shall provide written notice of these meetings with as much advance notice as possible but in no case less than three working days.

3.03 Submittals

A. For equipment to be commissioned Submit all field quality assurance documentation electronically in accordance with general and supplemental conditions of the contract and Division 1 Specification Section 01330 as required by the contract documents such as but not limited to the following:

1. Systems and Equipment Startup and Checkout documentation as required in specification 230050.
2. Piping flushing/cleaning and pressure testing documentation as required in specifications 221513, 226213, 226219, 232113, 232123, 232213.
3. Ductwork leak testing and cleaning documentation as required in specifications 233113, 233116,233119, 233300.
4. Field training session documentation as required in specification 230595.
5. Test & Balance Final Report as required in specification 230594.
6. Detailed product data for each piece of equipment including capacities, electrical components and requirements, startup procedures, etc.
7. Full and part load performance curves over the expected operated ranges for each piece of equipment that will operate at variable loads.
8. Manufacturers' certified equipment test reports, where applicable.
9. Manufacturers' detailed installation requirements.
10. Manufacturers' detailed start-up requirements.
11. Control system diagrams and sequences of operation.
12. Operation instructions and wiring diagrams.
13. Field installation Test Reports (i.e., pressure tests, x-ray).
14. Warranty and Owner's obligations to maintain warranty.
15. Manufacturers' recommended maintenance and troubleshooting procedures, including tools and replacement parts lists.

3.04 Schedule

A. The GC and appointed CCL shall integrate commissioning activities, including pre-startup meetings, completion of pre-startup checklists, equipment startup, test and balance, functional performance testing, and training for those systems identified in Part 1.05 into the master construction schedule.

B. The Contractor shall incorporate the sequence of commissioning activities into its schedule of values. Payments will be contingent upon submittal of the required commissioning documentation.

C. Commissioning of systems shall proceed per the criteria established in the specific sections, with activities to be performed on a timely basis. The CCL must be available to respond promptly to avoid delay to the schedule.

D. Problems observed shall be addressed immediately, in terms of notification to responsible parties and actions to correct deficiencies.

E. The Contractor shall update the schedule of commissioning-related activities at least monthly until the beginning of start-up activities and/or functional performance testing.

F. The CCL shall update the schedule of commissioning-related activities at least every two weeks once start-up activities and/or functional performance testing have begun.

3.05 Equipment Checklists

A. The prefunctional checklists are provided in the Cx Plan.

B. Commissioned equipment installation: Contractors, Subs, Manufacturers' Representatives, and/or Vendor/Suppliers are responsible for documenting installation verification via startup checklists and prefunctional checklists.

C. The CCL shall ensure all equipment checklists are completed correctly and on a timely basis.

D. The CCL shall provide a copy of all in process checklists to SNL/CxA in conjunction with each pay request. SNL will use this information to substantiate the Contractor's indicated percentage completion for the project.

E. The CCL shall provide a copy of all completed checklists to SNL/CxA within one (1) week of the completion of the checklist.

F. The following equipment checklists will be provided by the CxA for each piece of commissioned equipment. The contractor may provide a prefunctional checklist if review of the checklist is deemed sufficient by the CxA.

1. Prefunctional Checklist
   a. Purpose: This checklist documents the equipment has been verified to be installed, started, and operating per design intent prior to the functional performance test of the equipment or system.
   b. Responsible Party: Contractor

3.06 Site Observation AND Installation Verification

A. During construction the CxA with the support of the commission team will observe the work of the General Contractor and subcontractors to ensure all installations are being made in accordance with the intent of the contract documents, insofar as the installation impacts the goals of commissioning.

B. Before system startup begins, the Contractor shall conduct a final installation verification audit.

C. If any work is found to be incomplete, inaccessible, incorrect, or nonfunctional, the CxA and Contractor shall make note of deficiencies. The contractor shall correct the deficiencies before system startup work proceeds.

3.07 Coordination with SNL Delegated Representative (SDR)

A. The CCL shall coordinate with SDR and the CxA for commissioning witness testing. The CxA shall witness start-up and Functional performance test activities specified for those systems identified in Part 1.05. Other witnesses may include any or all of the following:

1. SNL PL
2. SNL PA
3. SNL SDR
4. SNL Project Technologist/Inspectors
5. EOR
6. CxA

B. Other required field quality tests as required in other Divisions 1-16 specifications requiring SNL Inspector witness shall be coordinated.

C. The CCL shall notify the Commissioning Team in writing a minimum of 10 days in advance of the date, time, location, and anticipated duration of startup and test activities.

D. The CCL shall obtain the signature of designated witnesses on all data forms. If a witness is unavailable at the scheduled time and location of the activity, so note, and proceed per schedule without the witness.

E. The Contractor shall not reschedule any test without receiving approval by the SNL PL.

3.08 Functional Performance Test Procedures

A. General Procedures

1. The Contractor shall demonstrate that the commissioned equipment and systems operate properly in all modes of operation.

2. Sequence of testing: Commissioning shall proceed from lower to higher levels of complexity. For each discrete subsystem or system, testing at the lower level shall be completed prior to starting the next higher level of tests. In general, the order of testing from lowest to highest is as follows.
   a. Static tests (such as pipe leak/pressure tests).

b. Component functional tests (of motors, actuators, sensors, etc.) and startup.
c. Point verification tests of FCS/Process Equipment Control Systems (performed by Controls Installation Contractor).
d. Balancing (Coordinated with SNL's T&B Contractor).
e. System functional performance tests.
f. Intersystem functional performance tests.

3. Equipment/Systems listed in Section 1.05 of this specification will be commissioned/functionally tested. Functional performance tests can be found in the Cx Plan.

4. Commissioning completion and acceptance of equipment/systems installation/operation is via successful completion of functional performance testing, System training, and O&M documentation submittal. The Cx Report constitutes positive verification of commissioning requirements.

B. In accordance with the construction schedule, the CCL shall manage the completion of the functional performance tests.

C. Functional Performance Test (FPT) Procedures

1. The CxA will develop functional performance test procedures with the support of the Commissioning Team which will verify the integrated functionality in the sequence of operations as stated on the contract drawings.

2. The FPT procedures are provided in the Cx Plan.

3. The Contractor shall review the FPT procedures and reply, in writing, whether the tests as written are acceptable, meet the installed conditions, and will not void any warranties. The Contractor shall provide any requested modifications to the test procedures in writing. No reply from the Contractor within four (4) weeks of its receipt of the FPT procedures signifies the Contractor's concurrence that the procedures are acceptable.

4. The FPT procedures will provide step-by-step instructions in a pass/fail format.

D. The Contractor shall complete and submit all applicable Equipment Checklists prior to scheduling of testing.

E. When the equipment and systems are ready to test, the FPT will be scheduled for a time mutually convenient to the CCL, the installation Contractor, the controls system contractor, the SNL FCS team if applicable, the CxA, and the SNL-specified witness.

F. The CxA will orchestrate the Functional Performance Test. The Contractor shall be responsible to provide personnel and equipment to perform the testing and to correct problems found during the testing. The CxA with support of the commissioning team will document the pass/fail of each procedure in the FPT. If the SNL FCS is controlling the equipment being functionally tested, the Contractor is not relieved of attendance at testing and correction of problems found. The Contractor shall provide means of access to the CxA to visually verify all aspects of the specified test.

G. If the total time required to correct minor problems during testing is greater than 15 minutes, the test shall be considered failed and must be repeated in its entirety.

H. If a major problem is discovered during the test, the Contractor shall correct the problem. Prior to retesting, the Contractor shall submit to the CxA the required data indicating the deficient items have been corrected. After review of this information by the CxA, a retest will be scheduled.

1. A major problem is any problem or group of problems that require more than 15 minutes to correct.

2. Any deficiency (major or minor) shall be recorded on the functional performance test form.

I. Retesting: Repeat, at no additional cost to SNL, any test for which acceptable results are not achieved. Repeat tests until acceptable results are achieved.

J. Correction of deficiencies:

1. Correct test deficiencies promptly and schedule retest.

2. Corrections during functional performance tests are generally prohibited to avoid consuming the time of personnel waiting for the test, but not involved in making the correction. Exceptions will be allowed if the cause of the failure is obvious and corrective action can be completed in less than five minutes. If corrections are made under this exception, the failure shall be noted on the test data form. A new functional performance test data form, marked “retest,” shall be initiated after the correction has been made. The entire test procedure shall be repeated.

K. Deferred/seasonal testing shall be performed as determined by the CxA.

3.09 Reports

A. The CCL shall ensure that all test reports, pre-startup checklists, verification forms, etc. as specified for those systems to be commissioned are completed and delivered to SNL via standard lines of communication.

3.10 Training

A. The CCL shall prepare and submit a training plan for approval. The plan shall include training as required in the specifications and as otherwise deemed appropriate by the Contractor and the SNL PL. The training plan shall include for each training session:

1. Dates, start and finish times, and locations.
2. Outline of the information to be presented.
3. Names and qualifications of presenters.
4. List of texts and other materials required to support training.

B. The Contractor shall provide final O&M manuals and training materials to SNL and CxA prior to training.

C. At a minimum, the Contractor shall provide the following material at the time of training:

1. Detailed agenda
2. Contractor contact information sheet
3. Detailed training material (divided by sections where appropriate)
4. Log sheets and maintenance checklists
5. Manufacturer training videos used to educate the factory-trained service technicians for this equipment

D. At a minimum, training topics shall include the following:

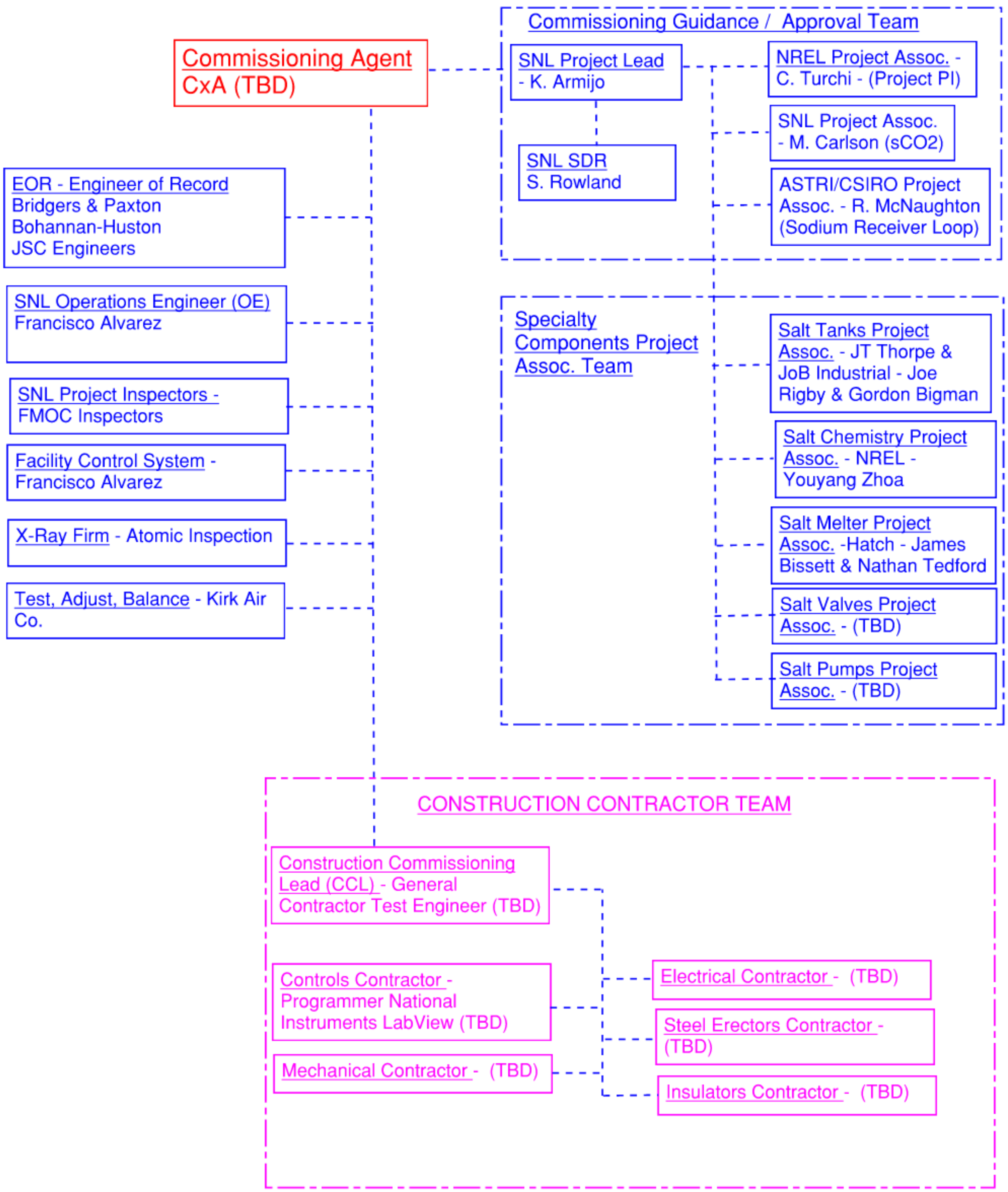
1. Description of equipment and systems
2. Warranties and guarantees
3. Equipment startup and shutdown
4. Normal and emergency operation
5. Seasonal changeover
6. Maintenance schedules
7. Health and safety issues
8. Special tools and spare parts

9. Emergency procedures
10. Hands-on operation
11. Troubleshooting
12. O&M manuals
13. FCS and sequences of operation

3.11 Project Closeout

A. See standard specification 01700, *Contract Closeout*, for additional information not specific to this commissioning specification.

END OF SECTION



COMMISSIONING TEAM COMMUNICATION DIAGRAM

PRELIMINARY FUNCTIONAL TEST PROCEDURES

Table of Content

Exceptional service in the national interest

Section 01 32 16 – Contractor's Project Schedule

June 2019

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Section 01 32 16 – Contractor's Project Schedule

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
1/23/17	Tim Peterson	Subst	• Made basic updates. • Added information on using Microsoft Office under Submittals. • Added bullet point under Section 2.2, “Baseline Schedule,” Section 4.3, “Change Orders,” Section 5.1, “Schedule of Values,” and Appendix A under “Schedule Activities.”
12/11/18	Tim Peterson, Josh	Subst	• Added information to Section 1.2, 1.4, 2.1, & 2.2
5/21/19	Jennifer Sawayda	Admin	• In 2.2B, changed resource loaded to non-resource loaded and added a sentence about resource loading
6/5/19	Jennifer Sawayda	Subst	• Added 2 sentences at the end of 2.1A; added E to Section 2.2; three-year review performed
2/5/20	Jennifer Sawayda	Admin	• Small changes to Part 1.1.C and 1.1.D – updated Primavera and Microsoft Project

Section 01 32 16 – Contractor's Project Schedule

Part 1 - General

1.1 Summary

A. This section includes the following:

The development and submission of all project schedules, updates, recovery plan schedules, changes, and schedule of values (SOV).

B. Related Sections:

- Section 01 33 00, “Submittal Procedures”
- Section 01453, “Construction Inspection Report Requirements”
- Section “01 77 19, “Contract Closeout”

C. Basis of Design:

Primavera P6, release 7.0 or later is required on all projects or at SDR discretion

D. Substitutions:

Microsoft® Project 2010 may be used on projects or at SDR discretion

1.2 Qualifications

Furnish a project scheduler to perform all scheduling, invoicing, and project-control management listed herein.

The project scheduler is considered a member of the Contractor’s key personnel since the Contractor is required to “furnish a project scheduler to perform all scheduling, invoicing, and project-control management listed herein.” At Sandia National Laboratories, hereafter referred to as Sandia, professional schedulers are available to assist with scheduling questions (not to build schedules for customers) and to provide scheduling education as needed to ensure scheduling criteria are met.

1.3 Description

The Contractor shall prepare and maintain a detailed schedule utilizing the critical path method. This schedule shall be the Contractor's baseline (target) schedule that shall be used to plan, organize, and execute the entire scope of work. The Contractor shall maintain a statused (working) copy of the resource loaded baseline schedule that shall be used to record the contractor’s actual performance and report the critical path to contract completion. The Contractor shall be extensively familiar with the schedule and be able to discuss the development, progress, and logic in great detail.

This is the key schedule progress measurement tool utilized at Sandia in evaluating the

Contractor's performance. The Contractor shall develop, implement, maintain, and status for Sandia a reasonable and achievable schedule.

1.4 Submittals

This section provides requirements for submittal types, formats, and layouts.

Information related to when, how often, and the objective of each submittal is included in parts two through five of this specification.

A. Submittal Types

1. Electronic: Submittals of the full project schedule shall be made in the native format of the scheduling software. Submittals in P6 native format shall be made in the Release 7.0 or later of the software. Submittals in Microsoft Office shall be made using Microsoft Office 2010 or later format. In addition to the native format, electronic submittals of schedule layout or other documents shall be accompanied by a Portable Document Format (PDF). When submitting PDFs of your schedule, please ensure the specified columns are contained within the document, including the following: Activity ID, Activity Name, Original Duration, Remaining Duration, Actual Duration, Activity % Complete, Start, Finish, and Total Float.

   The document requires the contractor to include in the footer of the PDF the "Gantt Chart Legend."

2. Hard Copy: Submittals may be printed from PDF or source files and shall contain the same data as the electronic file. Hard copies shall have a minimum of eight-point font, shall be printed on either 8½″ by 11″ or 11″ by 17″ paper, and shall be in full color if the original document contains colors other than black. The Contractor shall provide enough copies for all progress meeting attendees.

B. Submittal Format

Each layout shall have the following information in a clear and concise format:

1. In the header portion of the layout: Schedule title (schedule baseline, three-week look-ahead, etc.), project name, data date, and date printed.

2. In the footer portion of the layout: Contractor name, baseline name, Gantt Chart Legend, file name, and the "Page # of #."

C. Submittal Layout

Schedule submittals identified in parts two through five of this specification shall be in the following format and layout unless otherwise specified by the Sandia-

Delegated representative (SDR) or defined in the project specific details in Appendix A:

1. Full schedule shall include all schedule activities and milestones and the following columns:

    a. Activity ID
    b. Activity name
    c. Original duration
    d. Remaining duration
    e. Actual duration
    f. Activity % complete
    g. Start
    h. Finish
    i. Total float

2. The three week look-ahead schedule submittal shall include activities that are in progress or activities that are scheduled to start within three weeks of the data date. This schedule shall include columns included in item one above, with the exception of columns identifying any cost. This three week look-ahead schedule shall be submitted to Sandia two working days before the review meeting.

3. The PDF submission of the three-week look ahead shall include the original approved baseline for comparative purposes, the specified columns, and the addition of the following three columns:

    - Baseline start
    - Baseline Finish
    - Variance – Project Finish

    When submitting PDFs of your three-week look ahead schedule, ensure the specified columns are contained within the document, including the following: Activity ID, Activity Name, Original Duration, Remaining Duration, Actual Duration, Activity % Complete, Start, Finish, Total Float, Baseline Start, Baseline Finish, and Variance – Project Finish.

4. The critical path schedule submittal shall include all activities on the longest path. Critical path may be based on activities with a total float equal to or less than zero but is at the discretion of the SDR. This schedule shall include columns included in item one above, with the exception of columns identifying any cost.

PART 2 - Development and Implementation

2.1 Schedule Development Requirements

A. Schedule Criteria: The schedule shall identify and show all activities required to complete the project and their dependency relationships. At all times the schedule shall have a well-defined and contiguous critical path from the data date to the final milestone “Contract Complete.” Scheduling best practices shall be followed in development and management of contractor schedules. SNL personnel have the discretion to make suggestions and recommendations based on industry best practices.

B. Milestones:

1. All schedules shall initiate with a milestone identified as “Contract Award” and terminate with a milestone identified as “Contract Complete.”

2. Include the major and intermediate milestones necessary to track important events in each structure (and critical structure areas), and as listed in Appendix A.

3. Milestone activities are zero duration and zero cost. As such, they should not have an associated duration or cost. A responsible contractor may be assigned if desired, but it is not required.

C. Activity Requirements:

Include activities in the schedule that will be identified in the SOV and for monitoring purposes as listed in Appendix A.

The activities shall meet the following criteria:

a. Activities shall be broken out by a subcontractor or general contractor and identified by code or resource name that is performing the work. No activity shall be co-owned by more than one subcontractor or general contractor.

b. Each activity shall have a unique identification number.

c. Each activity shall have a unique description.

d. Each activity shall have an associated cost that will be used for invoicing.

e. All activities more than 0% complete must have an actual start date.

f. All activities that are 100% complete must have an actual finish date.

g. Each activity shall have total float measured against the contract completion or target completion date as agreed to by the Project Lead through an unobstructed logic string (no constraint dates other than the contract complete milestone and general conditions monthly activities).

h. With the exception of the two key milestones “Contract Award” and “Contract Complete,” all activities and milestones shall have a minimum of one predecessor and one successor within the schedule logic.

i. Total float for any activity shall not exceed 20 days with the exception of delivery of long lead materials. Negative total float shall not be allowed for baseline schedule development.

j. Activity durations shall be based on the Sandia Standard Work Hour Calendar and shall not exceed five working days, unless otherwise agreed to by the Project Lead *except for the following:*

1. Activities for procurement, fabrication, and delivery of equipment or materials

2. Any Sandia activities including but not limited to inspections, reviews, approvals, Sandia-furnished equipment, and materials

k. Developing characteristics for procurement, fabrication, and delivery activities shall be coordinated with the Sandia Project Lead prior to incorporation into the baseline schedule.

l. The Contractor shall include, at a minimum, six adverse weather days per calendar month (not aggregate) as part of the schedule, but these should not be identified on the schedule. If the amount of weather delays exceeds six days in any single month, the construction complete milestone may be extended, as per the Baseline Change Request process. Weather days that are exercised or construction complete milestones that are extended due to weather shall be at no additional cost to the project or Sandia.

Note: The six weather days per month are to be allocated throughout the activities occurring during each month and do not fall on a single activity called "Weather Days."

2.2 Baseline Schedule Development

A. The Baseline Schedule shall not contain any progress or negative float.

B. Non-resource loaded baseline schedule submission: Within 10 working days after award of the contract, the Contractor shall submit a non-resource loaded baseline schedule, which shall include activities and logic for the entire scope of the project. Contractor shall submit a resource loaded schedule three working days prior to first invoice.

C. Sandia personnel shall review and provide comments on the resource loaded baseline schedule within five working days of the submittal.

D. Prior to resubmitting a new submission for review and approval, Contractors shall ensure they have addressed the identified issues as contained in the Schedule Specification Checklist, and that their new submission has taken into account the previously given commentary and suggestions provided in this specification.

E. Positive lags are allowed if necessary and deemed justified based on their logic dependencies. Negative Lags (a.k.a. leads) are not permissible and shall not be used in contractor schedules as they can affect critical path and distort total float.

PART 3 - Schedule Submittal and Maintenance Requirements

3.1 Schedule Update Requirements

A. The first schedule update shall occur no sooner than five work days after Sandia's review.

B. Updates shall be submitted at the frequency determined by the Construction Manager and shall be used as the basis of percent complete.

C. Updates shall include but are not limited to the following:

a. Provide a percentage of the work completed to the data date.

b. Provide actual start and actual finish for activities that have completed these items.

c. Provide remaining durations for activities that have started.

d. Provide a critical path for all remaining work.

e. Identify any delays, project finish impacts, and recovery plans.

f. Identify other items as indicated by the Construction Manager.

D. When progress or changes delay the "Project Complete" milestone date more than four calendar days and less than 10 calendar days, a written narrative explaining the reasons for the delay shall accompany the schedule update submittal.

a. The narrative shall explain in clear terms what activities are causing the delay and identify the subcontractor responsible.

b. An analysis by the Contractor as to whether the trend will improve or will continue to delay the end date is required.

E. When progress or changes delay the "Project Complete" milestone date five days or more, a detailed recovery schedule submittal developed in a copy from the last status file native format and narrative recovery plan shall be submitted to Sandia within three working days.

a. Man-hour information and crew size shall be provided by the Contractor to justify any duration changes. The Contractor shall identify existing information as well as planned information so the changes can easily be identified.

b. The Contractor shall identify any required changes to the logic and be prepared to furnish justification for the proposed changes.

c. Details in the narrative describing actions to be taken by the Contractor to implement the recovery must be clear, quantifiable, reasonable, and achievable. The details shall include the following items:

1. A description of what the proposed changes will accomplish, as well as their effect on the critical path.

2. Identification of the subcontractors that will be involved with the recovery plan.

3. For all activities that overtime is identified as a recovery plan, identification of the subcontractor and amount of overtime.

4. Additional resources, changes in working time, etc., are required for schedule recovery and shall be at no cost to Sandia.

d. The recovery schedule and narrative plan submittal shall be reviewed and commented on by Sandia personnel within three working days of receipt. Recovery schedule layout shall be in accordance with Section 1.4 of this specification.

F. Progress Reviews: Sandia and the Contractor shall jointly review the status schedule in the weekly construction progress meeting.

PART 4 - Schedule Evaluation and Change Incorporation

4.1 Schedule Evaluation

A. Sandia personnel shall review each schedule submission and evaluate the Contractor's project status based on reported dates and total float. Sandia personnel will determine a project to be "on schedule" when the contractor meets the following condition:

a. The critical path total float to the contract completion date equals zero.

B. Additional schedule evaluation criteria may include but are not limited to:

a. Activities on or near the critical path that have not started on or before the baseline

b. Activities on or near the critical path that have not finished on or before the baseline finish date

c. Activities with excessive actual duration

d. Activities with negative float

e. Date changes for critical milestones

4.2 Baseline Change Proposals

A. The Contractor will not adjust baseline dates in past or current reporting periods or adjust reported percent complete unless directed by the Sandia Project Lead.

4.3 Change Orders

A. For any Change Order, the Contractor shall indicate if the requested change impacts the schedule individually or in aggregate. Under no circumstances will aggregate changes to the schedule be accepted unless the Contractor has submitted the change to the SDR for review.

B. Change Orders shall include the following:

a. The Contractor shall create at least one new activity for each approved Change Order.

b. A new activity shall be created for each subcontractor's scope that is affected by the Change Order. This activity(s) shall accurately represent the approved scope to be performed. The activity(s) shall be added in the schedule sequence at the logical point the work should be performed.

c. Added Change Order activities shall be identified with the Change Order number followed by the Change Order description.

d. When adding Change Order activities to the end of the base activity, the new scope is derived and does not constitute thoughtful planning. It will not be accepted by Sandia. (The new scope may be required to be completed before the base scope can continue, or it may be required to be performed in parallel with the base scope.) This type of analysis is encouraged to be performed prior to placing the activity(s) into the logic.

e. All time extension requests or changes that may affect the contract end date shall be accompanied by a written time impact analysis illustrating the influence of each change or delay on the current contract schedule completion date.

1. The written impact analysis shall be accompanied by a fragmented schedule network using the baseline schedule. The fragmented schedule network shall be evaluated in the baseline schedule with no consideration given to the statused schedule.

2. This narrative shall be included with each Change Order submitted that affects the project schedule and shall meet the details of the schedule information listed herein.

f. Negotiations for contract extensions shall be considered only to the extent that equitable time adjustments for the activity or activities affected exceed the total or remaining float along the path of activities at the time of actual delay.

1. Past performance on activities by the Contractor and the subcontractors along the completed and in-progress portion of the critical path shall be evaluated and included in any analysis to determine ownership of the delay.

2. Poor performance by the contractor shall not warrant a contract extension.

3. Concurrent delays by the Contractor shall be subtracted from any proposed owner delays.

g. Once the Baseline Schedule has been modified by the Change Order, the Contractor shall submit the revised Baseline Schedule to Sandia at the next schedule submission or prior to the next progress meeting, whichever is first. All future statused schedules shall utilize the approved revised Baseline Schedule for performance measurement.

PART 5 - Schedule of Values and Payment Process

5.1 Schedule of Values

A. The SOV is a detailed statement of project cost based on a detailed itemized list that establishes the value of each part of the work for the entire project and is sorted by Sandia work breakdown structure element or as specified by Sandia Project Lead. The SOV is used as the basis for resource loading the project schedule and as the basis of preparing, submitting, and reviewing progress payments. The allocation of costs should be reflective of the value associated with the work.

B. The SOV shall be developed from the Contractor's Baseline schedule.

C. Within ten working days of the contract award, the Contractor shall submit an SOV for review. Sandia personnel shall review the SOV and provide comments to the Contractor within five working days. The SOV layout shall be in accordance with section 1.4 of this specification.

D. The Contractor shall resolve all Sandia comments within five working days of receipt.

E. The approved SOV shall be submitted with the invoice.

5.2 Payment Process and Invoice Verification

A. The Contractor's invoice shall report costs at the subproject level.

B. At the time of closeout for each invoicing period, the SDR shall review and accept progress status prior to invoicing. Sandia personnel will review the proposed pay application with the Contractor and verify any variations from the Contractor's record of progress.

Invoice progress shall be recorded as “Percent Complete” (% Complete) in the Contractor’s SOV at the activity level.

C. The Contractor shall furnish copies of the proposed invoice, SOVs, and requested percent complete to each party of the pay application review team.

D. The performance measurement dollar amount in the month-end statused schedule shall match the cumulative dollar amount being submitted in the payment invoice by the Contractor for that period.

E. In such case the agreement between Sandia and the Contractor cannot be reached for the status of any activity, the Sandia Contracting Representative will make the final determination. Thereafter, the Contractor shall submit the payment invoice for the agreed upon progress to the SDR, adjust status in the schedule accordingly, and resubmit the month end status file.

F. The schedule submitted for the last accounting week according to the Sandia accounting calendar will be considered the month-end submittal. This will be used to calculate the performance measurement dollar amount, and all approved changes to the baseline shall be incorporated at that point.

END OF SECTION

Appendix A

_________________ Project Construction Schedule Requirements

CONSTRUCTION SCHEDULE MILESTONES:

The construction schedule shall incorporate but not be limited to the following relevant milestones to represent the scope of this contract:

1. Contract Award
2. Construction Notice to Proceed (NTP)
3. Civil Work Complete
4. Wall Demolition Complete
5. Ceiling Demolition Complete
6. Mechanical Demolition Complete
7. Above Ceiling Work Complete
8. Electrical System Start-Up
9. Heating, Ventilating, and Air Conditioning (HVAC) Systems Start-Up
10. Security System Complete
11. Technical Systems Ready for Testing
12. Architectural Finishes Complete (Floors, Doors, Hardware, Paint)
13. Sandia Above Ceiling Inspection Complete
14. Contractor Punch List Complete
15. Test and Balance Complete
16. Substantial Completion
17. Request for Sandia Final Inspection
18. Sandia Final Inspection Punch List Complete
19. Contract Complete

SCHEDULE ACTIVITIES:

The schedule shall incorporate but not be limited to the relevant following activities:

1. Construction activities broken out by subcontractor. (Co-ownership of an activity by more than one subcontractor is not allowed.)
2. Mobilizing
3. Testing and start-up
4. Submittals and shop drawings: preparation, review and approval
5. Lift Plan Submittal (include 10 days for Sandia review)
6. Purchasing, manufacturing, fabricating, and delivery of major equipment
7. Critical inspection activities to be performed by Sandia personnel (i.e., above ceiling)
8. Sandia-operated utilities, or equipment shutdowns (outages)
9. Request for Sandia operated utilities or equipment shutdowns (outages)
10. Third party support (i.e. Asbestos Management Services [AMS], Test and Balance [TAB], Communications, Security, etc.)
11. Close-out (such as operations and maintenance manual submittals)
12. As-built drawing submittals
13. Sandia-furnished equipment and material
14. All items as specified in “other conditions” of the contract

Section 01 33 00 – Submittal Procedures

February 2017

Release Date: 02/01/2017
Next Review Date: 02/01/2020

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 01 33 00 – Submittal Procedures

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
2/01/17	Tim Peterson/Jennifer Sawayda	Subst	• Basic updates • Bullets added to Section 1.2 and Section 1.10
8/10/18	Matt Pacheco	Admin	Added information about Spec 01 78 39, Project Record and Shop Drawings

Section 01 33 00 – Submittal Procedures

Part 1 - General

1.1 Summary

A. This Section includes the following for preparing and transmitting submittals required by specification sections for a product, material, or construction method:

1. Shop drawings
2. Product data
3. Manufacturer's certificates
4. Design data and calculations
5. Manufacturer's instructions
6. Manufacturer's field service reports
7. Samples
8. Operation and maintenance manuals (timing, quantity, content, and form)

B. It is the responsibility of General Contractors to convey the requirements of this Section to their subcontractors and their suppliers and vendors.

1.2 Submittals

A. Schedule submittals to expedite Work. Unless otherwise indicated in this Section, submittals shall be submitted within 30 days of date of Notice to Proceed.

B. Preparation:

1. Provide submittals as indicated in the Descriptive Submittal Log. Submittals identified in the Contract documents but not on the Descriptive Submittal Log shall be provided upon the request of Sandia National Laboratories (SNL) personnel.

2. Provide a separate submittal for each specification section requiring submittals, as indicated in the Descriptive Submittal Log. If approved by SNL personnel, where multiple sections relate to the same system or element and are being provided from the same source, a single combined submittal is acceptable.

3. Coordinate submission of related items. Group submittals of related products in a single transmission.

4. Include all submittal material requested for that Section.

5. Identify variations from requirements of Contract Documents. State product and system limitations that may adversely affect Work.

6. Mark or show dimensions and values in same units as specified.

C. Contractor responsibilities:

1. Review submittals prior to transmittal. Verify compatibility with field conditions and dimensions, product selections and designations, quantities, and conformance of submittal with requirements of Contract Documents. Return non-conforming submittals to preparer for revision rather than submitting for review.

2. Coordinate submittals to avoid conflicts between various items of work.

3. Submittal transmittal form:

a. Include with each submittal a transmittal form. A sample copy of an acceptable form is in Attachment A. A contractor's standard submittal form may be used provided it contains essentially the same information as the sample.

b. Identify Project, Contractor, subcontractor, supplier, manufacturer, pertinent drawing sheet and detail numbers, and associated Specification Section numbers.

c. Sequentially number transmittal forms. Re-submittals shall have an original number with a suffix. An acceptable form of number is SS SS SS-NN-T, where:

(1) SS SS SS indicates the six-digit specification section number.

(2) NN indicates different submittals for that specification section.

(3) T indicates the number of times that the submittal has been made.

4. Failure of Contractor to review submittals prior to transmittal for review shall be cause for rejection.

5. Incomplete or improperly packaged submittals, or submittals from sources other than Contractor, will not be accepted.

D. Transmittal: Transmit all submittals electronically through SNL’s project management software system. Where electronic submittal is not possible, submit five (5) paper copies for SNL’s retention plus as many copies as the Contractor desires to be returned after review. <u>Exception</u>: Retained quantities for samples, color charts, and manufacturer’s equipment manuals shall be as specified elsewhere herein.

E. Review: SNL personnel will review and return submittals with comments, if required.

F. Do not fabricate products or begin work that requires submittals until the return of the reviewed submittal with SNL acceptance.

G. Upon return, promptly distribute the reviewed submittals to concerned parties. Instruct parties to promptly report any inability to comply with provisions.

H. Resubmission:

1. Revise and resubmit submittals as required within 10 days of return from initial review.

2. Make re-submittals under procedures specified for initial submittals.

3. Identify all changes made since previous submittal.

1.3 Quality Assurance

A. Where required by Specification Sections, provide quality assurance submittals:

1. Qualification data: Written information demonstrating capabilities and experience of the firm or person. Include lists of complete projects with names contact information for references.

2. Manufacturer's certificates: Submit reference data, affidavits, and certifications on manufacturer's letterhead certifying that products conform to or exceed specified requirements. Certificates may be based on recent or previous test results supplied by the manufacturer and accepted by SNL representatives.

3. Installer approval: Certification on manufacturer's letterhead that installer complies with requirements and is approved for installing manufacturer's products.

4. Welding certificates: Written certification that welding procedures and personnel comply with requirements. Submit record of Welding Procedure Specifications (WPS) and Procedure Qualification Record (PQR) on American Welding Society (AWS) forms. Include names of firms and personnel certified.

5. Field test reports: Written reports from a qualified testing agency indicating and interpreting results of field tests performed either during or after installation for compliance with specified requirements.

1.4 Submittal Review

A. SNL personnel will review submittals for sole purpose of verifying general conformance with design intent and general compliance with Contract Documents. Approval of submittal by Architect/Engineer (A/E) or SNL Operations Engineer does not relieve Contractor of the responsibility for correcting errors that may exist in submittal or from meeting requirements of contract documents.

B. Review time: Initial review will be performed within 14 days of receipt. Reviewer reserves the right to withhold action on a submittal requiring review of related submittals until related submittal is received. Additional time will be required if processing must be delayed to permit review of related subsequent submittals. Re-submittals will be reviewed within 14 days.

C. Review actions: After review, submittals will be returned marked as follows to indicate action taken:

1. Approved: Part of the work covered by submittal may proceed provided it complies with requirements of contract documents. Final acceptance will depend upon that compliance. The term "Approved" shall only indicate that there is no exception taken to the submittal.

2. Approved except as noted: Part of the work covered by submittal may proceed provided it complies with notations and corrections on submittal and requirements of contract documents. Final acceptance will depend upon that compliance.

3. Revise and Resubmit: Do not proceed with the part of work covered by submittal, including purchasing, fabricating, and delivering. Revise or prepare new submittal in accordance with notations and resubmit.

1.5 Drawings

A. Where required by specifications or otherwise needed, prepare drawings illustrating portion of Work for use in fabricating, interfacing with other work, and installing products. Contract drawings shall not be reproduced and submitted as shop drawings.

When construction is complete, prepare and submit red-lined copies of the contract drawings showing clearly how construction deviated from the design, along with the authority for the deviation or change. Provide submittals as required by Specification Section 01 78 39, *Project Record Documents.*

B. Shop drawings: Design and as-built record drawings shall be submitted in both portable document format (PDF) and native computer-aided drafting and design (CADD) formats.

C. Electronic Format:

1. Size printable to 8½″ by 11″ minimum and 24″ by 36″ maximum.

2. Present in a clear and thorough manner. Title each drawing with Project name. Identify each element of the drawing with a reference number.

3. Plans, elevations, sections, and detail shop drawings shall be to scale with scale indicated.

4. Indicate field verified dimensions. Show the relationship of products to adjacent work. Note coordination requirements.

5. Schematics and diagrams shall be logically arranged and presented in a clear understandable manner with all items labeled.

6. Internal wiring diagrams: Provide internal wiring and elementary ladder diagrams for factory pre-wired equipment.

7. Control diagrams: Show relative positions of each component as a system diagram.

1.6 Product Data

A. Provide product data such as manufacturer's brochures, catalog pages, illustrations, diagrams, tables, performance charts, and other material that describe appearance, size, attributes, code and standard compliance, ratings, and other product characteristics.

B. Form:

1. Provide all critical information such as reference standards, performance characteristics, capacities, power requirements, wiring and piping diagrams, controls, component parts, finishes, dimensions, and required clearances.

2. Submit only data which are pertinent. Mark each copy of manufacturer's standard printed data to identify products, models, options, and other data pertinent to project.

3. Modify manufacturer's standard schematic drawings and diagrams and supplement standard data to provide specific information applicable to project. Delete information not applicable.

4. Colors and patterns: Unless the color and pattern is specified for the product, submit accurate color and pattern charts or samples illustrating manufacturer's full range for selection by the Sandia-Delegated Representative. Submit two (2) hard copies only.

1.7 Design Data and Calculations

A. Where required by specification sections, provide basic calculations, analyses, and data to support design decisions and demonstrate compliance with specified requirements. State assumptions and define parameters. Give general formulas and references. Provide sketches as required to illustrate design method and application.

B. Arrange calculations and data in a logical manner with suitable text to explain procedures and order.

C. Indicate name, title, and telephone number of individual performing design and include professional seal of designer where applicable or required.

1.8 Manufacturer's Instructions

A. Where required by specification sections, provide manufacturer's instructions for activities such as delivery, storage, assembly, installation, wiring, start-up, adjusting, and finishing.

B. Indicate pertinent portions and identify conflicts between manufacturer's instructions and contract documents.

C. Where appropriate include preparation procedures, service connection requirements, critical ambient conditions, foundation requirements, special precautions, adjustment requirements, alignment procedures, leveling, purging, charging, lubrication and cleaning prior to operation, and/or owner’s acceptance.

D. Installation (e.g., assembly, mounting, or wiring) and start-up instructions shall be submitted and available for review in the field prior to scheduled material or equipment installation.

1.9 Samples

A. Submit samples to illustrate functional and aesthetic characteristics of products with all integral parts and attachment devices. Include full range of manufacturer's standard finishes, indicating colors, textures, and patterns for A/E selection.

B. Submission: Submit the number of samples specified in individual specification sections. One sample will be retained by A/E and/or SNL personnel.

C. Label with identification related to submittal transmittal form.

1.10 Manufacturer's Field Service Reports

A. When an individual specification section requires the services of the manufacturer's field representative, submit report of observations, site decisions, and instructions given to installers.

B. Provide Reports Electronically.

1. Present complete information in clear concise manner.

2. Bind with titled cover in folder or binder.

C. Report shall include:

1. Time, location, conditions, and duration of activity.
2. Names of persons performing and witnessing activity.
3. Equipment used.
4. Description of activity, data recorded, and results.
5. Deficiencies found, corrective measures, and results of retesting.
6. Field notes, as required
7. Other pertinent data.

D. Submit report within 10 days of construction site service visit.

1.11 Operation and Maintenance Data

A. Where required by specification sections, provide operation and maintenance (O&M) manuals.

B. Submission:

1. O&M manuals should be submitted electronically when possible. The size of the file shall determine delivery method.

2. Submit for review one draft copy 30 days prior to need date or as otherwise specified. This copy will be returned after review with A/E's comments. Revise content as required.

3. Once approved, submit two (2) copies of complete, final O&M manuals. All manuals shall be submitted prior to or in conjunction with Notice of Substantial Completion.

C. Contents:

1. Equipment list (name and schedule #) as provided in drawings.

2. Operating instructions (normal and emergency), including diagnostic checks.

3. Preventive Maintenance Schedule.

4. Installation instructions and pre-operational checks for equipment and other products.

5. Equipment start-up sheets (by vendor in field).

6. Recommended spare parts list.

7. Wiring diagrams, as applicable.

8. Shop drawings, as applicable.

9. Test and balance (T&B) reports, and other field quality reports. Provide tab for T&B report, which may be supplied by separate SNL contract.

10. Statement of General Contractor's one-year warranty (See Specification 1700).

11. Copies of extended warranties.

12. Calibration procedures.

13. Installation, maintenance, and care instructions for hardware, coverings, and finishes.

14. Other material and information as indicated in individual specification sections and as necessary for O&M by SNL personnel.

D. Form:

1. Manuals shall be 8½″ by 11″ text pages bound in three ring expansion binders with a hard durable cover and with clear plastic pocket on front for title page.

2. Prepare binder covers with printed subject title of manual, title of project, date, and volume number when multiple binders are required. Printed project information shall be on face and spine.

3. Internally subdivide the binder contents with divider sheets with typed tab titles under reinforced plastic tabs. Place dividers at the beginning of each chapter, part, section, and appendix.

   a. All items in previous sub-section C shall be placed in specification section (2-16) order and shall be placed in tabs for associated equipment or products.

4. Provide pocket folders for folded sheets and/or shop drawings.

5. Provide a table of contents for each volume, with directory listing on subsequent pages.

   a. Directory listing shall have names, addresses, and telephone numbers of Contractor, subcontractors, equipment suppliers, nearest service representatives, and design consultant as appropriate (e.g., Design-Build).

Part 2 - Products

2.1 Paper and Binder Materials (When Used)

A. Paper: To the extent possible, copies of necessary hard copy documents shall be reproduced on paper with 30 percent minimum post-consumer recycled content and shall be double-sided copies.

B. Binders: To the extent possible, submittal binders shall have significant recycled content.

PART 3 - Execution

Not Used.

END OF SECTION

Attachment A: Sample Submittal Transmittal Form

Attachment A

Sample Submittal Transmittal Form

PROJECT TITLE:

____

CONTRACT NUMBER: ____

SUBMITTAL NUMBER: _____________________________ RESUBMITTAL: YES NO

DATE: ________________________ NUMBER OF COPIES SUBMITTED: __________

SUBMITTAL DESCRIPTION: ____

____

____

RELATED DESIGN DISCIPLINE (circle):

Civil Landscape Architectural Structural Mechanical Electrical

Telecommunications Security Fire Protection Controls

Other: ____

ASSOCIATED SPECIFICATION SECTION NO: _________________________________

REFERENCED DRAWING SHEET NO: ____

SUBCONTRACTOR/SUPPLIER/MANUFACTURER PROVIDING SUBMITTAL DATA:

Name: ____

Address: ____

Telephone Number: ____

CONTRACTOR:

Name: ____

Address: ____

Telephone Number: ____

CONTRACTOR'S CERTIFICATION:

The undersigned, as representative of Contractor for the above Project, submits the following and certifies that:

1. Submittal has been reviewed, and it is complete and conforms with the requirements of contract documents except as noted.
2. Required dimensions have been field verified and are acceptable for installation of proposed products and construction of proposed work.
3. Required quantities for products and materials covered by this submittal have been verified as correct.
4. Fabrication processes and construction methods proposed in this submittal are acceptable for this Project and will result in a complete, functional installation.
5. Submittal has been coordinated with other submittals and work and proposed products, and construction will properly interface with other construction.

NAME OF CONTRACTOR REVIEWER: ____

SIGNATURE OF CONTRACTOR REVIEWER: __________________________________

DATE: ____

Exceptional service in the national interest

Sandia National Laboratories

Section 01 57 26 – Dust Control

July 2019

Effective Date: 07/29/2019
Review Date: 07/29/2022

U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 01 57 26 – Dust Control

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
7/22/19	Tim Peterson	Subst	3-year review performed; removed attachments; updated formatting; updated 3.1A; eliminated bullets and other content under Section 1.4

Section 01 57 26 – Dust Control

Part 1 - General

1.1 Summary

A. Section includes requirements, methods, and materials for controlling dust and other particulate matter resulting from surface disturbance activities, pressure blasting, and demolition.

1. Disturbance of ground surface where activity exceeds 3/4 acre.
2. Disturbance of paved surface by grinding, milling, or other alteration: Surfaces exceeding 3/4 acre.
3. Demolition of building: Over 75,000 cubic feet.

B. Pressure blasting using sand or other abrasive. Related sections:

1. Section 02 41 13, "Selective Demolition": Demolition and removal activities to be coordinated with work of this Section.
2. Section 31 20 00, "Earthwork": Clearing, grubbing, excavation, rough grading, and other surface disturbing activities to be coordinated with work of this Section.

1.2 References

A. New Mexico Administrative Code (NMAC) – 20 NMAC 11.20:

1. Title 20 – Environmental Protection.
2. Chapter 11 – Albuquerque/Bernalillo County Air Quality Control Board (AQCB).
3. Part 20 – Fugitive Dust Control.

1.3 Definitions

A. Palliative: Agent applied to disturbed soil to mitigate and control dust.

B. Surface disturbance: Disturbance of ground, soil, or paved surface from its pre-existing conditions.

C. Transported material: Particulate matter moved off-site by wind, water erosion, truck spillage, and tracking by vehicles.

1.4 Submittals

Provide City of Albuquerque Fugitive Dust Control Application with Parts A and H completed for the associated project types (sign as operator in Section H).

1. Submit the completed Fugitive Dust Control Application to the SDR for distribution to the SNL Air Quality Compliance (AQC) Program. This application must be submitted for processing by the SNL AQC Program.

NOTE: The AQC Program will obtain the Fugitive Dust Control Permit from the City of Albuquerque and return the approved permit to the Contractor through the Project Manager.

2. Furnish a description and data for palliatives and other dust control materials that will be used for the project.

1.5 Quality Assurance

A. Regulatory Requirements

1. A complete copy of the Fugitive Dust Control Plan/Permit with all maps must be on site prior to beginning construction activity and all documents must be retained on-site at all times during project construction.
2. All reasonably available control measures listed in permit must be followed during the project.

   a. Comply with requirements of 20 NMAC 11.20.
   b. Comply with special requirements of Albuquerque Air Pollution Control Division.
   c. Coordinate time for obtaining required permits and approvals with Project schedule. Assume responsibility for delays caused by resubmittal and revocation of permits for non-compliance.

B. Dust palliative: Prior to submittal of Surface Disturbance/Demolition Permit application to Sandia-Delegated Representative (SDR) for approval, apply proposed dust palliative to test strip at job site. Demonstrate to SDR suitability of palliative to control dust.

PART 2 - Products

2.1 Dust Control Palliatives

A. Acceptable types:

1. Resinous petroleum–based emulsion not harmful to plants; Coherex as manufactured by Witco.
2. Penetration emulsion prime coat based on 38 percent minimum AC-5 asphalt cement: PEP as manufactured by Southwest Emulsions.
3. Prime dust oil emulsion based on 50 percent minimum AC-10 asphalt cement; PDOK as manufactured by Chevron USA.
4. Other type agent to mitigate dust as approved by SDR.

B. Formulation, dilution, and application rate: As recommended by manufacturer for specific soils at Project site.

PART 3 - Execution

3.1 Dust Control

A. Implement requirements identified in the approved Fugitive Dust Control Permit controls as specified in Paragraph 1.5, A.2. Coordinate with work of Section 31 20 00, "Earthwork" and Section 02 41 13, "Selective Demolition."

B. Use method or combination of methods listed below and approved by SDR to prevent particulate matter from becoming airborne and being transported off-site:

1. Phasing: Only disturb areas less than one acre at one time. Begin construction activities at west side of site and proceed to east to provide buffer area where shifting soil can be arrested.
2. Schedule: Do not perform earthwork and other activities generating particulate matter until wind velocity is less than 30 MPH.
3. Restricting vehicles: Use signs and other traffic controls to limit speed and access of job site vehicles. Limit speed to 10 MPH maximum. Restrict vehicle traffic in dust stabilized areas.
4. Excavated material: Keep out of active traffic lanes. Immediately remove excavated material deposited in roadways by erosion or spillage. Cover loads transported in earth-moving equipment.
5. Watering: Use sprinkler system or water truck with spray boom to water disturbed area daily and at intervals required to adequately control dust.
6. Windbreaks: Erect snow fences or similar windbreaks upwind and within disturbed areas. Place fences perpendicular to prevailing winds.
7. Palliatives: Apply dust palliative to stabilize soils after earthwork is completed and to sandy soils where watering is ineffective. Do not use palliative detrimental to vegetation in areas of future plant landscaping.
8. Other methods that substantially and effectively reduce transported material or emission of particulate matter into atmosphere.

END OF SECTION 01 57 26

Exceptional service in the national interest

Sandia National Laboratories

Section 01 77 19 – Contract Closeout

November 2019

Release Date: 11/20/2019
Next Review Date: 11/20/2022

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 01 77 19 – Contract Closeout

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
1/23/17	Tim Peterson	Subst	Changed the number of the spec, added a new section 3.3, added another bullet to section 3.4, basic editing
11/15/19	Gloria Hill and Tim Peterson	Subst	Added Appendix A and reference; 3-year review performed

Section 01 77 19 – Contract Closeout

Part 1 - General

1.1 Description of Work

This section includes administrative and procedural requirements for Contract Closeout.

1.2 Definitions

Beneficial Occupancy: The point at which the Project Team determines the facility or area can be occupied from both a regulatory and work function standpoint. The Sandia-Delegated Representative (SDR) shall determine if this milestone shall be used on this project.

Construction Complete: The point at which the Project Team determines the requirements of the Construction Phase, including the construction contract area fulfilled. This includes the resolution of any open items.

Contract Complete: The point at which the Project Team determines that all project activities are completed, closed, and/or approved for normal operations.

PART 2 - Products (Not Used)

PART 3 - Execution

3.1 Beneficial Occupancy (If Used)

When the Contract work is ready for its intended use, it will be incumbent on the Project Team (which includes the Contractor and SDR), using the Beneficial Occupancy checklist, to declare that the work is complete enough that Sandia National Laboratories (SNL) can beneficially occupy or employ the work for its intended use. As part of Beneficial Occupancy, a detailed and comprehensive list of items remaining to be completed or corrected will be agreed upon. Failure to include an item on such a list does not alter the responsibility of the Contractor to complete all work in accordance with the Contract documents. Within a reasonable time thereafter, the Project Team will make an inspection of the work to determine the status of completion. This process will repeat until the Project Team concurs that the work is "Construction Complete" (per the Construction Complete Checklist).

3.2 Construction Complete

A. Upon completion of all work, the General Contractor shall notify the SDR that:

1. Contract documents have been reviewed and complied with, as appropriate.

2. General Contractor and subcontractors have inspected all Contract work for compliance with Contract documents.

3. Equipment and systems have been tested per the test or Commissioning Plan and are functional, adjusted, and fully operational.

4. Final cleaning per Section 3.4 is complete.

5. Contractor is ready for SNL final inspection (or that final inspection has been completed).

B. Within a reasonable time after notification by the Contractor that the contract has been satisfied, the Project Team will accomplish the Construction Complete Checklist. If the contract work is considered incomplete by the Project Team, the General Contractor will be notified and given the reasons. The SDR will generally point out reasons, but is not obligated to provide an exhaustive list of discrepancies. The General Contractor shall take immediate steps to remedy the stated deficiencies and shall send a second notification to the SDR stating that work is complete and ready for re-review.

3.3 Contract Complete

A. Contract Complete determination shall be made by the SDR once all physical work has been completed and all administrative activities are complete, including ensuring that all submittals, warranty information, as-built drawings, and other pertinent documentation have been received and approved by SNL.

B. Within 30 days of Contract Complete, the Contractor shall submit his/her final invoice for the project.

NOTE: Final payment will not be processed until all Contract Complete Checklist Items assigned to the Contractor have been completed and found acceptable by the Project Team.

3.4 Final Cleaning by Contractor

A. Execute final cleaning prior to Beneficial Occupancy and/or Construction Complete.

1. Clean interior and exterior glass and surfaces exposed to view: Remove temporary labels, stains, and foreign substances; polish transparent and glossy surfaces; vacuum carpeted and soft surfaces; and wet-mop tiled surfaces.

2. Clean equipment and fixtures to sanitary conditions. Adjust and lubricate as needed operating products and equipment to ensure smooth and unhindered operation.

3. Clean permanent filters or replace filters of operating equipment.

4. Clean debris from roof, gutters, downspouts, and drainage systems. Debris includes but is not limited to paper, leaves, construction debris, and sand or rock.

5. Clean work site, sweep paved areas, and rake clean landscaped areas.

6. Remove all surplus materials to which SNL did not take title, including waste material, rubbish, and construction facilities, from site. Waste material and rubbish include but are not limited to paper, cans, personal trash, and removed or demolished construction materials.

7. Remove all project signage, temporary services, temporary offices, and staging areas and return all areas used for the project to their pre-construction state.

3.5 Completion and Warranty of Construction

Unless otherwise specified in the Contract, acceptance, as documented by the Beneficial Occupancy date and/or Construction Complete date, shall be final and conclusive except for latent defects, fraud, gross mistakes amounting to fraud, or SNL's rights under any warranty or guarantee. The Contractor shall remedy all defects in the work and pay for damage to the work and/or to other SNL property resulting from defective work, which shall appear within a minimum period of one (1) year from the date of Beneficial Occupancy and/or Construction Complete of the work under the Contract, unless a longer period is specified. SNL will give notice of observed defects with reasonable promptness. The one-year warranty period shall begin after any repairs are performed, if needed. The Contractor shall, in the case of work performed by his subcontractors, secure warranties from said subcontractors and deliver copies of same to SDR upon completion of the work. If any equipment provided under this Contract has a manufacturer's warranty longer than the minimum one year, such additional warranty shall devolve to SNL. A signed copy of the Contract Warranty Letter found in Appendix A shall be submitted by each subcontractor on the project.

Any additional warranty shall be addressed as such:

Name of Building: Sandia National Laboratories, Bldg. XXXX
Building Address: 1515 Eubank Blvd SE, Albuquerque, NM 87123

A final invoice or bill, complete with all claims, is due within 30 days of Contract Complete and acceptance of work, or within 30 days of written request from the SDR. The Contractor agrees that failure to execute and deliver the aforesaid final bill and all claims within the specified time limit shall be deemed to be, and shall have the same effect as, a fully executed release of all claims against SNL arising by virtue of this Contract. SNL, by virtue of the Contractor's failure to respond, may at its sole discretion execute final payment under the Contract. Additional requests for payment or claims will not be accepted after final payment has been executed.

Warranty of all Contractor-furnished equipment, systems, and work shall begin on the date of Beneficial Occupancy, Construction Complete, and/or the date repairs were finished on SNL observed defects. Contractors shall furnish a list of personnel able to respond on call to remedy or repair equipment, systems, and work that becomes defective, broken, or otherwise not operable under the warranty period. This list shall include names, telephone numbers, employer, and expected response times if it is an emergency, priority, or routine warranty work. This list shall be submitted with the final invoice for payment.

END OF SECTION

Appendix A: Warranty Letter Template

Company Letter Head
Address
Phone Number
Entity Email

*Required

Current Date:

Warranty Letter

Project/Job:	[Insert Project/Job Title]
Purchase Order Number:	[Insert Purchase Order Number]
Service Order Number:	[Insert Service Order Number]
Site/Building Location:	[Insert Site (SNL, KTF, Pantex, etc.), Building Location including Room(s) (i.e. A, B, C)]
Date of Substantial Completion:	[Insert Date of Substantial Completion]
Description of Work:	[Short description reflecting scope of work] (i.e., via UCP or statement of work on the drawings.)

*Required

The paragraph below is recommended verbiage and can be modified as needed according to the warranty coverage. (i.e., General Contractor 1 year, Installers 2–5 years. This doesn't include manufacturing warranties.

In accordance with the Subcontract, Section II warranty provisions, [Contractor Name] warrants for ____ year(s) to National Technology & Engineering Solutions of Sandia, LLC (NTESS) that work performed under this subcontract conforms to the subcontract requirements and is free of any defect in equipment, material, or design furnished, or workmanship performed by itself or any subcontractor or supplier at any tier. This General Contractor's warranty is an addition to any specific specifications' required warranties.

During the warranty period, upon notice from NTESS of any failure to conform or defect identified during the warranty period, [Contractor Name] will, at its expense, proceed to remedy such failure, defect, or damage within a reasonable time after receipt of such notice. The Subcontractor's warranty with respect to work repaired or replaced will run for ____ year(s) from the date of repair or replacement.

Our point of contact for warranty response is [Name, Phone Number, Email and Back-up POC]. *Required

Sincerely,

Signature: ____________________________
Print Name: ____________________________
Title: ________________________________
Date: _____________________

*Required

Exceptional service in the national interest

Sandia National Laboratories

Section 03 30 00 – Cast-in-Place Concrete

March 2018

Effective Date: 03/05/2018
Review Date: 03/05/2021

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 03 30 00 – Cast-in-Place Concrete

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
2/28/18	Tim Peterson	Admin	3-year review performed; Sentence was added to Section 3.1B; 2.8B rewritten to make clearer

Section 03 30 00 – Cast-in-Place Concrete

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes, for the following:

1. Footings
2. Foundation walls
3. Slabs-on-grade
4. Suspended slabs

B. Related Sections:

1. Section 31 20 00 “Earthwork”
2. Section 07 92 00 “Joint Sealants
3. Section 04 22 00 “Concrete Unit Masonry”
4. Section 05 50 00 “Metal Fabrications”
5. Section 01065 “ESH for Construction Contracts”

1.3 Definitions

A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.

1.4 Action Submittals

A. Product Data: For each type of product indicated.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

2. Product Data for Credit IEQ 4.3: For liquid floor treatments and curing and sealing compounds, documentation including printed statement of volatile organic compound (VOC) content.

3. Design Mixtures for Credit ID 1.1: For each concrete mixture containing fly ash as a replacement for portland cement or other portland cement replacements, and for equivalent concrete mixtures that do not contain portland cement replacements.

C. Design Mixtures: For each concrete mixture.

1. Indicate amounts of mixing water to be withheld for later addition at Project site.

D. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.

E. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer detailing fabrication, assembly, and support of formwork. Retain subparagraph below if shoring and reshoring are required.

1. Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and reshoring installation and removal.

F. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.

1. Location of construction joints is subject to approval of the Sandia Delegated Representative (SDR).

G. Samples: For Vapor Barriers, Polyethylene sheeting conforming to ASTM E 1745, Class A, not less than 15 mil thickness. Vapor Barriers Stego Industries, “Stego Wrap (15 mil) Vapor Barrier” or Fortifiber Building Systems Group “Moiststop Ultra 15.”

1.5 Informational Submittals

A. Qualification Data: For installer and manufacturer.

B. Welding certificates, PQR and WPS.

C. Material Certificates: For each of the following, signed by manufacturers:

1. Cementitious materials
2. Admixtures
3. Form materials and form-release agents
4. Steel reinforcement and accessories
5. Fiber reinforcement
6. Waterstops
7. Curing compounds
8. Floor and slab treatments
9. Bonding agents
10. Adhesives
11. Vapor retarders
12. Semirigid joint filler
13. Joint-filler strips
14. Repair materials
15. Manufacturer's installation instructions
16. Embeds and Anchors

D. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:

1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.
2. Reinforcing certified mill test reports.

E. If required or as indicated, floor surface flatness and levelness measurements indicating compliance with specified tolerances.

F. Field quality-control reports.

G. Minutes of preinstallation conference.

H. Manufacturer's installation instructions.

1.6 Quality Assurance

A. Installer Qualifications: A qualified installer who employs on Project personnel qualified to produce workmanship of specified quality.

B. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to National Ready Mixed Concrete Association's "Certification of Ready Mixed Concrete Production Facilities."

C. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

D. Welding Qualifications: Qualify procedures and personnel according to AWS D1.4/D 1.4M, "Structural Welding Code - Reinforcing Steel."

E. American Concrete Institute (ACI) Publications: Comply with the following unless modified by requirements in the Contract Documents:

1. ACI 301-10, "Specifications for Structural Concrete"
2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials"
3. ACI 347-04, "Guide to Formwork for Concrete"
4. ACI 302.2R-06, "Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials"
5. ACI 302.1R-04, "Guide for Concrete Floor and Slab Construction"
6. ACI 336.1, "Specification for the construction of Drilled Piers"

F. Concrete Testing Service: Sandia National Laboratories (SNL) will employ qualified independent testing agency to perform material evaluation tests.

G. Mockups: Cast concrete slab-on-grade and formed-surface panels to demonstrate typical joints, surface finish, texture, tolerances, floor treatments, and standard of workmanship.

1. Build panel approximately 200 sq. ft. (18.6 sq. m) for slab-on-grade and 100 sq. ft. (9.3 sq. m) for formed surface in the location indicated or, if not indicated, as directed by the SDR.

2. Approved mockups may become part of the completed Work if undisturbed at time of substantial completion.

H. Preinstallation Conference: Conduct conference at Project site for major concrete projects.

1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
   a. Contractor's superintendent.
   b. Independent testing agency responsible for concrete design mixtures.
   c. Ready-mix concrete manufacturer.
   d. Concrete subcontractor.
   e. Special concrete finish subcontractor.

2. Review special inspection and testing and inspecting agency procedures for field quality control, concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction contraction and isolation joints, joint-filler strips, semirigid joint fillers, forms and form removal limitations, shoring and reshoring procedures, vapor-retarder installation, anchor rod and anchorage device installation tolerances, steel reinforcement installation, floor and slab flatness and levelness measurement, concrete repair procedures, and concrete protection.

1.7 Delivery, Storage, and Handling

A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. Avoid damaging coatings on steel reinforcement.

B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

PART 2 - Products

2.1 Form-Facing Materials

A. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.

1. Plywood, metal, or other approved panel materials.

2. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
   a. High-density overlay, Class 1 or better.
   b. Medium-density overlay, Class 1 or better; mill-release agent treated and edge sealed.

c. Structural 1, B-B or better; mill oiled and edge sealed.
d. B-B (Concrete Form), Class 1 or better; mill oiled and edge sealed.

B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.

C. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that will produce surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.

D. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.

E. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.

F. Chamfer Strips: Wood, metal, Polyvinyl Chloride (PVC), or rubber strips, 3/4 by 3/4 inch (19 by 19 mm), minimum.

G. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.

H. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

I. Form Ties: Factory-fabricated, removable or snap-off metal form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

1. Furnish units that will leave no corrodible metal closer than 1 inch (25 mm) to the plane of exposed concrete surface.

2. Furnish ties that, when removed, will leave holes no larger than 1 inch (25 mm) in diameter in concrete surface.

3. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

2.2 Steel Reinforcement

A. Reinforcing Bars:

1. ASTM A 615/A 615M, Grade 60 bars deformed. No. 3 to 18, except as otherwise indicated.

2. ASTM A 615/615M, Grade 40 deformed bars. No. 3 to 4 for stirrups and ties.

B. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.

C. Plain-Steel Wire: ASTM A 82/A 82M, as drawn galvanized.

D. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, plain, fabricated from as-drawn steel wire into flat sheets.

2.3 Reinforcement Accessories

A. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.

B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to Concrete Reinforcing Steel Institute’s (CRSI's) "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

1. For concrete surfaces exposed to view where legs of wire bar support contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.

2. For concrete-on-grade, use supports with sand plates or horizontal runners if base material will not adequately support chair legs.

3. Use wire bar type supports complying with CRSI recommendations, unless otherwise indicated. Do not use wood, brick, stone, broken block, or pieces of concrete.

C. Shop fabricate reinforcing bars to conform to required shapes and dimensions, with fabrication tolerances complying with ACI 315-04. In case of fabricating errors, do not rebend or straighten reinforcement in manner that will injure or weaken material.

D. Unacceptable Materials: Defective reinforcement shall not be permitted in work:

1. Bar lengths, depths and bends exceeding specified fabrication tolerances.

2. Bends or kinks not indicated on contract drawings or final shop drawings.

3. Bars with reduced cross section due to excessive rusting or other cause.

2.4 Concrete Materials

A. Portland Cement: ASTM C150 Types I-II and III, “Low-Alkali” cement, unless otherwise specified. Use one brand of cement throughout project unless otherwise acceptable to the SDR.

B. Aggregates: ASTM C33 provide aggregates from single source for exposed concrete. Do not use sandstone aggregates.

1. Fine Aggregate: Clean, sharp, natural sand free from loam, clay lumps, or other deleterious substances. Do not use dune, bank run, or manufactured sand.

2. Coarse Aggregate: Clean, uncoated, processed aggregate containing no clay, mud, loam, or foreign matter, as follows:
   a. Crushed stone, processed from natural rock or stone.
   b. Natural or crushed gravel. Do not use pit or bank run gravel.

3. Maximum Aggregate Size: Not larger than one-fifth (1/5) of the most narrow dimension between side or forms, one-third (1/3) of the depth of slabs, or three-fourths (3/4) of the minimum clear spacing between individual reinforcing bars or bundles of bars. If workability and consolidation methods indicate concrete can be placed without honeycomb or voids, limitations may be waived if approved by SDR.

C. Water: Potable, clean, fresh, free from oil, acid, organic matter, or other deleterious substances.

D. Fly Ash: ASTM C618, Class F; use one brand of fly ash throughout project unless otherwise acceptable to the SDR.

2.5 Admixtures

A. Air-Entraining Admixture: ASTM C 260.

B. Water-Reducing Admixture: ASTM C494, Type A.

C. High Range Water-Reducing Admixture: ASTM C494 type F -

D. Water-Reducing, High Range Admixtures and Retarding Admixtures, Type

E. Water-Reducing, Retarding Admixture: ASTM C494, Type D

F. Water-Reducing and Accelerating Admixtures, Type E.

G. Plasticizing and Retarding Admixture: ASTM C1017, Type I and II

H. Color Pigment: ASTM C979, synthetic mineral oxide pigments or colored water-reducing admixtures; color stable, nonfading, and resistant to lime and other alkalis.

I. Chloride-containing admixtures are not permitted.

2.6 Fiber Reinforcement

A. Fiber Reinforcement: ASTM C1116 for Synthetic Micro-Fiber. ASTM A 820 for Carbon-Steel Fiber.

2.7 Waterstops

A. Provide waterstops at construction joints and other joints of type and size shown on drawings.

1. Provide either rubber or PVC waterstops, at Contractor's option, with rubber units complying with Corps of Engineers CRD-C513 and PVC units complying with CRD-C572. Configuration of waterstop shall be as shown on the drawings.

2.8 Vapor Retarders

A. Sheet Vapor Retarder: Provide under slabs on grade that are scheduled to receive resilient flooring materials.

1. Polyethylene sheeting conforming to ASTM E 1745, Class A, not less than 15 mil nominal thickness.

2. Products: Stego Industries, “Stego Wrap (15 mil) Vapor barrier” or Fortifiber Building Systems Group Moiststop Ultra 15″. Include manufacturer's recommended adhesive or pressure-sensitive tape.

B. Substitutions: Request for substitutions must be in writing. Approval of shop drawings, product data, or samples containing substitutions is not an approval of a substitution unless an item is clearly presented as a substitution at the time of submittal.

C. Granular Fill: Clean mixture of crushed stone or crushed or uncrushed gravel; ASTM D 448, Size 57, with 100 percent passing a 1-1/2-inch (37.5-mm) sieve and 0 to 5 percent passing a No. 8 (2.36-mm) sieve.

D. Fine-Graded Granular Material: Clean mixture of crushed stone, crushed gravel, and manufactured or natural sand; ASTM D 448, Size 10, with 100 percent passing a 3/8-inch (9.5-mm) sieve, 10 to 30 percent passing a No. 100 (0.15-mm) sieve, and at least 5 percent passing No. 200 (0.075-mm) sieve; complying with deleterious substance limits of ASTM C 33 for fine aggregates.

2.9 Floor and Slab Treatments

A. Slip-Resistive Emery Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive, crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.

B. Slip-Resistive Aluminum Granule Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of not less than 95 percent fused aluminum-oxide granules.

C. See Emery Dry-Shake Floor Hardener: Pigmented or unpigmented factory-packaged, dry combination of Portland cement, graded emery aggregate, and plasticizing admixture; with emery aggregate consisting of no less than 60 percent of total aggregate content.

1. Color: As selected by Project Architect.

D. Metallic Dry-Shake Floor Hardener: Pigmented or unpigmented, factory-packaged, dry combination of Portland cement, graded metallic aggregate, rust inhibitors, and plasticizing admixture; with metallic aggregate consisting of no less than 65 percent of total aggregate content.

1. Color: As selected by project architect.

2.10 Liquid Floor Treatments

A. VOC Content: Liquid floor treatments shall have a VOC content of 200 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or siliconate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces.

2.11 Curing Materials

A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) when dry.

C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

D. Water: Potable.

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

F. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, nondissipating, certified by curing compound manufacturer to not interfere with bonding of floor covering.

1. VOC Content: Curing and sealing compounds shall have a VOC content of 200 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.12 Related Materials

A. Expansion Joint-materials: ASTM D 1751, asphalt-saturated cellulosic fiber.

B. Hydraulic Structure Joints: ASTM D1752, preformed expansion joint fillers as specified on the Contract Documents.

C. Typical Building and Concrete Paved Roadway Joints: ASTM D994, preformed strips of a bituminous mastic composition.

D. Non-Shrink Grout: ASTM C1107, factory pre-mixed, non-metallic grout.

E. Bonding Compound: Polyvinyl acetate, rewettable type.

2.13 Concrete Mix Design

A. General: Provide "Ready-Mixed" concrete, unless otherwise approved or specified; in accordance with ASTM C94.

1. Compressive Strength

a. Structural concrete: Minimum 3000 psi (20.7 MPa) compressive strength shall be developed within 28 days as specified on the construction drawings.

b. Duct banks: Minimum 2500 psi (17 MPa) compressive strength at 28 days.

c. Site Concrete: Minimum 4000 psi (27.6 MPa) compressive strength at 28 days.

2. Select water-to-cementitious materials ratio required to produce 28-day strength corresponding to over designed mix, which is supported by sufficient experience data to assure that test results will fall within limits established in specification. Unless otherwise specified, the following proportions apply:

Strength psi	Min. Cement Bag/CY	Max. W/(C+FA)* Ratio Non-Air-Entrained	Max. W/(C+FA)* Ratio Air-Entrained
3000 (20.7 MPa)	5.0	0.60	0.58
4000 (27.6 MPa)	6.0	0.52	0.47

* W/(C+FA) = Water to cementitious material, cement plus fly ash by weight.

3. Slump due to water content alone (without the addition of super plasticizer) shall be as follows:

Allowable Slump	Min-Max (inch)
Reinforced foundation walls and footings	1-3 (25-76 mm)
Unreinforced footings, caissons and substructure walls	1-3 (25-76 mm)
Reinforced slabs, beams, and walls	1-4 (25-102 mm)
Building columns	2-3 (51-76 mm)
slabs-on-ground	2-4 (51-102 mm)
Sidewalks, driveways, curbs, and gutters	2-4 (51-102 mm)

After the addition of super plasticizers, slumps may range from 3 to 11 inches (76 mm to 279 mm) provided that the concrete mix is cohesive and non-segregating and has controlled time of set and minimal bleed water.

B. Aggregate: ASTM C33:

1. Coarse Aggregate: ASTM C33, Table 2, Grading Requirements for Coarse Aggregates.

2. Fine Aggregate: ASTM C33, Section 5.1 Sieve Analysis, Fine Aggregate.

C. Admixtures

1. Use water-reducing admixture or high range water-reducing admixture (super plasticizer) in concrete, as required, for placement and workability.

2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slab, concrete required to be water tight, and concrete with a water-cement ratio below 0.50.

4. Use air-entraining admixture in exterior exposed concrete, unless otherwise indicated. Use air content of 3.5 to 7.5 percent.

5. When air-entraining admixture is used solely for increasing workability of mix, use air content of 3 to 5 percent.

6. Fly Ash: Fly ash shall be used in all concrete mixes. Class F fly ash shall be proportioned by weight of cement to provide fly ash to Portland cement ratio not less than 20 percent, or greater than 25 percent of the sum of total weight of fly ash and cement.

D. High early strength concrete shall have compressive strength at 7 days equal to that specified for ordinary concrete at 28 days.

2.14 Plant, Equipment, Machines, and Tools

A. General: Plant, equipment, machines, and tools used in the work shall be subject to approval and shall be maintained in a satisfactory working condition at all times.

B. Soft-Cut Saw: Designed and shown to be able to cut concrete shortly after final set without causing raveling or other untoward effect upon the concrete finish. Provide diamond blade with thickness no greater than 1/8 inch (3.18 mm) to soft-cut joint of size indicated.

2.15 Fabricating Reinforcement

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.16 Concrete Mixing

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and ASTM C 1116/C 1116M, and furnish batch ticket information.

1. When air temperature is between 85 and 90 degrees F (30 and 32 degrees C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 degrees F (32 degrees C), reduce mixing and delivery time to 60 minutes.

PART 3 - Execution

3.1 Formwork

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.

B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

1. All foundations should be formed unless indicated otherwise.

C. Limit concrete surface irregularities, designated by ACI 347 as abrupt or gradual, as follows:

1. Class A, 1/8 inch (3.2 mm) measured 5 feet in any direction for smooth-formed finished surfaces.

2. Class B, 1/4 inch (6 mm), Class C, 1/2 inch (13 mm), Class D, 1 inch (25 mm) measured 5 feet in any direction for rough-formed finished surfaces.

D. Construct forms tight enough to prevent loss of concrete mortar.

E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.

1. Install keyways, reglets, recesses, and the like, for easy removal.

2. Do not use rust-stained steel form-facing material.

F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

H. Chamfer exterior corners and edges of permanently exposed concrete unless otherwise indicated in the contract drawings.

I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.2 Embedded Items

A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of American Institute of Steel Construction's "Code of Standard Practice for Steel Buildings and Bridges."

2. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.

3. Install dovetail anchor slots in concrete structures as indicated.

3.3 Removing and Reusing Forms

A. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 degrees F (10 degrees C) for 24 hours after placing concrete. Concrete has to be hard enough not to be damaged by form-removal operations, and curing and protection operations need to be maintained.

1. Leave formwork for beam soffits, joists, slabs, and other structural elements that support weight of concrete in place until concrete has achieved at least 70 percent of its 28-day design compressive strength.

2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.

C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by the SDR.

3.4 Shores and Reshores

A. Comply with ACI 318 (ACI 318M) and ACI 301 for design, installation, and removal of shoring and reshoring.

1. Do not remove shoring or reshoring until measurement of slab tolerances is complete.

B. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.

C. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

3.5 Vapor Retarders

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E 1643 and manufacturer's written instructions.

1. Lap joints 6 inches (150 mm) and seal with manufacturer's recommended tape or as recommended by the manufacturer.

3.6 Steel Reinforcement

A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.

   1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.

   1. Weld reinforcing bars according to AWS D1.4/D 1.4M, where indicated.

D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

E. Install welded wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.

F. Field bending and heating of reinforcement requires Engineer’s approval.

3.7 Joints

A. Construction Joints: Locate construction joints on slab on grade or structure, which are not shown on contract drawings, as approved by the Project Engineer.

   1. Provide keyways at least 1-1/2 inches (38.1 mm) deep in construction joints in walls and between walls and footings; accepted preformed keyways designed for this purpose may be used for slabs.

   2. Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints as approved by the Project Engineer.

B. Isolation Joints: Construct isolation joints in slabs-on-ground at points of contact between slabs on ground and foundations as shown on contract drawings.

C. Contraction (Control) Joints

   1. Contraction Joints in Slabs-on-Grade: Construct contraction joints in slabs-on-grade to form panels or patterns as shown. Use saw cuts 1/8 inch (3.18

mm) wide by one-fourth of slab depth, or inserts 1/4 inch (6.32 mm) wide by one-fourth of slab depth, unless otherwise indicated.

a. Form contraction joints by inserting premolded plastic, hardboard, or fiberboard strip into fresh concrete until top surface of strip is flush with slab surface. Tool slab edges round on each side of insert. Remove inserts and clean groove of loose debris after concrete has cured.
b. Form contraction joints in unexposed floor slabs by saw cuts as soon as possible after slab finishing as may be safely done without dislodging aggregate. Contraction joints formed by soft-cut saw shall be made no greater than eight hours (8 hrs.) after placement of concrete.
c. If joint pattern is not indicated in contract drawings, provide joints at intervals not exceeding 30 times the slab thickness in either direction, and located to conform to bay spacing wherever possible (at column centerlines, half bays, third bays).

D. Expansion Joints

1. Slabs-on-Ground: Expansion joint material shall be placed around utility access openings within the slab, including clean outs and utility valves, and between new concrete slab and adjacent masonry.

a. Provide premolded, asphalt impregnated joint material 1/2 inch (12.7 mm) thick.
b. Extend joint material to full depth of concrete.

3.8 Waterstop:

A. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.

B. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated, according to manufacturer's written instructions, adhesive bonding, mechanically fastening and firmly pressing into place. Install in longest lengths practicable.

3.9 Concrete Placement

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Do not add water to concrete during delivery, at project site, or during placement unless approved by the SDR.

C. Before test sampling and placing concrete, water may be added at project site, subject to limitations of ACI 301.

1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

D. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.

1. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.

2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.

3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

E. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.

2. Maintain reinforcement in position on chairs during concrete placement.

3. Screed slab surfaces with a straightedge and strike off to correct elevations.

4. Slope surfaces uniformly to drains where required.

5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

F. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When average high and low temperature is expected to fall below 40 degrees F (4.4 degrees C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.

2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

G. Hot-Weather Placement: Comply with ACI 301 and as follows:

1. Maintain concrete temperature below 90 degrees F (32 degrees C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

H. Placing Concrete in Forms: Concrete shall not be allowed to free fall more than 5 feet (1.5 m) unless confined by a closed chute. Concrete placed in walls 10 inches (254 mm) or less in thickness may free fall maximum of 8 feet (2.4 m).

I. Drilled Pier concrete placement shall comply with ACI 336.1-01.

3.10 Finishing Formed Surfaces

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces not exposed to public view.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces exposed to public view, to receive a rubbed finish, to be covered with a coating or covering material applied directly to concrete.

C. Rubbed Finish: Apply rubbed finishes as required by ACI 301-10.

D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

E. Unspecified Finish: If the finish is not designated in the contract documents, the following finishes shall be applicable:

1. Rough Form Finish: For all concrete surfaces not exposed to view.

2. Smooth Form Finish: For all concrete surfaces exposed to view.

3.11 Finishing Floors and Slabs

A. General: Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture.

1. Apply float finish to surfaces and concrete roof decks indicated to receive trowel finish and to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or as indicated on the contract drawings.

C. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.

1. Apply a trowel finish to surfaces indicated exposed to view or to be covered with resilient flooring, carpet, ceramic, or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.

2. Finish surfaces to the following tolerances, according to ASTM E 1155 (ASTM E 1155M), for a randomly trafficked floor surface:
   a. Specified overall values of flatness, F(F) 25; and of levelness, F(L) 20; with minimum local values of flatness, F(F) 17; and of levelness, F(L) 15 for non-critical areas.
   b. Specified overall values of flatness, F(F) 35; and of levelness, F(L) 25; with minimum local values of flatness, F(F) 24; and of levelness, F(L) 17; for slabs-on-grade.
   c. Specified overall values of flatness, F(F) 30; and of levelness, F(L) 20; with minimum local values of flatness, F(F) 24; and of levelness, F(L) 15; for suspended slabs.

3. Finish and measure surface so gap at any point between concrete surface and an unleveled, freestanding, 10-ft.- (3.05-m-) long straightedge resting on two high spots and placed anywhere on the surface does not exceed ¼ inch (4.7 mm).

D. Trowel and Fine-Broom Finish: Apply a first trowel finish to surfaces indicated where ceramic or quarry tile is to be installed by either thickset or thin-set method. While concrete is still plastic, slightly scarify surface with a fine broom.

1. Comply with flatness and levelness tolerances for trowel-finished floor surfaces.

E. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and elsewhere as indicated.

1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with the SDR before application.

F. Slip-Resistive Finish: Before final floating, apply slip-resistive aggregate or aluminum granule finish where indicated to concrete stair treads, platforms, and ramps. Apply according to manufacturer's written instructions and as follows:

1. Uniformly spread 25 lb./100 sq. ft. (12 kg/10 sq. m) of dampened slip-resistive aggregate or aluminum granules over surface in one or two applications. Tamp aggregate flush with surface, but do not force below surface.

2. After broadcasting and tamping, apply float finish.

3. After curing, lightly work surface with a steel wire brush or an abrasive stone and water to expose slip-resistive aggregate or aluminum granules.

G. Dry-Shake Floor Hardener Finish: After initial floating, apply dry-shake floor hardener to surfaces indicated according to manufacturer's written instructions and as follows:

1. Uniformly apply dry-shake floor hardener at a rate of 100 lb. /100 sq. ft. (49 kg/10 sq. m) unless greater amount is recommended by manufacturer.

2. Uniformly distribute approximately two-thirds of dry-shake floor hardener over surface by hand or with mechanical spreader, and embed by power floating. Follow power floating with a second dry-shake floor hardener application, uniformly distributing remainder of material, and embed by power floating.

3. After final floating, apply a trowel finish. Cure concrete with curing compound recommended by dry-shake floor hardener manufacturer and apply immediately after final finishing.

3.12 Miscellaneous Concrete Items

A. Filling In: Fill in holes and openings left in concrete structures after work of other trades is in place unless otherwise indicated. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates from manufacturer furnishing machines and equipment.

D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in inserts and accessories as shown on drawings. Screed and trowel finish concrete surfaces.

3.13 Concrete Protecting and Curing

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.

B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb./sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.

D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.

E. Cure concrete according to ACI 308.1, by one or a combination of the following methods:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

   a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.

b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies will not interfere with bonding of floor covering used on project.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

   a. Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer, unless manufacturer certifies curing compound will not interfere with bonding of floor covering used on Project.

4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

3.14 Concrete Surface Repairs

A. Defective Concrete: Remove and replace concrete that cannot be repaired and patched to the project engineer’s approval.

B. Patching Mortar: Mix dry-pack patching mortar, consisting of one part Portland cement to two and one-half parts fine aggregate passing a No. 16 (1.18-mm) sieve, using only enough water for handling and placing.

C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins, and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.

1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch (13 mm) in any dimension to solid concrete. Limit cut depth to 3/4 inch (19 mm). Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.

2. Repair defects on surfaces exposed to view per product manufacturer’s recommendation. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by the project engineer.

D. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing, and cracks in excess of 0.01 inch (0.25 mm) wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width and other objectionable conditions.

2. After concrete has cured at least 14 days, correct high areas by grinding.

3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.

4. Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.

5. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch (6 mm) to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane and level surface.

6. Repair defective areas, except random cracks and single holes 1 inch (25 mm) or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch (19-mm) clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.

7. Repair random cracks and single holes 1 inch (25 mm) or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

E. Perform structural repairs of concrete, subject to structural engineer’s approval, using epoxy adhesive and patching mortar.

F. Repair materials and installation not specified above may be used, subject to SDR approval.

G. Floor and Wall repairs requiring jackhammering shall be saw-cut to allow for neat transition and tie-in. Reinforcing will be added to match existing, doweled, and epoxied to 3 inches in depth with corner bars to minimize cracking unless otherwise indicated in the drawings. Any projections above the floor subgrade shall be cut and/or removed.

3.15 Field Quality Control

A. Inspections:

1. Steel reinforcement placement.

2. Headed bolts and studs.

3. Verification of use of required design mixture.

4. Concrete placement, including conveying and depositing.

5. Curing procedures and maintenance of curing temperature.

6. Verification of concrete strength before removal of shores and forms from beams and slabs.

B. Testing and Inspecting: SNL will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

1. Steel reinforcement welding.

C. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd. (4 cu. m), but less than 25 cu. yd. (19 cu. m), plus one set for each additional 50 cu. yd. (38 cu. m) or fraction thereof. Structure concrete at discretion of inspector.

2. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. (76 cu. m) or fraction thereof of each concrete mixture placed each day.

3. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

4. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.

5. Air Content: ASTM C 231, pressure method, for normal-weight concrete; ASTM C 173/C 173M, volumetric method, for structural lightweight

concrete; **one** test for each composite sample, but not less than one test for each day's pour of each concrete mixture.

6. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 degrees F (4.4 degrees C) and below and when 80 degrees F (27 degrees C) and above, and one test for each composite sample.

7. Unit Weight: ASTM C 567, fresh unit weight of structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.

8. Compression Test Specimens: ASTM C 31/C 31M.

   a. Cast and laboratory cure two sets of two standard cylinder specimens for each composite sample.
   b. Cast and field cure two sets of two standard cylinder specimens for each composite sample.

9. Coordinate the number of compression test specimens in subparagraph above with number of compressive-strength tests in first subparagraph below.

10. Compressive-Strength Tests: ASTM C 39/C 39M; test one set of two laboratory-cured specimens at 7 days and one set of three specimens at 28 days.

    a. Test one set of two field-cured specimens at 7 days and one set of three specimens at 28 days.
    b. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.

11. Retain first subparagraph below if field-cured specimens are required.

12. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.

13. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).

14. Test results shall be reported in writing to the SDR, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

15. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by the SDR but will not be used as sole basis for approval or rejection of concrete.

16. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by the SDR. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by the SDR

17. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

18. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the contract documents.

D. Measure floor and slab flatness and levelness according to ASTM E 1155 (ASTM E 1155M) within 72 hours of finishing.

3.16 Protection OF Liquid Floor Treatments

A. Protect liquid floor treatment from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by liquid floor treatments installer.

END OF SECTION 03 30 00

Exceptional service in the national interest

Sandia National Laboratories

Section 05 12 00 – Structural Steel Framing

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Section 05 12 00 – Structural Steel Framing

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
8/7/17	Tim Peterson	Admin	Three-year review cycle; added Steel Fabricator bullet to Section 2.6 Shop Connections; removed bullet in Section 1.5 Action Sub-mittals

Section 05 12 00 – Structural Steel Framing

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section Includes:

1. Structural steel
2. Prefabricated building columns
3. Grout
4. Primer
5. Anchor bolts
6. Bolted connections

B. Related Sections:

1. Section 05 40 00 "Cold Formed Metal Framing" for light-gauge, load-bearing metal framing.
2. Section 05 31 00 "Steel Decking" for field installation of shear connectors through deck.
3. Section 05 50 00 "Metal Fabrications" for steel lintels and shelf angles not attached to structural-steel, frame miscellaneous steel fabrications, and other metal items not defined as structural steel.
4. Section 09 90 00 "Painting."

1.3 Definitions

A. Structural Steel: Elements of structural-steel frame, as classified by AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

B. Seismic-Load-Resisting System: Elements of structural-steel frame designated as "SLRS" or along grid lines designated as "SLRS" on Drawings, including columns, beams, and braces and their connections.

C. Heavy Sections: Rolled and built-up sections as follows:

1. Shapes included in ASTM A 6/A 6M with flanges thicker than 1-1/2 inches (38 mm).
2. Welded built-up members with plates thicker than 2 inches (50 mm).
3. Column base plates thicker than 2 inches (50 mm).

D. Protected Zone: Structural members or portions of structural members indicated as “Protected Zone” on Drawings. Connections of structural and nonstructural elements to protected zones are limited.

E. Demand Critical Welds: Those welds, the failure of which would result in significant degradation of the strength and stiffness of the Seismic-Load-Resisting System and which are indicated as “Demand Critical” or “Seismic Critical” on Drawings.

1.4 Performance Requirements

A. Connections: Provide details of connections required by the Contract Documents to be selected or completed by structural-steel fabricator, including comprehensive engineering analysis by a qualified professional engineer, to withstand loads indicated and comply with other information and restrictions indicated.

B. Moment Connections: Type PR, partially restrained. FR, fully restrained as indicated on the drawings.

C. Construction: Moment frame, braced frame, shear wall system or combined system of moment frame, braced frame, and shear walls as indicated on the drawings.

1.5 Action Submittals

A. Product Data: For each type of product indicated.

B. Leadership in Energy and Environmental Design® (LEED) Submittals:

1. Product Data for Credit Materials & Resources (MR) 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.
2. Laboratory Test Reports for Credit Indoor Environmental Quality (IEQ) 4: For primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services’ “Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers.”

C. Shop Drawings: Show fabrication of structural-steel components.

1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
2. Indicate welds by standard American Welding Society (AWS) symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.
3. Indicate type, size, and length of bolts. Identify pretensioned and slip-critical high-strength bolted connections.
4. Identify members and connections of the seismic-load-resisting system.
5. Indicate locations and dimensions of protected zones.
6. Identify demand critical welds.

7. For structural-steel connections indicated to comply with design loads, include structural analysis data.

D. Welding Procedure Specifications (WPSs) and Procedure Qualification Records (PQRs): Provide according to AWS D1.1/D1.1M, "Structural Welding Code – Steel," for each welding process whether prequalified or qualified by testing, including the following:

1. Electrode manufacturer and trade name, for demand critical welds.

1.6 Informational Submittals

A. Qualification Data: For qualified Installer, fabricator**.**

B. Welding certificates.

C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

D. Mill test reports for structural steel, including chemical and physical properties.

E. Product Test Reports: For the following:

1. Bolts, nuts, and washers including mechanical properties and chemical analysis.
2. Direct-tension indicators.
3. Tension-control, high-strength bolt-nut-washer assemblies.
4. Shear stud connectors.
5. Shop primers.
6. Nonshrink grout.

F. Source quality-control reports.

1.7 Quality Assurance

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code – Steel."

1. Welders and welding operators performing work on bottom-flange, demand-critical welds shall pass the supplemental welder qualification testing, as required by AWS D1.8. FCAW-S and FCAW-G shall be considered separate processes for welding personnel qualification.

B. Comply with applicable provisions of the following specifications and documents:

1. AISC 303.
2. AISC 341 and AISC 341s1.
3. AISC 360.
4. Research Council on Structural Connections' (RCSC's) "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

C. Preinstallation Conference: Conduct conference prior to structural steel fabrication.

1.8 Delivery, Storage, and Handling

A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.

1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.

B. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.

1. Fasteners may be repackaged provided Owner's testing and inspecting agency observes repackaging and seals containers.
2. Clean and relubricate bolts and nuts that become dry or rusty before use.
3. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F 1852 fasteners and for retesting fasteners after lubrication.

1.9 Coordination

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work.

PART 2 - Products

2.1 Structural Steel Materials

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent. Attempt to achieve higher recycled content.

B. W-Shapes: ASTM A 992/A 992M Grade 50

C. Channels, Angles ASTM A 36/A 36M

D. Plate and Bar: ASTM A 36/A 36M

E. Corrosion-Resisting Structural-Steel Shapes, Plates, and Bars: ASTM A 588/A 588M, Grade 50.

F. Cold-Formed Hollow Structural Sections: ASTM A 500, Grade B structural tubing.

G. Corrosion-Resisting Cold-Formed Hollow Structural Sections: ASTM A 847/A 847M, structural tubing.

H. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade B.

1. Weight Class: As indicated on the drawings.
2. Finish: Black, except where indicated to be galvanized.

I. Welding Electrodes: Comply with AWS requirements.

2.2 Bolts, Connectors, and Anchors

A. Non-High-Strength Bolts, nuts, and Washers: ASTM 307, Grade A carbon-steel, hex-head bolts; carbon-steel nuts; and flat, unhardened steel washers.

1. Finish: hot-dip zinc coating, ASTM A 153, class C.

B. High-Strength Bolts, Nuts, and Washers: ASTM A 325 (ASTM A 325M), Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade C (ASTM A 563M, Class 8S) heavy-hex carbon-steel nuts; and ASTM F 436 (ASTM F 436M), Type 1, hardened carbon-steel washers; all with plain finish.

1. Direct-Tension Indicators: ASTM F 959, Type 325 (ASTM F 959M, Type 8.8), compressible-washer type with plain finish.

2. Finish: Hot-dip zinc coating, ASTM A 153, class C.

C. High-Strength Bolts, Nuts, and Washers: ASTM A 490 (ASTM A 490M), Type 1, heavy-hex steel structural bolts or tension-control, bolt-nut-washer assemblies with splined ends; ASTM A 563, Grade DH (ASTM A 563M, Class 10S) heavy-hex carbon-steel nuts; and ASTM F 436 (ASTM F 436M), Type 1, hardened carbon-steel washers with plain finish.

1. Direct-Tension Indicators: ASTM F 959, Type 490 (ASTM F 959M, Type 10.9), compressible-washer type with plain finish.

D. Zinc-Coated High-Strength Bolts, Nuts, and Washers: ASTM A 325 (ASTM A 325M), Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade DH (ASTM A 563M, Class 10S) heavy-hex carbon-steel nuts; and ASTM F 436 (ASTM F 436M), Type 1, hardened carbon-steel washers.

1. Finish: Hot-dip zinc coating.
2. Direct-Tension Indicators: ASTM F 959, Type 325 (ASTM F 959M, compressible-washer type as required).

E. Shear Connectors: ASTM A 108, Grades 1015 through 1020, headed-stud type, cold-finished carbon steel; AWS D1.1/D1.1M, Type B.

F. Unheaded Anchor Rods: ASTM A 572/A 572M, Grade 50.

G. Headed Anchor Rods: ASTM F 1554, Grade 55, weldable straight.

H. Threaded Rods: A 572/A 572M, Grade 50

I. Clevises and Turnbuckles: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1035.

J. Eye Bolts and Nuts: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1030.

K. Sleeve Nuts: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1018.

2.3 Primer

A. Low-Emitting Materials: Paints and coatings shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Primer: Comply with Section 09 90 00 "Painting."

C. Primer: Fabricator's standard lead- and chromate-free, nonasphaltic, rust-inhibiting prier complying with MPI#79 and compatible with topcoat.

D. Galvanizing Repair Paint: SSPC Paint 20, ASTM A 780.

2.4 Grout

A. Metallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, metallic aggregate grout, mixed with water to consistency suitable for application and a 30-minute working time.

B. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.5 Fabrication

A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to American Institute of Steel Construction's (AISC's) "Code of Standard Practice for Steel Buildings and Bridges" and AISC 360.

1. Camber structural-steel members where indicated.
2. Fabricate beams with rolling camber up.
3. Identify high-strength structural steel according to ASTM A 6/A 6M and maintain markings until structural steel has been erected.
4. Mark and match-mark materials for field assembly.
5. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.

B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.

1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1/D1.1M.

C. Bolt Holes: Drill or punch standard bolt holes perpendicular to metal surfaces.

D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.

E. Cleaning: Clean and prepare steel surfaces that are to remain unpainted according to SSPCSP 1, “Solvent Cleaning,” SSPC SP 2, “Hand Tool Cleaning,” SSPC-SP 3, “Power Tool Cleaning.”

F. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer’s written instructions.

G. Steel Wall-Opening Framing: Select true and straight members for fabricating steel wall-opening framing to be attached to structural steel. Straighten as required to provide uniform, square, and true members in completed wall framing.

H. Welded Door Frames: Build up welded door frames attached to structural steel. Weld exposed joints continuously and grind smooth. Plug-weld fixed steel bar stops to frames. Secure removable stops to frames with countersunk machine screws, uniformly spaced not more than 10 inches (250 mm) off center unless otherwise indicated.

I. Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel framing members.

1. Drill or punch holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning.
2. Baseplate Holes: Drill or punch holes perpendicular to steel surfaces.
3. Weld threaded nuts to framing and other specialty items indicated to receive other work.

2.6 Shop Connections

A. High-Strength Bolts: Shop install high-strength bolts according to RCSC’s “Specification for Structural Joints Using ASTM A 325 or A 490 Bolts” for type of bolt and type of joint specified.

1. Joint Type: Snug tightened unless indicated as Pretensioned or Slip critical connection.

B. Weld Connections: Comply with AWS D1.1/D1.1M and AWS D1.8/D1.8M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

1. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances in AISC 303 for mill material.

C. Fabricator Quality Procedures: Fabricator to provide welders quality control procedure for production with qualified shop welders. Include WPS.

1. Shop welders will be required to weld within the specified parameters of the applicable WPS.

2.7 Shop Priming

A. Shop prime steel surfaces except the following:

1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches (50 mm).
2. Surfaces to be field welded.
3. Surfaces to be high-strength bolted with slip-critical connections.
4. Surfaces to receive sprayed fire-resistive materials (applied fireproofing).
5. Galvanized surfaces.

B. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:

1. SSPC-SP 2, "Hand Tool Cleaning."
2. SSPC-SP 3, "Power Tool Cleaning."
3. SSPC-SP 7/NACE No. 4, "Brush-Off Blast Cleaning."
4. SSPC-SP 11, "Power Tool Cleaning to Bare Metal."
5. Cleaning in first subparagraph below exceeds SSPC-SP 7/NACE No. 4 but is less than cleaning specified in SSPC-SP 6/NACE No. 3.
6. SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning."
7. Cleaning in subparagraph below requires complete removal of rust and mill scale by acid, duplex, or electrolytic pickling. Pickling is not widely available.

C. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5 mils (0.038 mm). Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

2.8 Galvanizing

A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A 123/A 123M.

2.9 Source Quality Control

A. Testing Agency: Sandia National Laboratories (SNL) will engage an independent testing and inspecting agency to perform shop tests and inspections and prepare test reports.

1. Provide testing agency with access to places where structural-steel work is being fabricated or produced to perform tests and inspections.

B. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

C. Bolted Connections: Shop-bolted connections will be tested and inspected according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

D. Welded Connections: In addition to visual inspection, shop-welded connections will be tested and inspected according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:

1. Liquid Penetrant Inspection: ASTM E 165.
2. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
3. Ultrasonic Inspection: ASTM E 164.
4. Radiographic Inspection: ASTM E 94.

E. In addition to visual inspection, shop-welded shear connectors will be tested and inspected according to requirements in AWS D1.1/D1.1M for stud welding and as follows:

1. Bend tests will be performed if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
2. Tests will be conducted on additional shear connectors if weld fracture occurs on shear connectors already tested, according to requirements in AWS D1.1/D1.1M.

PART 3 - Execution

3.1 Examination

A. Verify, with steel Erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedment's for compliance with requirements.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Preparation

A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.

3.3 Erection

A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.

B. Base Bearing and Leveling Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.

1. Set plates for structural members on wedges, shims, or setting nuts as required.
2. Weld plate washers to top of baseplate.

3. Tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
4. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage resistant grouts.

C. Maintain erection tolerances of structural steel within AISC's "Code of Standard Practice for Steel Buildings and Bridges."

1. Maintain erection tolerances of architecturally exposed structural steel within AISC's "Code of Standard practice for Steel Buildings and Bridges."

D. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

1. Level and plumb individual members of structure.
2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.

E. Splice members only where indicated.

F. Do not use thermal cutting during erection unless approved by the Engineer. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.

G. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.

3.4 Field Connections

A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.

B. Weld Connections: Comply with AWS D1.1/D1.1M and AWS D1.8/D1.8M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
2. Remove backing bars or runoff tabs, back gouge, and grind steel smooth.
3. Assemble and weld built-up sections by methods that will maintain true alignment of axis without exceeding tolerances in AISC's "Code of Standard Practice for Steel Buildings and Bridges" for mill material.

3.5 Field Quality Control

A. Testing Agency: SNL will engage a qualified independent testing and inspecting agency to inspect field welds and high strength bolted connections and will perform the tests as indicated below.

1. The contractor will coordinate required inspections and provide access to the work for the testing agency.

B. Bolted Connections: Bolted connections will be tested and inspected according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

1. Direct-tension gaps will be verified to comply with ASTM F 959, Table 2

C. Welded Connections: Field welds will be visually inspected according to AWS D1.1/D1.1M.

1. In addition to visual inspection, field welds will be tested and inspected according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:

a. Liquid Penetrant Inspection: ASTM E 165.
b. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
c. Ultrasonic Inspection: ASTM E 164.
d. Radiographic Inspection: ASTM E 94 and ASTM E-142.

D. In addition to visual inspection, test and inspect field-welded shear connectors according to requirements in AWS D1.1/D1.1M for stud welding and as follows:

1. Perform bend tests if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
2. Conduct tests on additional shear connectors if weld fracture occurs on shear connectors already tested, according to requirements in AWS D1.1/D1.1M.

E. Correct deficiencies in Work that test reports and inspections indicate do not comply with the Contract Documents.

3.6 Repairs and Protection

A. Galvanized Surfaces: Clean areas where galvanizing is damaged or missing and repair galvanizing to comply with ASTM A 780.

B. Touchup Painting: Immediately after erection, clean exposed areas where primer is damaged or missing and paint with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

1. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.

C. Touchup Painting: Cleaning and touchup painting are specified in Section 09 90 00 "Painting."

END OF SECTION 05 12 00

Section 05 31 00 – Steel Decking

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 05 31 00 – Steel Decking

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
3/27/18	Tim Peterson	Admin	3-year review performed; no changes made

Section 05 31 00 – Steel Decking

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section Includes:

1. Roof deck.
2. Composite floor deck.
3. Noncomposite form deck.
4. Noncomposite vented form deck.

B. Related Requirements:

1. Section 03 30 00 “Cast-in-Place Concrete” for normal-weight and lightweight structural concrete fill over steel deck.
2. Section 05 12 00 “Structural Steel Framing” for shop- and field-welded shear connectors.
3. Section 05 50 00 “Metal Fabrications” for framing deck openings with miscellaneous steel shapes.
4. Section 09 90 00 “Painting.”

1.3 Action Submittals

A. Product Data: For each type of deck, accessory, and product indicated.

B. Leadership in Energy and Environmental Design (LEED) Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.
2. Laboratory Test Reports for Credit EQ 4: For primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services’ “Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers.”

C. Shop Drawings:

1. Include layout and types of deck panels, anchorage details, reinforcing channels, pans, cut deck openings, special jointing, accessories, and attachments to other construction.

1.4 Informational Submittals

A. Welding certificates: Provide welding procedures and welding personnel certifications

B. Product Certificates: For each type of steel deck. Submit manufacturer's certification that the decking complies with Steel Deck Institute (SDI) specifications.

C. Evaluation Reports: For steel deck.

D. Field quality-control reports.

1.5 Quality Assurance

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.3, "Structural Welding Code - Sheet Steel."

B. Retain "Electrical Raceway Units" paragraph below if using cellular floor-deck systems as raceways.

C. Factory Mutual (FM) Global Listing: Provide steel roof deck evaluated by FM Global and listed in its "Approval Guide, Building Materials" for Class 1 fire rating and Class 1-90 windstorm ratings.

D. Fire Rated Assemblies: Provide deck units complying with requirements of Underwriter's Laboratories, Inc. (UL) "Fire Resistance Directory" for use in any rated design indicated.

1.6 Delivery, Storage, and Handling

A. Protect steel deck from corrosion, deformation, and other damage during delivery, storage, and handling.

B. Stack steel deck on platforms or pallets and slope to provide drainage. Protect with a waterproof covering and ventilate to avoid condensation.

C. Store materials to permit easy access for inspection and identification.

D. Do not store materials on structure in a manner that might cause distortion or damage to members or supporting structures.

E. Replace damaged deck panels.

PART 2 - Products

2.1 Performance Requirements

A. American Iron and Steel Institute (AISI) Specifications: Comply with calculated structural characteristics of steel deck according to AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members."

B. Fire-Resistance Ratings: Comply with ASTM E 119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.

C. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

D. Low-Emitting Materials: Paints and coatings shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.2 Materials

A. Uncoated (Black) Sheet Steel: Deck panels shall conform to SDI Publication No. 29, and ASTM A611. See plans for type, size, and finish.

1. Minimum Yield Strength: 33 ksi (230 MPa)
2. Minimum Thickness: 0.024 in (0.71 mm), unless indicated otherwise.
3. Grade

   a. Composite Steel Deck: Grades C or D.
   b. Non-Composite Steel Deck: Grades C, D, or E.
   c. Steel Roof Deck: Grades C, D, or E

B. Galvanized Sheet Steel: Deck panels shall conform to SDI Publication No. 29, and ASTM A653 Structural Quality. See plans for type, size, and finish.

1. Minimum Yield Strength: 33 ksi (230 MPa).
2. Minimum Uncoated Thickness: 0.024 in (0.71 mm), unless indicated otherwise.
3. Galvanization: Conform to ASTM A924 (replaced ASTM A525) with a minimum coating class of G60 as defined in ASTM A653.

C. Miscellaneous Finishes

1. Shop Primer: Manufacturer's baked-on, lead-free and chromate-free, rust inhibitive primer, conforming to performance requirements of FS TT-P-664.
2. Galvanized Repair Paint: Comply with requirements of MIL P-21035B, Type I or II.

3. Concrete Topping: Unless indicated otherwise, all deck to receive concrete shall be galvanized.

2.3 Accessories

A. General: Provide manufacturer's standard accessory materials for deck that comply with requirements indicated.

B. Mechanical Fasteners: Manufacturer’s standard galvanized hardened steel, self-tapping.

C. Side-Lap Fasteners: Corrosion-resistant, hexagonal washer head; self-drilling, carbon-steel screws, No. 10 (4.8-mm) minimum diameter.

D. Flexible Closure Strips: Vulcanized, closed-cell, synthetic rubber.

E. Miscellaneous Sheet Metal Deck Accessories: Steel sheet, minimum yield strength of 33,000 psi (230 MPa), not less than 0.0359-inch (0.91-mm) design uncoated thickness, of same material and finish as deck; of profile indicated or required for application.

F. Pour Stops and Girder Fillers: Steel sheet, minimum yield strength of 33,000 psi (230 MPa), of same material and finish as deck, and of thickness and profile recommended by SDI Publication No. 31 for overhang and slab depth.

G. Column Closures, End Closures, Z-Closures, and Cover Plates: Steel sheet, of same material, finish, and thickness as deck unless otherwise indicated.

H. Piercing Hanger Tabs: Piercing steel sheet hanger attachment devices for use with floor deck.

I. Weld Washers: Uncoated steel sheet, shaped to fit deck rib, 0.0598 inch (1.52 mm) thick, with factory-punched hole of 3/8-inch (9.5-mm) minimum diameter.

J. Flat Sump Plates: Single-piece steel sheet, 0.0747 inch (1.90 mm) thick, of same material and finish as deck. For drains, cut holes in the field.

K. Recessed Sump Pans: Single-piece steel sheet, 0.0747 inch (1.90 mm) thick, of same material and finish as deck, with 3-inch- (76-mm-) wide flanges and sloped recessed pans of 1-1/2-inch (38-mm) minimum depth. For drains, cut holes in the field.

L. Galvanizing Repair Paint: SSPC-Paint 20 or MIL-P-21035B, with dry film containing a minimum of 94 percent zinc dust by weight.

M. Repair Paint: Manufacturer's standard rust-inhibitive primer of same color as primer.

2.4 Fabrication

A. General: Fabricate deck panels conforming to SDI Publication No. 29 and the requirements of this specification.

1. Deck units shall be selected to provide the load capacities as indicated on the Contract drawings, and as determined using the SDI construction loading criteria.

2. Deck shall span three or more supports, unless indicated otherwise.

B. Roof Deck Units: Provide deck panels without top-flange stiffening grooves conforming to SDI specifications, of thickness and depth as indicated on the Contract drawings.

PART 3 - Execution

3.1 Examination

A. Review all discipline drawings prior to deck installation to determine the locations of deck penetrations that will require openings. Inform the Sandia-Delegated Representative (SDR) of any openings that will require steel frames that are not shown on the structural drawings

B. All edge angles shall be in place with proper attachment prior to installation of metal deck. All roof and floor opening frames shall be installed prior to deck installation.

C. Examine field conditions and substrates to receive metal decking, and verify that existing conditions are acceptable before commencing installation.

3.2 Installation, General

A. General: Install deck units and accessories in compliance with the final shop drawings, manufacturer's recommendations, SDI specifications, and requirements of this specification.

1. Fasten deck units to supports promptly after placement and alignment.
2. Do not leave placed sheet unattached at end of working day.

B. Bearing: Install deck ends over framing supports with minimum end bearing of the following; align and level deck units.

1. Non-Steel Support: 6 inches (152 mm)
2. Steel Support: 3 inches (76 mm)

C. Placement

1. Place deck units flat and square, secure to framing without excessive warp or deflection.
2. Place deck units in straight alignment for entire length of run.
3. Place deck units to permit proper attachment to perimeter deck angle. Deck shall be fully supported at all perimeter edges.

   a. Provide steel filler fabricated of same material as perimeter deck angle in required size and shape to provide full structural support.

4. Place deck units on supporting steel framework and adjust to final position with ends accurately aligned and bearing on supporting members before being permanently fastened. Do not stretch or contract side lap interlocks.
5. Cut and neatly fit deck units and accessories around other work projecting through or adjacent to the decking, as shown.

D. End Laps: Lap ends of deck units a minimum of two inches (51 mm) over supports.

1. End laps may be staggered or on a continuous line.
2. Butt ends only where laps would be more than two (2) layers thick or otherwise unable to be lapped and weld each panel at its ends with the specified pattern.
3. Where deck slopes more than 1/2 inch per foot, start placement of deck units and ridge and valley plates at low end and lap ends shingle fashion with high side over low side.

E. Butt Ends: Butt ends of deck units at stud shear connectors.

1. Stud shear connectors may not be welded through more than one thickness of deck.
2. Tape butted ends of deck units to close gaps of 1/8 inch (3.18 mm) or less.

F. Openings: Reinforce openings greater than the width between deck flutes made by other trades, as indicated on the Contract Drawings.

1. Reinforce openings less than 15 inches (381 mm) with flat steel sheet of the same quality as the deck units, thickness of not less than 0.0358 (0.91 mm).

   a. Place steel sheet over opening and fusion weld to the top surface of the deck, in accordance with the Contract Drawings and this specification.

2. Reinforce openings greater than 15 inches (381 mm) with angles or channels of A36 steel framing around the opening to the adjacent deck supports in accordance, and adequate to support the loads that would normally be carried by the deck where the opening has occurred.

   a. Weld or mechanically fasten the deck to the frame in accordance with the Contract Drawings and this specification.

G. Provide additional metal reinforcement as shown on the Contract Drawings and as required for strength, continuity of decking and support of other work shown.

H. Install closure strips as shown on the Contract Drawings and as recommended by the manufacturer to provide a complete installation.

1. Where joist ends terminate on a shear wall and the deck does not contact the wall, provide metal closure strips from deck to the wall between the joists.

3.3 Anchorage

A. General: Fasten deck units to supporting members including perimeter support steel and/or bearing walls by either welding or by mechanical fastening, immediately after alignment. Comply with the requirements of SDI.

1. Comply with AWS D1.1 and D1.3 for requirements and procedures for welding.
2. Care shall be exercised in the selection of electrodes and amperages to provide positive welds and to prevent burn-through of the supporting members. If supporting membrane do become cut during deck welding, the Contractor shall repair or replace the member at no cost to Sandia National Laboratories (SNL).

B. Weld Spacing: Weld edge ribs of panels at each support. Space welds as follows:

1. Floor Deck: Average of 12 inches (305 mm) apart, but not more than 18 inches (457 mm).
2. Roof Deck: Maximum 12 inches (305 mm) apart.

C. Side Lap and Perimeter Edge Attachment: Fasten side laps and perimeter edges of units between supports at intervals not exceeding 36 inches (914 mm) on center by welding or mechanical fasteners.

1. Deck units with spans greater than 5 feet (1.5 m) shall have side laps and perimeter edges at perimeter support steel fastened at midspan or 36-inch (914 mm) intervals, whichever.

3.4 Field Quality Control

A. Testing Agency: A qualified testing agency will be engaged to perform tests and inspections at SNL.

B. Field welds will be subject to inspection.

C. Testing agency will report inspection results promptly and in writing to the SDR.

D. Remove and replace work that does not comply with specified requirements.

E. Additional inspecting, at Contractor's expense, will be performed to determine compliance of corrected work with specified requirements.

3.5 Cleaning and Touch Up

A. Clear debris from deck before floor or roof substrate is placed.

B. Provide cleaning and touch-up painting of field welds, abraded areas, and rust spots, as required for all exposed areas after erection and before proceeding with field painting.

END OF SECTION 05 31 00

Exceptional service in the national interest

Sandia National Laboratories

Section 05 40 00 – Cold-Formed Metal Framing

May 2019

Effective Date: 05/01/2019
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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 05 40 00 – Cold-Formed Metal Framing

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
5/1/19	Carlos Medrano	Admin	3-year review performed; deleted sentence under Section 1.3

Section 05 40 00 – Cold-Formed Metal Framing

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section includes:

1. Load-bearing wall framing
2. Exterior non-load-bearing wall framing
3. Floor joist framing
4. Roof rafter framing
5. Ceiling joist framing
6. Soffit framing.

B. Related Requirements:

1. Section 05 50 00 "Metal Fabrications" for masonry shelf angles and connections.
2. Section 09 22 16 "Non-Structural Metal Framing" for interior non-load-bearing, metal-stud framing, and ceiling-suspension assemblies.

1.3 Preinstallation Meetings

A. Preinstallation Conference: Conduct conference at project site.

1.4 Action Submittals

A. Product Data: For each type of cold-formed steel framing product and accessory.

B. Leadership in Energy and Environmental Design (LEED) Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.

C. Shop Drawings:

1. Include layout, spacing, sizes, thicknesses, and types of cold-formed steel framing; fabrication; and fastening and anchorage details, including mechanical fasteners.

2. Indicate reinforcing channels, opening framing, supplemental framing, strapping, bracing, bridging, splices, accessories, connection details, and attachment to adjoining work.

1.5 Informational Submittals

A. Welding certificates: Provide welders certificates.

B. Welding Procedures: Provide written welding procedure specification (WPS) document per American Welding Society (AWS) Code requirements.

C. Product Test Reports: For each listed product, for tests performed by manufacturer and/or witnessed by a qualified testing agency.

1. Steel sheet
2. Expansion anchors
3. Power-actuated anchors
4. Mechanical fasteners
5. Vertical deflection clips
6. Horizontal drift deflection clips
7. Miscellaneous structural clips and accessories.

D. Research Reports: For non-standard cold-formed steel framing, from International Code Council Evaluation Service (ICC-ES).

1.6 Quality Assurance

A. Product Tests: Mill certificates or data indicating steel sheet complies with requirements, including base-metal thickness, yield strength, tensile strength, total elongation, chemical requirements, and metallic-coating thickness.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.7 Delivery, Storage, and Handling

A. Deliver to project site in manufacturer's unopened containers or bundles, fully identified with name, brand, type, and grade.

B. Protect cold-formed steel framing from corrosion, moisture staining, deformation, and other damage during delivery, storage, and handling.

PART 2 - Products

2.1 Manufacturers

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include but are not limited to the following.

1. USG Industries
2. Clark Dietrich Building Systems Inc.

2.2 Performance Requirements

A. Delegated Design: Engage a qualified professional engineer to design cold-formed steel framing.

B. Structural Performance: Provide cold-formed steel framing capable of withstanding design loads indicated on the drawings.

C. Cold-Formed Steel Framing Design Standards:

1. Floor and Roof Systems: AISI S210
2. Wall Studs: AISI S211
3. Headers: AISI S212
4. Lateral Design: AISI S213
5. AISI S200 "North American Standard for Cold-Formed Steel Framing – General provisions"
6. AISI S201 "North American Standard for Cold-Formed Steel Framing – Product Standard"

D. American Iron and Steel Institute (AISI) Specifications and Standards: Unless more stringent requirements are indicated, comply with AISI S100 and AISI S200.

E. Fire-Resistance Ratings: Comply with ASTM E 119, testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Indicate design designations from Underwriters Laboratory's (UL) "Fire Resistance Directory" or from the listings of another qualified testing agency.

2.3 Cold-Formed Steel Framing, General

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of pre-consumer recycled content not less than 25 percent.

B. Steel Sheet: ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated

C. Metal Framing

1. System Components: Manufacturers' standard load-bearing steel studs and joists of type, size, shape, and gauge as indicated. With each type of metal framing required, provide manufacturer's standard steel runners (tracks), blocking, lintels, reinforcements, shoes, clip angles, fasteners, and accessories for applications indicated, as needed to provide a complete metal framing system.
2. Materials and Finishes:

   a. For 16 gauge and heavier units, fabricate metal framing components of structural quality steel sheet with a minimum yield point of 40,000 psi, ASTM A 446 Grade C.
   b. For 18 and 20-gauge units, fabricate metal framing components of commercial quality steel sheet with a minimum yield point of 33,000 psi, ASTM A 446 Grade A.
   c. Provide galvanized finish to metal framing components complying with ASTM A 525 for minimum G 60 coating.
   d. Finish of installation accessories to match that of main framing components, unless otherwise indicated.
   e. Fasteners: Provide nuts, bolts, washers, screws, and other fasteners with corrosion-resistant plated finish.
   f. Electrodes for Welding: Comply with AWS Code and as recommended by stud manufacturer.
   g. Galvanizing Repair: Where galvanized surfaces are damaged, prepare surfaces and repair in accordance with procedures specified in ASTM A 780.

2.4 Framing Accessories

A. Fabricate steel-framing accessories from steel sheet, ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated, of same grade and coating weight used for framing members.

B. Provide accessories of manufacturer's standard thickness and configuration, unless otherwise indicated, as follows:

   1. Supplementary framing
   2. Bracing, bridging, and solid blocking
   3. Web stiffeners
   4. Anchor clips
   5. End clips
   6. Foundation clips
   7. Gusset plates
   8. Stud kickers and knee braces
   9. Joist hangers and end closures
   10. Hole reinforcing plates
   11. Backer plates

C. Expansion Anchors: Fabricated from corrosion-resistant materials, with allowable load or strength design capacities calculated according to ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing per ASTM E 488 conducted by a qualified testing agency.

D. Power-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with allowable load capacities calculated in accordance with ICC-ES AC70, greater than or equal to the design load, as determined by testing per ASTM E 1190 conducted by a qualified testing agency.

E. Mechanical Fasteners: ASTM C 1513, corrosion-resistant-coated, self-drilling, self-tapping steel drill screws.

  1. Head Type: Low-profile head beneath sheathing, manufacturer's standard elsewhere.

F. Welding Electrodes: Comply with AWS standards.

2.5 Miscellaneous Materials

A. Galvanizing Repair Paint: ASTM A 780

2.6 Fabrication

A. Fabricate cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened, according to referenced AISI's specifications and standards, manufacturer's written instructions, and requirements in this Section.

  1. Fabricate framing assemblies using jigs or templates.
  2. Cut framing members by sawing or shearing; do not torch cut.
  3. Fasten cold-formed steel framing members by welding, screw fastening, pneumatic pin fastening, or riveting as standard with fabricator. Wire tying of framing members is not permitted. Do not field weld units of 20ga or lighter.

    a. Comply with AWS D1.3/D1.3M requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
    b. Locate mechanical fasteners and install according to shop drawings, with screw penetrating joined members by not less than three exposed screw threads.

  4. Fasten other materials to cold-formed steel framing by welding, bolting, pneumatic pin fastening, or screw fastening, according to shop drawings.

B. Reinforce, stiffen, and brace framing assemblies to withstand handling, delivery, and erection stresses. Lift fabricated assemblies to prevent damage or permanent distortion.

C. Fabrication Tolerances: Fabricate assemblies level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:

  1. Spacing: Space individual framing members no more than plus or minus 1/8 inch (3 mm) from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.
  2. Squareness: Fabricate each cold-formed steel framing assembly to a maximum out-of-square tolerance of 1/8 inch (3 mm).

PART 3 - Execution

3.1 Examination

A. Examine supporting substrates and abutting structural framing for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Installation, General

A. Cold-formed steel framing may be shop or field fabricated for installation, or it may be field assembled.

B. Install cold-formed steel framing according to AISI S200 and to manufacturer's written instructions unless more stringent requirements are indicated.

C. Install shop or field-fabricated, cold-formed framing and securely anchor to supporting structure.

1. Screw, bolt, or weld wall panels at horizontal and vertical junctures to produce flush, even, true-to-line joints with maximum variation in plane and true position between fabricated panels not exceeding 1/16 inch (1.6 mm).

D. Install cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened.

1. Cut framing members by sawing or shearing; do not torch cut.
2. Fasten cold-formed steel framing members by welding, screw fastening, clinch fastening, or riveting. Wire tying of framing members is not permitted.

    a. Comply with AWS D1.3/D1.3M requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
    b. Locate mechanical fasteners and install according to shop drawings, and complying with requirements for spacing, edge distances, and screw penetration.

E. Install framing members in one-piece lengths unless splice connections are indicated for track or tension members.

F. Install temporary bracing and supports to secure framing and support loads comparable in intensity to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.

G. Do not bridge building expansion joints with cold-formed steel framing. Independently frame both sides of joints.

H. Install insulation, specified in Section 07 21 00 "Thermal Insulation," in built-up exterior framing members, such as headers, sills, boxed joists, and multiple studs at openings, that are inaccessible on completion of framing work.

I. Fasten hole reinforcing plate over web penetrations that exceed size of manufacturer's approved or standard punched openings.

J. Erection Tolerances: Install cold-formed steel framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:

1. Space individual framing members no more than plus or minus 1/8 inch (3 mm) from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.

K. Runner Tracks: Install continuous tracks sized to match studs. Align tracks accurately to layout at base and tops of studs.

1. All track butt joints, abutting pieces of track shall be securely anchored to a common structural element or they shall be spliced together.

L. Wall Studs: Secure studs to top and bottom runner tracks, except where provisions for structure vertical movement is provided on drawings, by either welding or screw fastening at both inside and outside flanges.

1. Set studs plumb, except as needed for diagonal bracing or required for non-plumb walls or warped surfaces and similar requirements.
2. Where stud system abuts structural columns or walls, including masonry walls, anchor ends of stiffeners to supporting structure.
3. Axially loaded studs shall have full bearing against the inside web of top and bottom tracks. Splices in axially loaded studs are not permitted.

M. Install supplementary framing, blocking, and bracing in metal framing system wherever walls or partitions are indicated to support fixtures, equipment, services, casework, heavy trim and furnishings, and similar work requiring attachment to the wall or partition. Where type of supplementary support is not otherwise indicated, comply with stud manufacturer's recommendations.

N. Frame wall openings larger than 2'-0" square with double stud at each jamb of frame, except where more than two studs are either shown or indicated in manufacturer's instructions.

1. Install runner tracks and jack studs above door openings, and above and below wall openings.
2. Anchor tracks to jamb studs with stud shoes or by welding, and space jack studs same as full-height studs of wall.
3. Secure stud system wall opening frame in manner indicated.

O. Install horizontal bridging in all load-bearing and exterior stud wall systems, with two (2) equally spaced rows for walls less than 10 feet high and rows spaced not more than 48 inches o.c. at walls higher than 10 feet.

P. Horizontal bridging is not required for non-loadbearing interior stud walls unless noted on the drawings.

Q. Provisions for structure vertical movement shall be provided where indicated on the drawings.

R. All welds shall be touched up using zinc-rich paint

S. Installation of Joists: Install level, straight, and plumb, complete with bracing and reinforcing as indicated on drawings. Provide not less than 1-1/2-inch end bearing.

1. Reinforce ends with end clips, steel hangers, steel angle clips, steel stud section, or as otherwise recommended by joist manufacturer.
2. When required, reinforce joists at interior supports with single short length of joist section located directly over interior support, Snap-On shoe, 30 percent side-piece lapped reinforcement, or other method recommended by joist manufacturer.
3. Secure joists to interior support systems to prevent lateral movement of bottom flange.

3.3 Field Quality Control

A. Field and shop welds will be subject to testing and inspecting.

B. Remove and replace work where test results indicate that it does not comply with specified requirements.

3.4 Repairs and Protection

A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed steel framing with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.

B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and installer that ensure that cold-formed steel framing is without damage or deterioration at time of substantial completion.

END OF SECTION 05 40 00

Section 05 50 00 – Metal Fabrications

May 2019

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 05 50 00 – Metal Fabrications

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
4/30/19	Carlos Medrano and Tim Peterson	Subst	3-year review performed; ladder safety cages and metal ships' ladders removed from Section 1.2; included safety gates in Section 2.10; removed Ladder Safety Cages section

SECTION 05 50 00 – METAL FABRICATIONS

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section includes:

1. Miscellaneous framing, support, and trim
2. Framing and supports framing and supports and trim
3. Mounting brackets-and-anchorages for window-washing equipment
4. Elevator machine beams, hoist beams, and-divider beams
5. Rough hardware
6. Shelf and ledger angles
7. Metal ladders
8. Metal floor plate and supports
9. Structural-steel door frames
10. Miscellaneous steel trim including steel angle corner guards steel edgings and loading dock edge angles
11. Metal bollards
12. Abrasive metal nosings treads and thresholds
13. Loose bearing and leveling plates for applications where they are not specified in other Sections
14. Steel-framed stairs.

B. Related Sections:

1. Section 03 30 00 "Cast-in-Place Concrete" for installing anchor bolts, steel pipe sleeves, slotted-channel inserts, wedge-type inserts, and other items cast into concrete.
2. Section 04 22 00 "Concrete Unit Masonry" for installing loose lintels, anchor bolts, and other items built into unit masonry.
3. Section 05 12 00 "Structural Steel Framing."
4. Section 12 93 00 "Site Furnishings" for bicycle racks.
5. Section 09 90 00 “Painting.”

1.3 Performance Requirements

A. Delegated Design: Design ladders including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.

1. Temperature Change: 100 degrees F (67 degrees C), ambient; 160 degrees F (100 degrees C), material surfaces.

1.4 Action Submittals

A. Product Data: For the following:

1. Nonslip aggregates and nonslip-aggregate surface finishes
2. Metal nosings and treads
3. Paint products
4. Grout
5. Fasteners.

B. Leadership in Energy and Environmental Design (LEED) Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
2. Laboratory Test Reports for Credit IEQ 4: For primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Show fabrication and installation details for metal fabrications.

1. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items.

1.5 Informational Submittals

A. Mill Certificates: Signed by manufacturers of stainless-steel certifying that products furnished comply with requirements.

B. Welding certificates: Submit current welders' qualifications in accordance with AWS D1.1.

C. Welding Procedures: Provide written welding procedure specification (WPS) document per American Welding Society (AWS) Code requirements.

D. Qualification data for firm specified in 1.6.C to demonstrate their capabilities and experience

E. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.

1.6 Quality Assurance

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
3. AWS D1.6, "Structural Welding Code - Stainless Steel."

C. Fabricator Qualifications: Firm experienced in successfully producing metal fabrications similar to that shown on the drawings, with sufficient production capacity to produce required units without causing delay in the work.

D. All materials used shall be free of lead and asbestos fibers.

E. Use of damaged items is prohibited except by specific authorization of Sandia Delegated Representative (SDR) in writing.

1.7 Delivery, Storage, and Handling

A. Deliver materials to the job site in good condition and properly protected against damage to finished surfaces.

B. Storage on Site: Store materials in a location and in a manner to avoid damage. Stacking shall be done in a way which will prevent bending.

C. Store metal components and materials in a clean, dry location. Cover with waterproof paper, tarpaulin, or polyethylene sheeting in a manner that will permit circulation of air inside the cover.

D. Keep handling on-site to a minimum. Exercise care to avoid damage to finishes of material.

1.8 Project Conditions

A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

1.9 Coordination

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorages, sleeves, concrete inserts, anchor bolts, and items with integral anchors that are to be embedded in concrete or masonry.

PART 2 - Products

2.1 Metals, General

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

2.2 Ferrous Metals

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of pre-consumer recycled content not less than 25 percent.

B. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

C. Stainless-Steel Sheet, Strip, and Plate: ASTM A 240/A 240M or ASTM A 666**,** Type 304.

D. Stainless-Steel Bars and Shapes: ASTM A 276, Type 304.

E. Rolled-Steel Floor Plate: ASTM A 786/A 786M.

F. Rolled-Stainless-Steel Floor Plate: ASTM A 793.

G. Steel Tubing: ASTM A 500, cold-formed steel tubing.

H. Steel Pipe: ASTM A 53/A 53M, standard weight (Schedule 40) unless otherwise indicated.

I. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.

2.3 Nonferrous Metals

A. Aluminum Plate and Sheet: ASTM B 209 (ASTM B 209M), Alloy 6061-T6.

B. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T6.

C. Aluminum-Alloy Rolled Tread Plate: ASTM B 632/B 632M, Alloy 6061-T6.

D. Aluminum Castings: ASTM B 26/B 26M, Alloy 443.0-F.

E. Bronze Plate, Sheet, Strip, and Bars: ASTM B 36/B 36M, Alloy UNS No. C28000 (muntz metal, 60 percent copper).

F. Bronze Extrusions: ASTM B 455, Alloy UNS No. C38500 (extruded architectural bronze).

G. Bronze Castings: ASTM B 584, Alloy UNS No. C83600 (leaded red brass) or No. C84400 (leaded semi-red brass).

H. Nickel Silver Extrusions: ASTM B 151/B 151M, Alloy UNS No. C74500.

I. Nickel Silver Castings: ASTM B 584, Alloy UNS No. C97600 (20 percent leaded nickel bronze).

2.4 Fasteners

A. General: Unless otherwise indicated, provide Type 304 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required. Suspect/counterfeit bolts will not be accepted and will be replaced at contractor's expense.

1. Provide stainless-steel fasteners for fastening aluminum.
2. Provide stainless-steel fasteners for fastening stainless steel.
3. Provide stainless-steel fasteners for fastening nickel silver.
4. Provide bronze fasteners for fastening bronze.

B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6); with hex nuts, ASTM A 563 (ASTM A 563M); and, where indicated, flat washers.

C. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 325, Type 3 (ASTM A 325M, Type 3); with hex nuts, ASTM A 563, Grade C3 (ASTM A 563M, Class 8S3); and, where indicated, flat washers.

D. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, ASTM F 593 (ASTM F 738M); with hex nuts, ASTM F 594 (ASTM F 836M); and, where indicated, flat washers; Alloy Group 1 (A1) Anchor Bolts: ASTM F 1554, Grade 36, of dimensions indicated; with nuts, ASTM A 563; and, where indicated, flat washers.

1. Hot-dip galvanize or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.

E. Eyebolts: ASTM A 489.

F. Machine Screws: ASME B18.6.3 (ASME B18.6.7M).

G. Lag Screws: ASME B18.2.1 (ASME B18.2.3.8M).

H. Wood Screws: Flat head, ASME B18.6.1.

I. Plain Washers: Round, ASME B18.22.1 (ASME B18.22M).

J. Lock Washers: Helical, spring type, ASME B18.21.1 (ASME B18.21.2M).

2.5 Miscellaneous Materials

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Low-Emitting Materials: Paints and coatings shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Primers: Provide primers that comply with Section 09 90 00 "Painting."

1. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

2.6 Fabrication, General

A. Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

D. Form exposed work with accurate angles and surfaces and straight edges.

E. Weld corners and seams continuously to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.

G. Fabricate seams and other connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.

I. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

J. Allow for thermal movement resulting from the following maximum change (range) in ambient temperature in the design, fabrication, and installation of installed metal assemblies to prevent buckling, opening up of joints, and overstressing of welds and fasteners. Base design calculations on actual surface temperatures of metals due to both solar heat gain and nighttime sky heat loss.

2.7 Rough Hardware

A. Provide bent or otherwise custom fabricated bolts, plates, anchors, hangers, dowels, and other miscellaneous steel and iron shapes as required. Fabricate items to sizes, shapes, and dimensions required.

2.8 Miscellaneous Framing and Supports

A. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.

B. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.

C. Galvanize miscellaneous framing and supports where indicated.

2.9 Shelf Angles

A. Fabricate shelf angles from steel angles of sizes indicated and for attachment to concrete framing.

B. Provide wedge-type concrete inserts, complete with fasteners, for attachment of shelf angles to cast-in-place concrete.

C. Prime shelf angles located in exterior walls with specified primer.

2.10 Metal Ladders

A. General:

1. Comply with ANSI A14.3 unless otherwise indicated.
2. For elevator pit ladders, comply with ASME A17.1.

B. Steel Ladders:

1. General: Fabricate ladders for the locations shown, with dimensions, spacings, details, and anchorages as indicated. Comply with requirements of ANSI A14.3 and CFR 29 1910.27; where conflicts occur, comply with the more stringent requirements.

2. Side Rails: Continuous steel flat bars, minimum size (cross section) 2-1/2" x 3/8" (63.5 mm x 9.5 mm), with eased edges, spaced 18 inches (0.46 m) apart.

   a. For ladders subject to unusually corrosive atmospheric exposures, steel flat bars 2-1/2" x 1/2" (63.5 mm x 12.7 mm).

3. Bar Rungs: Round steel bars, minimum 3/4-inch (19.1 mm) diameter, spaced no greater than 12 inches (305 mm) o.c. and uniform throughout the length of the ladder.

   a. Individual metal rungs embedded in concrete, which serve as access to pits and other areas under floors, should have a minimum diameter of 1 inch (25 mm) or shall otherwise be treated to resist corrosion and rusting.

4. Fit rungs in centerline of side rails; plug weld and grind smooth on outer rail faces.

5. Climbing Safety System: Provide a ladder climbing safety system for ladders greater than 20 feet; “Miller Vi-Go Ladder Climbing safety system.”

6. Safety Gate: Provide Occupational Safety and Health Administration (OSHA) approved safety gate on 10-foot ladder or greater.

7. Support each ladder at top and bottom and at intermediate points spaced not more than 5'-0" (1.5 m) o.c. by means of welded brackets, unless otherwise indicated.

   a. Size brackets to support design dead and live loads indicated and to hold centerline of ladder rungs clear of the wall surface by not less than 7 inches (178 mm).

   b. Extend side rails 42 inches (1.1 m) above top rung and return rails to wall or structure unless other secure handholds are provided. If the adjacent structure does not extend above the top rung, goose-neck the extended rails back to the structure to provide secure ladder access.

2.11 Metal Floor Plate

A. Fabricate from steel, stainless-steel, or aluminum plate-thickness as indicated on the drawings.

B. Provide grating sections where indicated, fabricated from welded or pressure-locked steel, stainless-steel, or aluminum bar grating or extruded-aluminum plank grating as indicated on the drawings.

C. Provide steel, stainless-steel, aluminum angle supports as indicated.

D. Include steel, stainless-steel, aluminum angle stiffeners, and fixed and removable sections as indicated.

E. Provide flush steel, stainless-steel, or aluminum bar drop handles for lifting removable sections, one at each end of each section.

2.12 Structural-Steel Door Frames

A. Fabricate structural-steel door frames from steel shapes, plates, and bars of size and to dimensions indicated, fully welded together, with 5/8- by 1-1/2-inch (16-by-38-mm) steel channel stops, unless otherwise indicated. Plug-weld built-up members and continuously weld exposed joints. Secure removable stops to frame with countersunk machine screws, uniformly spaced at not more than 10 inches (250 mm) o.c. Reinforce frames and drill and tap as necessary to accept finish hardware.

1. Provide with integrally-welded steel strap anchors for securing door frames into adjoining concrete or masonry.

B. Extend bottom of frames to floor elevation indicated, with steel angle clips welded to frames for anchoring frame to floor with expansion shields and bolts.

C. Prime exterior steel frames with specified primer.

2.13 Miscellaneous Steel Trim

A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.

B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.

1. Provide with integrally-welded steel strap anchors for embedding in concrete or masonry construction.

C. Galvanize exterior miscellaneous steel trim where indicated.

D. Prime exterior miscellaneous steel trim with specified primer.

2.14 Metal Bollards

A. Fabricate pipe bollards from 4-inch (102 mm) standard black steel pipe, Schedule 40, unless otherwise indicated.

B. Prime bollards with specified primer.

2.15 Loose Bearing and Leveling Plates

A. Provide loose bearing and leveling plates for steel items bearing on masonry or concrete construction. Drill plates to receive anchor bolts and for grouting.

B. Prime plates with specified primer.

2.16 Loose Steel Lintels

A. Fabricate loose steel lintels from steel angles and shapes of size indicated for openings and recesses in masonry walls and partitions at locations indicated. Fabricate in single lengths for each opening unless otherwise indicated. Weld adjoining members together to form a single unit where indicated.

B. Size loose lintels to provide bearing length at each side of openings equal to 1/12 of clear span but not less than 8 inches (200 mm), unless otherwise indicated.

C. Prime loose steel lintels located in exterior walls with specified primer.

2.17 Steel Weld Plates and Angles

A. Provide steel weld plates and angles not specified in other Sections for items supported from concrete construction as needed to complete the Work. Provide each unit with no fewer than two integrally welded steel strap anchors for embedding in concrete.

2.18 Finishes, General

A. Comply with National Association of Architectural Metal Manufacturer's (NAAMM) "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Finish metal fabrications after assembly.

C. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.

2.19 Steel and Iron Finishes

A. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A 153/A 153M for steel and iron hardware and with ASTM A 123/A 123M for other steel and iron products.

1. Do not quench or apply post-galvanizing treatments that might interfere with paint adhesion.

B. Shop prime iron and steel items not indicated to be galvanized unless they are to be embedded in concrete, sprayed-on fireproofing, or masonry, or unless otherwise indicated.

1. Shop prime with primers specified in Section 09 90 00 "Painting" as indicated.

C. Preparation for Shop Priming: Prepare surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning or," SSPC-SP 3, "Power Tool Cleaning" requirements indicated below:

1. Exterior Items: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
2. Other Items: SSPC-SP 3, "Power Tool Cleaning."

D. Painting: Immediately after surface preparation, apply structural steel primer paint in accordance with manufacturer's instructions and at a rate to provide dry film thickness of not less than 3.0 mils (0.076 mm). Use painting methods that result in full coverage of joints, corners, edges, and exposed surfaces.

1. Apply two coats of paint to surfaces that are inaccessible after assembly or erection.

2.20 Aluminum Finishes

A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

B. As-Fabricated Finish: AA-M10 (Mechanical Finish: as fabricated, unspecified).

2.21 Steel Framed Stairs

A. General: Construct stairs to conform to sizes and arrangements indicated with welded connections, unless otherwise indicated. Provide complete stair assemblies, including metal framing, hangers, columns, railings, newels, balusters, struts, clips, brackets, bearing plates, and other components necessary for the support of stairs and platforms, and as required to anchor and contain the stairs on the supporting structure.

1. Fabricate treads and platforms of exterior stairs to accommodate slopes to drain in finished traffic surfaces.

B. Stair Framing: Fabricate stringers of structural steel channels, or plates, or a combination thereof, as indicated. Provide closures for exposed ends of stringers. Construct platforms of structural steel channel headers and miscellaneous framing members as indicated. Bolt or weld headers to stringers, newels, and framing members to stringers and headers; fabricate and join so that bolts, if used, do not appear on finish surfaces.

C. Metal Pan Risers, Subtreads, and Subplatforms: Shape metal pans for risers and subtreads to conform to configuration shown. Provide thickness of structural steel sheet for metal pans as indicated.

1. Form metal pans of uncoated cold-rolled steel sheet, unless otherwise indicated.
2. Form metal pans of galvanized steel sheet, where indicated on the drawings.
3. Attach risers and subtreads to stringers by the following methods:
   a. Directly weld risers and subtreads to stringers; locate welds on side of metal pans to be concealed by concrete fill.
   b. Attach by means of brackets made of steel angles or bars. Weld brackets to stringers and attach metal pans to brackets by welding or bolting.
4. Provide subplatforms of configuration and construction shown, with thickness of structural steel sheet as indicated. Attach subplatform to platform framing members with welds or as otherwise indicated.
   a. Construct subplatforms with smooth soffits.

D. Steel Floor Plate Treads and Platforms: Provide raised pattern steel floor plate in pattern indicated or, if not indicated, as selected from manufacturer's standard patterns.

1. Form treads of 1/4-inch (6.4 mm) thick raised pattern steel floor plate with integral nosing and back edge stiffener. Weld steel supporting brackets to stringers and treads to brackets.
2. Fabricate platforms of raised pattern steel floor plate of thickness indicated. Provide nosing matching that on treads at all landings. Secure to platform framing members with welds.

E. Floor Grating Treads and Platforms: Provide patterns, spacing, and bar sizes indicated; fabricate to comply with NAAMM MBG 531.

1. Finish to be shop prime paint, unless otherwise indicated.
2. Fabricate grating treads with steel plate nosing on one edge and with steel angle or steel plate carrier at each end for stringer connections. Secure treads to stringers with bolts or as otherwise indicated.
3. Fabricate grating platforms, with nosing matching that on grating treads, at all landings. Provide toe plates at open-sided edges of grating platform. Secure grating to platform frame with welds or as otherwise indicated.

F. Stair Guardrails and Handrails: Comply with applicable requirements specified elsewhere in this section for steel pipe guardrails and handrails, and as follows:

1. Fabricate newels of steel tubing and provide newel caps of gray-iron castings, as shown.
2. Railings may be bent at corners, rail returns, and wall returns, instead of using prefabricated fittings.
3. Connect railing posts to stair framing by direct welding, unless otherwise indicated.

PART 3 - Execution

3.1 Examination

A. Examine the areas and conditions under which metal fabrication items are to be installed. Notify the SDR in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer and SDR.

3.2 Installation, General

A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.

Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

C. Field Welding: Comply with AWS Code for procedures of manual shielded metal-arch welding, appearance and quality of welds made, methods used in correcting welding work, and the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.

E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

F. Grout: Follow manufacturer's recommendations for substrate preparation and application.

3.3 Installing Miscellaneous Framing and Supports

A. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on shop drawings.

B. Anchor supports for operable partitions securely to and rigidly brace from building structure.

C. Support steel girders on solid grouted masonry, concrete, or steel pipe columns. Secure girders with anchor bolts embedded in grouted masonry or concrete or with bolts through top plates of pipe columns.

1. Where grout space under bearing plates is indicated for girders supported on concrete or masonry, install as specified in "Installing Bearing and Leveling Plates" article.

D. Install pipe columns on concrete footings with grouted baseplates. Position and grout column baseplates as specified in "Installing Bearing and Leveling Plates" article.

1. Grout baseplates of columns supporting steel girders after girders are installed and leveled.

3.4 Installing Metal Bollards

A. General: Install bollards at locations shown on drawings. After installation, fill pipe with concrete and provide a smooth convex curve at the top of the pipe.

1. Do not fill removable bollards with concrete.

3.5 Installing Nosings, Treads, and Thresholds

A. Center nosings on tread widths unless otherwise indicated.

B. For nosings embedded in concrete steps or curbs, align nosings flush with riser faces and level with tread surfaces.

C. Seal thresholds exposed to exterior with elastomeric sealant complying with Section 07 92 00 "Joint Sealants" to provide a watertight installation.

3.6 Installing Bearing and Leveling Plates

A. Clean concrete and masonry bearing surfaces of bond-reducing materials and roughen to improve bond to surfaces. Clean bottom surface of plates.

B. Set bearing and leveling plates on wedges, shims, or leveling nuts. After bearing members have been positioned and plumbed, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with grout.

1. Use nonshrink grout, either metallic or nonmetallic, in concealed locations where not exposed to moisture; use nonshrink, nonmetallic grout in exposed locations unless otherwise indicated.
2. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

3.7 Adjusting and Cleaning

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

1. Apply by brush or spray to provide a minimum 3.0-mil (0.076-mm) dry film thickness.

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780

END OF SECTION 05 50 00

Exceptional service in the national interest

Sandia National Laboratories

Section 09 90 00 – Painting

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 09 90 00 – Painting

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Freeman Leaming	Subst	Updated for 2004 formatting.
8/15/17	Tim Peterson	Subst	Added LEED language; formatting and copy editing
12/15/17	Daniel Garcia	Admin	Changed verbiage in Section 3.8/B/4

SECTION 09 90 00 – Painting

Part 1 – General

1.1 Summary

A. This section includes surface preparation, painting, and finishing of exposed interior and exterior items and surfaces, including touch-up painting on prefinished items. Surface preparation, priming, and finish coats specified in this section are in addition to shop-priming and surface treatment specified under other sections.

1. Painting includes field painting of exposed bare and covered pipes and ducts (including color coding), hangers, exposed steel and iron supports, and surfaces of mechanical and electrical equipment that do not have a factory finish applied.

B. Definition: The term "paint" as used herein includes emulsions, primers, enamels, stains, varnishes, sealers, cement-emulsion filler, and other coatings, whether used as prime, intermediate, or finish coat. Standard coating terms defined in ASTM D 16 apply to this section.

C. Surfaces to Be Painted

1. Paint all exposed surfaces whether or not colors are designated in articles 3.6 and 3.7, except where surface or material is specifically indicated not to be painted or to remain natural.
2. Where an item or surface is not specifically mentioned, paint the same as similar adjacent materials or surfaces.
3. If color or finish is not designated, the Sandia-Delegated Representative (SDR) will select from standard colors or finishes available.
4. Surfaces listed in articles 3.6, 3.7, and 3.8, other than those listed in sub-articles 1.1 D and E, will receive the surface preparation, paints, and number of coats prescribed in the schedule.
5. Existing work shall be painted where specified.
6. Electrical items to be painted include conduit, fittings, cabinets, panels, enclosures, junction and pull boxes, hangers, and other associated electrical items which are in "Public Spaces" and are therefore visible to the building occupants. Painting shall not obscure manufacturer's labels or additional nameplates, nor conduit color banding, nor other identification.
7. Mechanical items to be painted include but are not limited to:

   a. Exposed piping, vessels, and equipment rooms shall be color-coated per Part 3.
   b. Exposed piping, ductwork, and hangers and supports in occupied areas shall be painted to match adjacent surfaces.
   c. Exterior piping, uninsulated ductwork, and equipment shall be painted to match the building exterior.
   d. It is preferred that exterior equipment be factory finished with a color that blends with the building colors. Provide available color samples with equipment submittals.

D. Surfaces Not Requiring Painting

1. Prefinished items including the following factory-finished components:

   a. Metal toilet enclosures, unless otherwise specified
   b. Acoustic materials
   c. Architectural woodwork and casework
   d. Finished mechanical and electrical equipment
   e. Switchgear
   f. Distribution cabinets
   g. Metal roofing
   h. Galvanized components of prefabricated metal buildings
   i. Factory painted mechanical equipment with approved finishes.

2. Concealed surfaces including wall or ceiling surfaces in unfinished spaces.

   a. Foundation spaces
   b. Duct shafts
   c. Elevator shafts

3. Factory finished surfaces such as:

   a. Anodized aluminum
   b. Stainless steel
   c. Chromium plate
   d. Glass
   e. Bronze and brass

4. Operating parts including moving parts of operating equipment such as the following:

   a. Valve and damper operators
   b. Linkages
   c. Sensing devices
   d. Motor and fan shafts
   e. Regulators, controls, instruments

5. Electrical conduit, boxes, panels, and other associated electrical equipment located in mechanical or electrical equipment rooms, above ceilings, in chases, in basements, or in other locations where they are not normally visible to the building occupants, unless otherwise specified.

E. Surfaces for which painting is prohibited:

1. Sprinkler heads
2. Heat and smoke detectors
3. Pre-painted electrical equipment in equipment rooms including Lighting Inverters, Variable Frequency Controllers, Motor Control Centerss, Switchboards, Fire Alarm, and Facility Control System (FCS) panels. (<u>Exception</u>—To touch up existing paint damaged during installation or other construction).
4. Conduit color banding or other identification
5. Equipment in hazardous (classified) locations
6. Labels: Do not paint over Underwriter's Laboratories, Factory Mutual, or other code-required labels or equipment name, identification, performance rating, or nomenclature plates.

7. Concealed auto-releasing sprinkler head covers (i.e., escutcheon plates).
8. Glass, brass, or chrome-plated portions of fire protection system control valves (i.e., post indicator valves, gate valves) hydrants and fire department connections. (Reference NFPA 13 and Section 21 13 13, "Automatic Sprinkler and Water Based Fire Protection Systems.")

1.2 References

A. American Society of Testing and Materials (ASTM)

1. D 16 Standard Terminology for Paint, Related Coatings, Materials, and Applications

B. National Fire Protection Association (NFPA)

1. NFPA 13 Standard for the Installation of Sprinkler Systems

C. Code of Federal Regulations (CFR)

1. Title 29 Part 1910 Labor – Occupational Safety and Health Standards
2. Title 29 Part 1926 Safety and Health Regulations for Construction

D. Green Seal (GS)

1. GS-11 Paints

1.3 Submittals

A. The following shall be submitted in accordance with Section 01 33 00, "Submittal Procedures":

1. Product Data: Manufacturer's catalog data, label analysis, volatile organic compound (VOC) content, and application instructions for each material proposed for use.

   a. List the VOC content of each product.
   b. List each material and cross-reference the specific coating and finish system and application. Identify each material by the manufacturer's catalog number and general classification.
   c. Samples for initial color selection shall be in the form of manufacturer's color charts.

2. For Projects designated as Leadership in Energy and Environmental Design® (LEED) v4 by the SDR:

   a. Provide submittals in accordance with 01350 1.6.D LEED Documentation Submittals.

3. Qualification Data: For applicator.
4. Samples: For each color specified, apply a complete liquid glaze coating system to representative samples of the actual substrate to be used in the work and submit for approval. The approved sample panels will be used for quality control in applying the glaze coating system.

a. Provide a list of material and application for each coat of each sample. Label each sample as to location and application.
b. Submit samples on the following substrates for the SDR's review of color and texture only:

(1) Concrete: Provide two 4 inch x 4 inch samples for each color and finish.
(2) Concrete Masonry: Provide two 4 inch x 8 inch samples of masonry, with mortar joint in the center, for each color and finish.
(3) Gypsum Board: Provide one 6 inch x 6 inch sample of each color and finish.
(4) Painted Wood: Provide two 6 inch x 6 inch samples of each color and material on hardboard.
(5) Stained or Natural Wood: Provide two 4 inch x 8 inch samples of natural and stained wood finish on the actual wood surfaces.
(6) Ferrous Metal: Provide two 4 inch x 4 inch samples of flat metal and two 8 inch long samples of solid metal for each color and finish.

1.4 Quality Assurance

A. Single-Source Responsibility: Provide primers and undercoat paint produced by the same manufacturer of the finish coats.

B. Coordination of Work: Review other sections in which primers are provided to ensure compatibility of the total coating systems for various substrates. On request, furnish information on characteristics of finish materials to ensure use of compatible primers.

1. Notify the SDR of problems anticipated using the materials specified.

C. Material Quality: Provide the manufacturer's best quality trade sale paint material of the various coating types specified. Paint material containers not displaying manufacturer's product identification are not acceptable.

1. Proprietary names used to designate colors or materials are not intended to imply that products named are required, or to exclude equal products of other manufacturers.

D. Applicator Qualification: A firm or individual experienced in applying paints and coatings similar in material, design, and extent to those indicated for this project, whose work has resulted in applications with a record of successful in-service performance.

1.5 Delivery, Storage, and Handling

A. Deliver materials to the job site in the manufacturer's original, unopened packages and containers bearing manufacturer's name, label, and the following information:

1. Product name or title of material
2. Product description (generic classification or binder type)
3. Manufacturer's stock number and date of manufacture
4. Contents by volume, for pigment and vehicle constituents
5. Thinning instructions
6. Application instructions
7. Color name and number
8. VOC content

B. Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 45°F. Store all flammable materials not in use in Underwriter's Laboratories, Inc., NFPA, or other approved flammable storage cabinets. Reference OSHA 29 CFR 1926 if storage of combustible or flammable liquids exceeds 25 gallons. Maintain containers and cabinets used for storage in a clean condition, free of foreign materials and residue.

1. Protect from freezing. Keep storage area neat and orderly. Remove oily rags and waste daily. Take necessary measures to ensure that workers and work areas are protected from fire and health hazards resulting from handling, mixing, and application.

1.6 Project Conditions

A. Apply water-based paints only when the temperature of surfaces to be painted and surrounding air temperatures are between 50°F and 90°F.

B. Apply solvent-thinned paints only when the temperature of surfaces to be painted and surrounding air temperatures are between 45°F and 95°F.

C. Do not apply paint in snow, rain, fog, or mist, when the relative humidity exceeds 85 percent, at temperatures less than 5°F above the dew point, or to damp or wet surfaces.

1. Painting may continue during inclement weather if surfaces and areas to be painted are enclosed and heated within temperature and humidity limits specified by the manufacturer during application and drying periods.

Part 2 – Products

2.1 Materials

A. The following compounds shall not be used in paints or primers on any Sandia National Laboratories (SNL) projects:

1. Prohibited organic compounds

a.	Methylene chloride	k.	Di-n-butyl phthalate
b.	1,1,1-Trichloroethane	l.	Di-noctyl phthalate
c.	Benzene	m.	Diethyl phthalate
d.	Toluene (methylbenzene)	n.	Dimethyl phthalate
e.	Ethylbenzene	o.	Isophorone
f.	Vinyl chloride	p.	Formaldehyde
g.	Naphthalene	q.	Methyl ethyl ketone
h.	1,2-Dichlorobenzene	r.	Methyl isobutyl ketone
i.	Di (2-ethylhexyl) phthalate	s.	Acrolein
j.	Butyl benzyl phthalate	t.	Acrylonitrile

2. Prohibited metals (including their oxides)

a.	Antimony	d.	Lead

b. Cadmium
c. Hexavalent chromium
e. Mercury

B. For Projects designated as LEED v4 by SDR:

1. Provide submittals as required by Table "Submittal Requirement for LEED v4 Material & Resources Credits."
2. Provide submittals as required by Table "Submittal Requirement for LEED v4 Indoor Environmental Quality Credits."

2.2 Manufacturers

A. Basis-of-Design Product: Subject to compliance with requirements, provide Sherwin-Williams Company products indicated or comparable product from one of the manufacturers listed below. Subject to compliance with requirements, manufacturers offering products that may be incorporated in the work include but are not limited to the following:

1. Wellborn, a Dunn Edwards Company (W)
2. Benjamin Moore and Co. (BM)
3. Sherwin-Williams Company (S-W)
4. Visions Recycling, Inc. (VRI)
5. Kwal Paint (KW)

2.3 Masonry Block Filler

A. High-Performance Latex Block Filler: Heavy-duty latex block fillers used for filling open, textured interior and exterior concrete masonry block before application of top coats.

B. Block filler used under high-performance polyamide epoxy coatings.

2.4 Primers/Sealers

A. Interior Latex Enamel: To be used as under-coat for smooth cementitious surfaces and bare wood.

1. VOC content shall comply with GS-11, or not exceed 150 grams per liter (g/L)

B. Interior Latex-Based White Primer: Latex-based primer coating to be used on interior gypsum drywall under a flat latex paint or a semi-gloss latex enamel.

C. Exterior Primer Coating: Exterior alkyd wood primer used for priming wood under alkyd enamels.

D. Rust-Inhibiting Primer: Quick-drying, rust-inhibiting primer used for priming ferrous metal on the exterior under high-gloss enamel and on the interior under enamel.

E. Galvanized Metal Primer: Primer used to prime interior and exterior zinc-coated (galvanized) metal surfaces.

F. Pigmented Sealer: Pigmented sealers over concrete used under high performance polyamide epoxy coatings.

2.5 Exterior Finish Paint Material

A. Exterior Acrylic: Quick-drying, flat, acrylic paint used on the exterior over concrete, stucco, and masonry (including concrete masonry block).

1. VOC content shall comply with GS-11, or not exceed 100 g/L.

B. Alkyd Enamel: Weather-resistant, air-drying, semi-gloss enamel used on the exterior over prime-coated wood, and over primed ferrous metal surfaces.

1. VOC content shall comply with GS-11, or not exceed 200 g/L.

2.6 Interior Finish Paint Material

A. Interior Semi-Gloss Latex Enamel: Semi-gloss, latex enamel used over a primer on concrete, masonry (including concrete masonry block), wood and hardboard, ferrous and zinc-coated (galvanized) metal surfaces, and over a primer on gypsum drywall.

1. VOC content shall comply with GS-11, or not exceed 150 g/L.

B. Latex-Based, Interior Flat Paint: Ready-mixed, latex-based paint used as a “size” on cotton or canvas covering over insulation.

1. VOC content shall comply with GS-11, or not exceed 50 g/L.

C. High-Performance Polyamide Epoxy Coating: High-gloss coating used over concrete and concrete masonry.

1. VOC content shall comply with GS-11, or not exceed 200 g/L.

2.7 Miscellaneous Wood Finishing materials

A. Solvent Thinned Interior Wood Stain: Slow-penetrating solvent thinned wood stain for general use on interior wood surfaces under clear finishes.

B. Sanding Sealer: Manufacturer’s recommended sanding sealer, compatible with catalyzed polyurethane finish coat.

Sand Paper: 220 grit.

Part 3 – Execution

3.1 Examination

A. Examine substrates and conditions under which painting will be performed for compliance with requirements for application of paint. Do not begin paint application until unsatisfactory conditions have been corrected. Start of painting will be construed as applicator's acceptance of surfaces and conditions within a particular area.

3.2 Preparation

A. General Procedures: Remove hardware and hardware accessories, plates, machined surfaces, lighting fixtures, and similar items in places that are not to be painted, or provide surface-applied protection prior to surface preparation and painting. Remove these items if necessary for complete painting of the items and adjacent surfaces. Clean surfaces before applying paint or surface treatments. Remove oil and grease prior to cleaning. Schedule cleaning and painting so that dust and other contaminants from the cleaning process will not fall on wet, newly-painted surfaces. Following completion of painting operations in each space or area, items shall be reinstalled in the same manner that they were removed.

B. Surface Preparation: Clean and prepare surfaces to be painted in accordance with the manufacturer's instructions for each particular substrate condition and as specified. Provide barrier coats over incompatible primers or remove and reprime. Notify SDR in writing when problems are anticipated in using the specified finish-coat material with substrates primed by others.

C. Cementitious Materials: Prepare concrete, concrete masonry block, and stucco to be painted. Remove efflorescence, chalk, dust, dirt, grease, oils, and release agents. Roughen as required to remove glaze. If hardeners or sealers have been used to improve curing, use mechanical methods of surface preparation.

1. Use abrasive blast-cleaning methods if recommended by the paint manufacturer.
2. Determine alkalinity and moisture content of surfaces by performing appropriate tests. Pay special attention to concrete masonry unit mortar joints and patched concrete surfaces. If surfaces are sufficiently alkaline to cause blistering and burning of finish paint, correct this condition before application. Do not paint surfaces where moisture content of surface to be painted exceeds that permitted in manufacturer's printed directions.
3. Clean concrete floors to be painted with a 5 percent solution of muriatic acid or other etching cleaner. Flush the floor with clean water to remove acid, neutralize with ammonia, and rinse; allow to dry and vacuum before painting.

D. Wood Materials: Clean surfaces of dirt, oil, and other foreign substances with scrapers, mineral spirits, and sandpaper. Sand smooth surfaces exposed to view and dust off.

1. Scrape and clean small, dry, seasoned knots and apply a thin coat of white shellac or other recommended knot sealer before application of primer.
2. Prime, stain, or seal wood to be painted immediately upon delivery. Prime edges, ends, faces, undersides, and backsides of wood, including cabinets, counters, cases, and paneling. After priming, fill holes and imperfections in finish surfaces with putty or plastic wood filler. Sand smooth when dried.
3. When transparent finish is required, back prime with spar varnish.
4. Back prime paneling on interior partitions where masonry, plaster, or other wet wall construction occurs on backside.
5. Seal tops, bottoms, and cutouts of unprimed wood doors with a heavy coat of varnish or sealer immediately upon delivery to jobsite.

E. Ferrous Metals: Clean non-galvanized ferrous-metal surfaces that have not been shop-coated; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with recommendations of the Steel Structures Painting Council.

1. Treat bare and sand-blasted or pickled clean metal with a metal treatment wash coat before priming.
2. Touch up bare areas and shop-applied prime coats that have been damaged. Wire-brush, clean with solvents recommended by the paint manufacturer, and touch up with the same primer as the shop coat.

F. Galvanized Surfaces: Clean galvanized surfaces with non-petroleum-based solvents so that the surface is free of oil and surface contaminants. Remove pretreatment from galvanized sheet metal fabricated from coil stock by mechanical methods.

G. Gypsum Board: Surfaces shall be dry and shall have all loose dirt and dust removed by brushing with a soft brush, rubbing with a dry cloth, or vacuum-cleaning prior to application of first-coat material. Repair blemishes, irregularities, and damaged surfaces.

H. Material Preparation: Carefully mix and prepare paint materials in accordance with the manufacturer's directions.

1. Maintain containers used in mixing and application of paint in a clean condition, free of foreign materials and residue.
2. Stir material before application to produce a mixture of uniform density; stir as required during application. Do not stir surface film into material. Remove film and, if necessary, strain material before using.
3. Use only thinners approved by the paint manufacturer, and only within recommended limits. Use odorless thinner with alkyd enamel.

3.3 Application

A. General

1. Apply paint in accordance with manufacturer's directions. Use applicators and techniques best suited for substrate and type of material being applied. Spray applications will require prior approval from the SDR.
2. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to formation of a durable paint film.
3. Surface treatments and finishes shall be as indicated in articles 3.6, 3.7, and 3.8 or as selected by SDR.
4. Provide finish coats that are compatible with primers used.
5. The number of coats and film thickness required is the same regardless of the application method. Do not apply succeeding coats until the previous coat has cured as recommended by the manufacturer. Sand between applications where sanding is required to produce an even, smooth surface in accordance with the manufacturer's directions.
6. Apply additional coats when undercoats, stains, or other conditions show through final coat of paint until paint film is of uniform finish, color, and appearance. Give special

attention to ensure that surfaces, including edges, corners, crevices, welds, and exposed fasteners, receive a dry film thickness equivalent to that of flat surfaces.

7. The term “exposed surfaces” includes areas visible when permanent or built-in fixtures, convector covers, covers for finned tube radiation, grilles, and similar components are in place. Extend coatings in these areas as required to maintain the system integrity and provide desired protection.
8. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Paint surfaces behind permanently fixed equipment or furniture with prime coat only before final installation of equipment.
9. Paint interior surfaces of ducts, where visible through registers or grilles, with a flat, non-specular black paint.
10. Paint back sides of access panels and removable or hinged covers to match exposed surfaces.
11. Finish exterior doors on tops, bottoms, and side edges same as exterior faces.
12. Sand lightly between each succeeding enamel or varnish coat.
13. Omit primer on metal surfaces that have been shop-primed and touch up painted.

B. Scheduling Painting: Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration. Allow time between successive coats to permit proper drying per manufacturer’s recommendations.

C. Minimum Coating Thickness: Apply materials at not less than the manufacturer’s recommended spreading rate. Provide a total dry film thickness of the entire system as recommended by the manufacturer or as specified, whichever is greater.

D. Mixing and Thinning: Unless otherwise recommended by the manufacturer, paints may be thinned immediately prior to application with an approved manufacturer’s thinner and used only within recommended limits when necessary to suit conditions of suface temperature, weather, and application methods. The use of thinner shall not relieve the Contractor from obtaining complete hiding, full film thickness, or required gloss. Paints of different manufacturers shall not be mixed.

E. Mechanical Work: Color-coding of mechanical piping systems is limited to those items exposed in mechanical equipment rooms and as noted on drawings. Paint shall be applied directly to the insulation and pipe on systems which are not insulated. Label pipe systems appropriately after painting. Painting of other mechanical items is limited to those exposed in mechanical equipment rooms and occupied spaces except as otherwise indicated. Use paint and color specified or other manufacturer’s equivalent. Treat pipes as ferrous metal. Ferrous Metal: Primer is not required on shop-primed items.

1. Alkyd Enamel: Two (2) finish coats over primer.

   a. Prime Coat: Primer, water-based, anti-corrosive for metal: S-W Pro Industrial Pro-Cryl Universal Primer, B66-310 Series, 5.0 to 10.0 mils wet, 2.0 to 4.0 mils dry or equivalent product
   b. Prime Coat: Shop primer specified in Section where substrate is specified
   c. Intermediate Coat: Light industrial coating, exterior, water based, and matching topcoat

d. Topcoat: Light industrial coating, exterior, water based, semi-gloss: S-W Pro Industrial Acrylic Semi-Gloss Coating, B66-650 Series, at 2.5 to 4.0 mils dry, per coat or equivalent

F. Items to be painted and color-coded include the following:

1. Chilled Water Systems: Piping, pumps, chillers, air separators, and expansion tank. SW4086 Safety Blue
2. Tower Water System: Piping and pumps. SW 4061 Hydro Blue
3. Steam and Condensate: Piping, flash tank, condensate pump. SW4084 Safety Yellow
4. Heating Hot Water System: Piping, pumps, air separator, heat exchanger, and expansion tank. SW 4083 Safety Orange
5. Compressed Air System: Piping and receiver tank. SW4026 Slate Gray
6. Fire Protection System: Piping, valves, alarms, and drains. “Fire Protection Red” (refer to article 3.8 A and B).
7. Natural Gas: SW4084 Safety Yellow
8. Domestic Cold Water: SW4071 Rainforest (dark green)
9. Domestic Hot Water: Piping, pumps, and heat exchanger. SW4069 Emerald Ice (light green)
10. Non-Potable Water: SW 4083 Safety Orange

G. Block Fillers: Apply block fillers to concrete masonry block at a rate to ensure complete coverage with pores filled. Apply at a dry film thickness of not less than that recommended by the manufacturer.

H. Prime Coats: Before application of finish coats, apply a prime coat of material as recommended by the manufacturer to material that is required to be painted or finished and has not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to assure a finish coat with no burn-through or other defects due to insufficient sealing.

I. Pigmented (Opaque) Finishes: Completely cover to provide an opaque, smooth surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections are not acceptable.

J. Transparent (Clear) Finishes: Use multiple coats to produce a glass-smooth surface film of even luster. Provide a finish free of laps, cloudiness, color irregularity, runs, brush marks, orange peel, nail holes, or other surface imperfections. Provide satin finish for final coats.

K. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or repaint work not in compliance with specified requirements.

3.4 Cleaning

A. Cleanup: At the end of each work day, completely remove empty cans, rags, tools, rubbish, and other discarded paint materials from the project site.

B. Do not clean tools, brushes, applicators, and equipment at the project site unless specifically authorized by the SDR. Do not use sinks in restrooms, janitors’ closets, or in locations where food is prepared.

C. Upon completion of painting, clean glass and paint-spattered surfaces. Remove spattered paint by washing and scraping, using care not to scratch or damage adjacent finished surfaces.

3.5 Protection

A. Protect work of other trades, whether to be painted or not, against damage by painting. Correct damage by cleaning, repairing or replacing, and repainting, as acceptable to the SDR.

B. Provide "wet paint" signs to protect newly painted finishes. Remove temporary protective wrappings provided by others for protection of their work after completion of painting operations. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.6 Exterior Paint Schedule

A. Provide the following paint systems for the various substrates indicated.

1. No primer or block filler is required on previously painted surfaces, unless specified on contract documents or where alkaline, moisture, or freeze-thaw cycles have caused blistering or peeling.

B. Concrete, Stucco, and Masonry (other than concrete masonry units):

1. Lusterless (Flat) Acrylic Finish: Two (2) coats with total dry film thickness per manufacturer's recommendations.

   a. Prime Coat: Primer sealer, latex, exterior: S-W Loxon Concrete & Masonry Primer Sealer, A24W8300, at 8.0 mils wet, 3.2 mils dry
   b. Intermediate Coat: Latex, exterior, matching topcoat
   c. Topcoat: Latex, exterior, flat: S-W A-100 Exterior Latex Flat, A6 Series, at 4.0 mils wet, 1.2 mils dry, per coat

C. Concrete Masonry Units

1. Lusterless (Flat) Acrylic Finish: Two (2) coats over block filler with total dry film thickness (filler excluded) per manufacturer's recommendations.

   a. Block Filler: Block filler, latex, interior/exterior: S-W PrepRite Block Filler, B25W25, at 75 to 125 sq. ft. per gal (1.8 to 3.1 sq. m per L)
   b. Intermediate Coat: Latex, exterior, matching topcoat
   c. Topcoat: Latex, exterior, flat: S-W A-100 Exterior Latex Flat, A6 Series, at 4.0 mils wet, 1.2 mils dry, per coat

D. Wood

1. Latex Finish: Two (2) finish coats over primer with total dry film thickness per manufacturer's recommendations.

a. Prime Coat: Primer, latex for exterior wood
b. Intermediate Coat: Latex, exterior, matching topcoat
c. Topcoat: Latex, exterior, semi-gloss: S-W Solo Acrylic Semi-Gloss, A76 Series, at 4.0 mils wet, 1.5 mils dry, per coat

E. Ferrous Metal: Primer is not required on shop-primed items.

1. Alkyd Enamel: Two (2) finish coats over primer.

a. Prime Coat: Primer, water-based, anti-corrosive for metal: S-W Pro Industrial Pro-Cryl Universal Primer, B66-310 Series, 5.0 to 10.0 mils wet, 2.0 to 4.0 mils dry
b. Prime Coat: Shop primer specified in Section where substrate is specified
c. Intermediate Coat: Light industrial coating, exterior, water based, matching topcoat
d. Topcoat: Light industrial coating, exterior, water-based, semi-gloss: S-W Pro Industrial Acrylic Semi-Gloss Coating, B66-650 Series, at 2.5 to 4.0 mils dry, per coat

F. Galvanized Metal

1. Alkyd Enamel: Two (2) finish coats over primer.

a. Prime Coat: Primer, water-based, anti-corrosive for metal: S-W Pro Industrial Pro-Cryl Universal Primer, B66-310 Series, 5.0 to 10.0 mils wet, 2.0 to 4.0 mils dry
b. Prime Coat: Shop primer specified in Section where substrate is specified
c. Intermediate Coat: Light industrial coating, exterior, water-based, matching topcoat
d. Topcoat: Light industrial coating, exterior, water based, semi-gloss: S-W Pro Industrial Acrylic Semi-Gloss Coating, B66-650 Series, at 2.5 to 4.0 mils dry, per coat

3.7 Interior Paint Schedule

A. General: Provide the following paint systems for the various substrates, as indicated.

1. No primer or block filler is required on previously painted surfaces.

B. Concrete and Masonry (other than concrete masonry units):

1. Semi-Gloss Enamel Finish: Three (3) coats with total dry film thickness per manufacturer's recommendations.

a. Prime Coat: Primer sealer, latex, interior: S-W Loxon Concrete & Masonry Primer Sealer, A24W8300, at 8.0 mils wet, 3.2 mils dry
b. Intermediate Coat: Latex, interior, matching topcoat
c. Topcoat: Latex, interior, semi-gloss: S-W ProMar 200 Zero VOC Latex Semi-Gloss, B31-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat

2. Polyamide Epoxy Coating: Two (2) coats of polyamide epoxy coating over pigmented sealer.

a. Prime Coat: Primer sealer, latex, interior: S-W Loxon Concrete & Masonry Primer Sealer, A24W8300, at 8.0 mils wet, 3.2 mils dry
b. Intermediate Coat: Light industrial coating, interior, water-based, matching topcoat
c. Topcoat: Light industrial coating, interior, water-based, semi-gloss: S-W Pro Industrial Pre-Catalyzed Water Based Epoxy, K46-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat

C. Concrete Masonry Units

1. Semi-Gloss Alkyd Enamel Finish: Two (2) coats over filled surface with total dry film thickness (filler excluded) per manufacturer's recommendations.

a. Block Filler: Block filler, latex, interior/exterior: S-W PrepRite Block Filler, B25W25, at 100 to 200 sq. ft. per gal (2.4 to 4.9 sq. m per L)
b. Intermediate Coat: Latex, interior, matching topcoat
c. Topcoat: Latex, interior, semi-gloss: S-W ProMar 200 Zero VOC Latex Semi-Gloss, B31-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat

2. Polyamide Epoxy Coating: Two (2) coats of polyamide epoxy coating over concrete masonry block filler.

a. Block Filler: Block filler, latex, interior/exterior: S-W PrepRite Block Filler, B25W25, at 100 to 200 sq. ft. per gal (2.4 to 4.9 sq. m per L)
b. Intermediate Coat: Light industrial coating, interior, water based, matching topcoat
c. Topcoat: Light industrial coating, interior, water based, semi-gloss: S-W Pro Industrial Pre-Catalyzed Water Based Epoxy, K46-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat

D. Gypsum Drywall Systems

1. Semi-Gloss Latex Enamel Finish: Three (3) coats (drywall decoration primer excluded) with total dry film thickness per manufacturer's recommendations.

a. Prime Coat: Primer, latex, interior: S-W ProMar 200 Zero VOC Latex Primer, B28W2600, at 4.0 mils wet, 1.5 mils dry
b. Intermediate Coat: Latex, interior, matching topcoat
c. Topcoat: Latex, interior, semi-gloss: S-W ProMar 200 Zero VOC Latex Semi-Gloss, B31-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat

E. Woodwork and Hardboard

1. Semi-Gloss Enamel Finish: Three (3) coats.

a. Prime Coat: Primer sealer, latex, interior: S-W PrepRite ProBlock Primer Sealer, B51-620 Series, at 4.0 mils wet, 1.4 mils dry
b. Intermediate Coat: Latex, interior, matching topcoat
c. Topcoat: Latex, interior, semi-gloss: S-W ProMar 200 Zero VOC Latex Semi-Gloss, B31-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat

F. Stained Woodwork

1. Stained, Polyurethane Finish: Premium grade, two (2) coats over stain on open-grain wood.

    a. Sanding: Sand (220 Grit)

    1st Coat: S-W WoodClassics Oil Stain, <250 VOC A49 Series (450-500 sq ft/gal)
    2nd Coat: S-W WoodClassics Waterborne Polyurethane Varnish, A68 Series
    3rd Coat: S-W WoodClassics Waterborne Polyurethane Varnish, A68 Series (400-500 sq ft/gal)

G. Natural-Finish Woodwork

1. Polyurethane Finish: Premium grade, two (2) finish coats on open-grain wood.

    a. Sanding: Sand (220 Grit)

    1st Coat: S-W WoodClassics Waterborne Polyurethane Varnish, A68 Series
    2nd Coat: S-W WoodClassics Waterborne Polyurethane Varnish, A68 Series (400-500 sq ft/gal)

H. Ferrous Metal

1. Semi-Gloss Enamel Finish: Two (2) coats over primer with total dry film thickness per manufacturer's recommendations.

    a. Prime Coat: Primer, rust-inhibitive, water based: S-W Pro Industrial Pro-Cryl Universal Primer, B66-310 Series, at 5.0 to 10 mils wet, 2.0 to 4.0 mils dry
    b. Intermediate Coat: Water-based acrylic, interior, matching topcoat
    c. Topcoat: Water-based acrylic, semi-gloss: S-W Pro Industrial Acrylic Semi-Gloss Coating, B66-650 Series, at 2.5 to 4.0 mils dry, per coat

I. Zinc-Coated Metal

1. Semi-Gloss Finish: Two (2) coats over primer, with total dry film thickness not less than 2.5 mils (0.064 mm).

    a. Prime Coat: Primer, rust-inhibitive, water based: S-W Pro Industrial Pro-Cryl Universal Primer, B66-310 Series, at 5.0 to 10 mils wet, 2.0 to 4.0 mils dry
    b. Intermediate Coat: Water-based acrylic, interior, matching topcoat
    c. Topcoat: Water-based acrylic, semi-gloss: S-W Pro Industrial Acrylic Semi-Gloss Coating, B66-650 Series, at 2.5 to 4.0 mils dry, per coat

J. Cotton or Canvas Covering over Insulation

    a. Top Coat: Dry-fall latex, flat: S-W Pro Industrial Waterborne Acrylic Dryfall Flat, B42-80 Series, at 6.0 mils wet, 1.7 mils dry

3.8 Fire Protection Painting

A. Contractor shall paint those portions of fire protection as required by SNL as follows, except as required in article 1.1, E.1-5:

B. Color Coding of Outdoor Water-Based Fire Protection System

1. Hydrants: All fire hydrants shall be painted “Traffic Yellow.” The top portion (bonnet) shall be reflective (glass beaded) paint.
2. Post Indicator Valves: Sprinkler controlled post indicator valves shall be painted “Fire Protection Red.” Water distribution system division post indicator valves shall be painted “Traffic Yellow.”
3. Water Motor Alarms: All water motor alarms, gongs, and sprinkler system drains through walls shall be painted “Fire Protection Red.”
4. Sprinkler Piping: All visibly exposed sprinkler piping shall be painted “Fire Protection Red” unless approved for another color by SNL Fire Protection Engineering. Contact Daniel Garcia (4879) for any questions.

END OF SECTION 09 90 00

Exceptional service in the national interest

Sandia National Laboratories

Section 22 07 19 – Plumbing Piping Insulation

February 2019

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 22 07 19 – Plumbing Piping Insulation

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to fit new Masterspec format.
2/7/19	Tim Peterson	Admin	3-year review performed; removed hyperlinks; basic copy editing; spelled out acronyms the first time

SECTION 22 07 19 – PLUMBING PIPING INSULATION

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic recirculating hot-water piping.
4. Domestic chilled-water piping for drinking fountains.
5. Sanitary waste piping exposed to freezing conditions.
6. Storm-water piping exposed to freezing conditions.
7. Roof drains and rainwater leaders.
8. Supplies and drains for handicap-accessible lavatories and sinks.

B. Related Sections:

1. Section 22 07 16 "Plumbing Equipment Insulation."

C. This section includes preformed, rigid, and flexible pipe insulation; field-applied jackets; accessories and attachments; and sealing compounds for above-ground, interior, and exterior mechanical piping systems. This section also includes mechanical equipment insulation requirements.

1.3 Action Submittals

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any). Provide manufacturer's installation requirements for each type of insulation and piping. Show compliance with necessary industry standards and listing agencies**.**

B. Leadership in Energy and Environmental Design (LEED) Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of volatile organic compound (VOC) content and chemical components.
2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Preformed Pipe Insulation Materials: 12 inches long by nominal pipe size (NPS) 2.
2. Jacket Materials for Pipe: 12 inches long by NPS 2.
3. Sheet Jacket Materials: 12 inches square.
4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 Informational Submittals

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 Quality Assurance

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Sandia-delegated representative (SDR). Use materials indicated for the completed Work.

a. One 10-foot section of NPS 2 straight pipe.
b. One each of a 90-degree threaded, welded, and flanged elbow.
c. One each of a threaded, welded, and flanged tee fitting.
d. One NPS 2 or smaller valve, and one NPS 2-1/2 or larger valve.
e. Four support hangers including hanger shield and insert.
f. One threaded strainer and one flanged strainer with removable portion of insulation.
g. One threaded reducer and one welded reducer.
h. One pressure temperature tap.
i. One mechanical coupling.

2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
3. Notify SDR seven days in advance of dates and times when mockups will be constructed.
4. Obtain SDR's approval of mockups before starting insulation application.
5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless SDR specifically approves such deviations in writing.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Approved mockups may become part of the completed work, if undisturbed at time of "Substantial Completion.

D. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 Delivery, Storage, and Handling

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

B. Insulation materials must be new and undamaged with the manufacturer's name and brand marking clearly displayed on all containers.

C. Insulation materials must be kept dry and protected from the weather at all times until installation is complete. Insulation material found to be wet or damaged must be replaced by the contractor at no cost to the owner.

1.7 Coordination

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with piping installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

D. Coordinate with other trades, to prevent delays in applying insulation; be aware of testing, painting, hanger installation, and heat-tracing requirements; coordinate clearance requirements with piping installer for insulation application.

E. Protect work of other contractors and Sandia National Laboratories (SNL) from dirt and debris caused by the insulation work; remove rubbish daily and at the conclusion of work.

F. Do not insulate over nameplates or sight/light glasses.

G. Coordinate with pump layout to ensure that pressure switches and gauges are extended outside of pump-insulation boxes.

1.8 Scheduling

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - Products

2.1 Insulation Materials

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use chlorofluorocarbons (CFC) or hydrochlorofluorocarbons (HCFC) blowing agents in the manufacturing process.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, products that may be incorporated into the Work include but are not limited to the following:

    a. Pittsburgh Corning Corporation; Foamglas.

2. Block Insulation: ASTM C 552, Type I.

3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
5. Preformed Pipe Insulation with Factory-Applied All Surface Jacketing/Self-Sealing Lap (ASJ-SSL): Comply with ASTM C 552, Type II, Class 2.
6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Aeroflex USA, Inc.; Aerocel.
b. Armacell LLC; AP Armaflex.
c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

H. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. CertainTeed Corp.; SoftTouch Duct Wrap.
b. Johns Manville; Microlite.
c. Knauf Insulation; Friendly Feel Duct Wrap.
d. Manson Insulation Inc.; Alley Wrap.
e. Owens Corning; SOFTR All-Service Duct Wrap.

I. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements**,** available products that may be incorporated into the Work include but are not limited to the following:

a. Fibrex Insulations Inc.; Coreplus 1200.
b. Johns Manville; Micro-Lok.
c. Knauf Insulation; 1000-Degree Pipe Insulation.
d. Manson Insulation Inc.; Alley-K.
e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850-degree F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. Phenolic:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Kingspan Tarec Industrial Insulation NV; Koolphen K.
b. Resolco International BV; Insul-phen.

2. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
3. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
4. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket: ASJ. Requirements are specified in "Factory-Applied Jackets" Article.

K. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Armacell LLC; Tubolit.
b. Nomaco Insulation; IMCOLOCK and NOMALOCK.

2.2 Insulating Cements

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: Subject to compliance with requirements, products that may be incorporated into the Work include but are not limited to the following:

a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Ramco Insulation, Inc.; Thermokote V.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 Adhesives

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 degrees F.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 Code of Federal Regulations (CFR) 59, Subpart D (Environmental Protection Agency [EPA] Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Aeroflex USA, Inc.; Aeroseal.
b. Armacell LLC; Armaflex 520 Adhesive.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Phenolic Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 degrees F.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-33.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. ASJ Adhesive, and Foil Scrim Kraft (FSK) Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-20.
d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

G. Polyvinyl Chloride (PVC) Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Dow Corning Corporation; 739, Dow Silicone.
b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.
d. Speedline Corporation; Polyco VP Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 Mastics

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

   a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
   b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 degrees F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
   b. Eagle Bridges - Marathon Industries; 501.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
   d. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 degrees F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
   b. Eagle Bridges - Marathon Industries; 570.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 degrees F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
   b. Eagle Bridges - Marathon Industries; 550.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
   d. Mon-Eco Industries, Inc.; 55-50.
   e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 degrees F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 Lagging Adhesives

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
   c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 degrees F.
5. Color: White.

2.6 Sealants

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass and Phenolic Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
d. Mon-Eco Industries, Inc.; 44-05.
e. Pittsburgh Corning Corporation; Pittseal 444.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 degrees F.
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, products that may be incorporated into the Work include but are not limited to the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
b. Eagle Bridges - Marathon Industries; 405.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, Polyvinylidene Chloride (PVDC), and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees F.
5. Color: White.

6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 Factory-Applied Jackets

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.8 Field-Applied Fabric-Reinforcing Mesh

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas Number 10.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.

2.9 Field-Applied Cloths

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.10 Field-Applied Jackets

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, ultraviolet- (UV-) resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

    a. Johns Manville; Zeston.
    b. P.I.C. Plastics, Inc.; FG Series.
    c. Proto Corporation; LoSmoke.
    d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

    a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Metal Jacket:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
    b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
    c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, Temper H-14.

    a. Roll stock ready for shop or field sizing to indicated sizes of factory cut and rolled to size.
    b. Finish and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper.
    d. Moisture Barrier for Outdoor Applications: **3-mil-**thick, heat-bonded polyethylene and kraft paper.
    e. Factory-Fabricated Fitting Covers:

        1) Same material, finish, and thickness as jacket.
        2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
        3) Tee covers.
        4) Flange and union covers.
        5) End caps.

6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. Sheet and roll stock ready for shop or field sizing.
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: **1-mil-**thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: **3-mil-**thick, heat-bonded polyethylene and kraft paper.
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

D. Underground Direct-Buried Jacket: 125-mil thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. Pittsburgh Corning Corporation; Pittwrap.
b. Polyguard Products, Inc.; Insulrap No Torch 125.

2.11 Tapes

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

a. ABI, Ideal Tape Division; 428 AWF ASJ.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.

4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

   a. ABI, Ideal Tape Division; 491 AWF FSK.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   c. Compac Corporation; 110 and 111.
   d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

   a. ABI, Ideal Tape Division; 370 White PVC tape.
   b. Compac Corporation; 130.
   c. Venture Tape; 1506 CW NS.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

   a. ABI, Ideal Tape Division; 488 AWF.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corporation; 120.
   d. Venture Tape; 3520 CW.

2. Width: 2 inches.
3. Thickness: 3.7 mils.

4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.12 Securements

A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

    a. ITW Insulation Systems; Gerrard Strapping and Seals.
    b. RPR Products, Inc.; Insul-Mate Strapping and Seals.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.020-inch thick, ¾-inch wide with wing seal or closed seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch thick, ¾-inch wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal ¾-inch wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless steel.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

    a. C & F Wire.

2.13 Protective Shielding Guards

A. Protective Shielding Pipe Covers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

    a. Engineered Brass Company.
    b. Insul-Tect Products Co.; a subsidiary of MVG Molded Products.
    c. McGuire Manufacturing.
    d. Plumberex.
    e. Truebro; a brand of IPS Corporation.
    f. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

   a. Truebro; a brand of IPS Corporation.
   b. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.

2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 - Execution

3.1 Examination

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

   1. Verify that systems to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Preparation

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 degrees F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 degrees F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 General Installation Requirements

A. Install insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties; apply insulation with the least number of joints practical.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches on-center (o.c.).
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at **2 inches** o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.4 Penetrations

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

3.5 General Pipe Insulation Installation

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gauges, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 Installation of Cellular-Glass Insulation

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 Installation of Flexible Elastomeric Insulation

A. Follow manufacturer's written instructions for applying insulation to straight pipes, tubes, and fittings. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.

2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 Installation of Mineral-Fiber Insulation

A. Insulation Installation on Straight Pipes and Tubes: Use preformed pipe insulation when possible; use pipe and tank insulation for larger-diameter piping, if preformed insulation is not available; for required thickness, apply multiple layers of insulation with longitudinal and end seams staggered.

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, any penetrations in the insulation, and protrusions with vapor-barrier mastic and joint sealant.
3. Keep SSL adhesive and contact surfaces clean and free of dirt and moisture; seal immediately, once adhesive is exposed; seal circumferential joints with a minimum 3-inch-wide tape, and secure with two outward-clinching staples at the overlap; rub the longitudinal joints firmly with a squeegee, and secure with two outward-clinching staples evenly spaced in each 3-foot section of insulation.
4. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
5. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
6. Taper the ends of insulation at terminations; seal all raw edges of insulation with mastic.
7. Fill all voids and seal all raw edges of insulation with vapor-retarder mastic

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.9 Installation of Phenolic Insulation

A. General Installation Requirements:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

3.10 Installation of Polyolefin Insulation

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.11 Field-Applied Jacket Installation

A. Interior

Apply either aluminum or PVC jacketing to exposed insulated pipe, valves, fittings, and specialties, at an elevation of 8 feet or less above finished floor in mechanical/electrical rooms, penthouses, and services aisles/pipe chases; fittings of aluminum-jacketed piping may be either aluminum or standard PVC fitting covers; jacketing for piping in existing areas must match existing jacketing.

B. Exterior

Apply aluminum jacketing to all external piping that is insulated; cover all fittings, valves, and specialties with aluminum jacketing.

C. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

D. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

E. Where PVC jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

F. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints. Secure jacket with aluminum bands or sheet-metal screws on 12-inch centers and at end joints; on piping operating below 60 degrees F, seal all screw penetrations with caulking.

3.12 Finishes

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 90 00, “Painting.”

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

   a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by the SDR. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.13 Field Quality Control

A. Testing Agency: SNL personnel will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by SDR, by removing field-applied jacket and insulation in layers in reverse order of their installation.

1. Inspect fittings and valves randomly selected by SDR.
2. Remove fitting covers from 20 elbows or 1 percent of elbows, whichever is less, for various pipe sizes.
3. Remove fitting covers from 20 valves or 1 percent of valves, whichever is less, for various pipe sizes.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements. Remove defective work and replace with new materials according to these specifications.

E. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these specifications.

3.14 Piping Insulation Schedule, General

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.15 Indoor Piping Insulation Schedule

A. Domestic Cold Water: Insulation of domestic cold water is only required in exterior walls, in ceiling spaces below roofs, and in areas subject to freezing.:

1. All sizes: Insulation shall be one of the following:

    a. Cellular Glass: 1-1/2 inches thick.
    b. Flexible Elastomeric: 1 inch thick.
    c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
    d. Phenolic: 1 inch thick.
    e. Polyolefin: 1 inch thick.

B. Domestic Hot and Recirculated Hot Water:

1. 3-inch and Smaller: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
d. Phenolic: 1 inch thick.
e. Polyolefin: 1 inch thick.

2. 3-1/2 inch and Larger: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inch thick.
d. Phenolic: 1 inch thick.
e. Polyolefin: 1 inch thick.

C. Domestic Chilled Water (Potable):

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
d. Phenolic: 1 inch thick.
e. Polyolefin: 1 inch thick.

D. Stormwater and Overflow:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
d. Phenolic: 1 inch thick.
e. Polyolefin: 1 inch thick.

E. Roof Drain and Overflow Drain Bodies:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
d. Phenolic: 1 inch thick.
e. Polyolefin: 1 inch thick.

F. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Flexible Elastomeric: 1 inch thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

c. Polyolefin: 1 inch thick.

G. Sanitary Waste Piping Where Heat Tracing Is Installed:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 2 inches thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inches thick.
c. Phenolic: 1-1/2 inches thick.

H. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 degrees F:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
d. Phenolic: 1 inch thick.
e. Polyolefin: 1 inch thick.

I. Hot Service Drains:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch thick.

J. Hot Service Vents:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch thick.

3.16 Outdoor, Aboveground Piping Insulation Schedule

A. Domestic Water Piping:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 2 inches thick.
b. Flexible Elastomeric: 2 inches thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
d. Phenolic: 2 inches thick.
e. Polyolefin: 2 inches thick.

B. Domestic Hot and Recirculated Hot Water:

1. 3-inch and smaller: Insulation shall be one of the following:

a. Cellular Glass: 2 inches thick.

b. Flexible Elastomeric: 2 inches thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
d. Phenolic: 2 inches thick.
e. Polyolefin: 2 inches thick.

2. 3-1/2 inch and Larger: Insulation shall be the following:

a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2-1/2 inches thick.

C. Sanitary Waste Piping Where Heat Tracing Is Installed:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 2 inches thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2-1/2 inches thick.
c. Phenolic: 2 inches thick.

D. Hot Service Drains:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

E. Hot Service Vents:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type II: 2 inches thick.

3.17 Outdoor, Underground Piping Insulation Schedule

A. Sanitary Waste Piping, All Sizes, Where Heat Tracing Is Installed: Cellular glass, 2 inches thick.

B. Chilled Water, All Sizes: Cellular glass, 2 inches thick.

3.18 Indoor, Field-Applied Jacket Schedule

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. None above 8 feet above finished floor.

2. PVC: 20 mils thick.
3. Aluminum, Stucco Embossed: 0.016 inch thick.

3.19 Outdoor, Field-Applied Jacket Schedule

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. Aluminum, Stucco Embossed: 0.016 inch thick.

3.20 Underground, Field-Installed Insulation Jacket

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 22 07 19

Section 22 15 13 – Compressed-Air Piping

December 2018

Effective Date: 02/26/2018
Review Date: 02/26/2021

Section 22 15 13 – General-Service Compressed-Air Piping

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to fit new Masterspec format.
10/26/16	Russ Matheson; Jennifer Sawayda	Admin	1.9 - Quality Assurance added reference to 230050 in ASME compliance. Added information in installer qualifications for copper and steel pressure sealed joints; explained some acronyms
2/23/18	Jennifer Sawayda	Admin	3-Year review cycle completed; corrected spec number in 1.6C, added NPS and DN in Section 1.4 as definitions; reformatted tables to make consistent with other Facilities documents
3/22/19	Jennifer Sawayda	Subst	Rewritten to incorporate Spec 22 61 13 into one larger document; title changed to reflect these changes

Section 22 15 13 –Compressed-Air Piping

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. This Section includes piping and related specialties for compressed-air systems including general service and laboratory systems operating at 200 pounds per square inch gauge (psig) (1380 kilopascals [kPa]) or less.

B. Related Sections include the following:

1. Section 22 15 19, "General-Service Packaged Air Compressors and Receivers" for general-service air compressors and accessories.

1.3 References

The current editions of the following standards are a part of this specification:

A. Sandia National Laboratories (SNL) Construction Standards and Specifications

B. American National Standards Institute (ANSI)

Number	Title
B1.1	Unified Inch Screw Threads
B1.2	Hose Coupling Screw Threads
B2.1	Standard Welding Procedure Specification (WPS) Gas Metal Arc Welding of Austenitic Stainless Steel (M-8 or P-8), 10 through 18 Gauge, in the As-Welded Condition, With or Without Backing
B16.11	Forged Fittings, Socket-Welding and Threaded
B16.22	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

C. American Society of Mechanical Engineers (ASME)
Section IX, Boiler and Pressure Vessel Code, *Welding and Brazing Qualifications*

Number	Title
B1.20.1	Pipe Threads, General Purpose
B31.3	Code for Pressure Piping, Chemical Plant and Petroleum
B31.9	Building Services Piping

D. American Society of Testing and Materials (ASTM)

Number	Title
A53/A53M	Standard Specification for Pipe Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless
A269	Standard Specification for Seamless and Welded Austenitic Stainless-Steel Tubing for General Service
A307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 pounds per square inch (psi) Tensile Strength
A334M	Standard Specification for Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service
A420M	Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Low-Temperature Service
A632	Seamless and Welded Austenitic Stainless-Steel Tubing (Small Diameter) for General Service
B88	Standard Specification for Seamless Copper Water Tube for Air Conditioning
B16.18	Cast Copper Alloy Solder Joint Pressure Fittings
B819	Standard Specification for Seamless Copper Tube for Medical Gas Systems
G93	Standard Practice for Cleaning Methods and Cleanliness Levels for Materials and Equipment Used in Oxygen-Enriched Environments

E. American Welding Society (AWS)

Number	Title
A5.8	Specification for Filler Metals for Brazing
B2.2	Standard for Brazing Procedure and Performance Qualifications
	Brazing Manual, 3rd Edition, 1976

F. National Fire Protection Association (NFPA)

Number	Title
50	Standard for Bulk Oxygen Systems
50a	Gaseous Hydrogen Systems
50b	Liquefied Hydrogen Systems
99	Health Care Facilities

G. Compressed Gas Association

Number	Title
G-4.1	Cleaning of Equipment for Oxygen Service

H. Manufacturers Standardization Society

Number	Title
SP-73	Brazing Joints for Copper and Copper Alloy Pressure Fittings

SP-123	Non-Ferrous Threaded and Solder-Joint Unions for Use with Copper Water Tube

I. Copper Development Association: Copper Tube Handbook

1.4 Definitions

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. CDA: Compressed Dry Air

C. DN: Diameter Nominal (mm)

D. EPDM: Ethylene-propylene-diene terpolymer rubber.

E. MAWP: Maximum Allowable Working Pressure

F. NPS: Nominal pipe size (inches)

G. High-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures of 150 psig (1035 kPa) or more.

H. Low-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures of 150 psig (1035 kPa) or less.

1.5 Action Submittals

A. Product Data: For the following:

1. Dielectric fittings.
2. Flexible pipe connectors.
3. Safety valves.
4. Pressure regulators. Include rated capacities and operating characteristics.
5. Automatic drain valves.
6. Filters. Include materials, rated capacities, and operating characteristics.
7. Lubricators. Include rated capacities and operating characteristics.
8. Quick couplings.
9. Hose assemblies.

B. Product data must indicate the maximum allowable working pressure and temperature of each component and any related manufacturing standard.

C. General: Submit the following in accordance with Conditions of Contract documents and Section 01 33 00, "Submittal Procedures."

1.6 Informational Submittals

A. All certifications for installers, welders and brazers, and welding and brazing procedures must be submitted for verification of quality assurance at least two weeks before starting any work. The procedures and certifications are reviewed by the SNL-designated certified welding inspector.

B. Field quality-control test reports.

1.7 Closeout Submittals

A. Operation and Maintenance Data: For compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

B. As-Built Drawings

1. On completion of the work, the Contractor must revise all drawings with a red marker to agree with the construction materials, capacities, locations, and routing as actually accomplished. The notation "As-Built" must be entered in the revision block, dated, and initialed.

1.8 Quality Assurance

A. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or to AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

C. ASME Compliance:

1. Welded pipe shall comply with the guidelines as specified in 23 00 50, “Basic Mechanical Materials and Methods,” part 1; section 1.5; paragraph C.
2. Comply with ASME B31.9, "Building Services Piping," for low-pressure compressed-air piping.

D. Welding and brazing procedures must address cleaning, joint clearance, overlaps, internal purge gas, purge gas flow rate, and filler metal.

E. Certification of procedures and operators applies for both shop and job site welding and brazing of pipe work.

F. Soldering is to conform to ANSI/ASME B31.9, Building Services Piping, and the Copper Development Association recommended practices.

G. Operators must have completed the SNL Welding Safety Class.

H. Performance qualification of welders/brazers must remain in effect indefinitely unless the welder/brazer does not weld or braze with the qualified procedure for a period exceeding 6 months by proof of continuity logs, or there is a specific reason to question the ability of the welder/brazer.

I. Operators must comply with SNL Construction Specification 01065, “ES&H for Construction and Service Contracts,” Section 3.4.F, Hot Work Permit.

1.9 Delivery, Storage, and Handling

A. Deliver materials to the job site in good condition and properly protected against damage to finished surfaces.

B. Storage on Site: Store materials in a location and in a manner to avoid damage. Stacking must be done to prevent bending.

C. Store metal components and materials in a clean, dry location. Cover with waterproof paper, tarpaulin, or polyethylene sheeting to permit circulation of air inside the cover.

D. Keep handling onsite to a minimum. Exercise care to avoid damage to material finishes.

E. Pipe, fittings, and valves specified for "Cleaned and Packaged for Oxygen Service" must be capped and bagged until use.

PART 2 - Products

2.1 Materials

A. General: Materials must be as follows unless otherwise indicated on the applicable contract drawings (valves of equal quality and characteristics may be substituted for those listed in this specification):

B. Piping, fittings, valves, and other components that are required to be "Cleaned and Capped/Packaged for Oxygen Service" for compressed dry air (CDA) systems must be per ASTM G93: Type L, hard-drawn copper tubing, ASTM B88 or ASTM B819, or hard-drawn air-conditioning and refrigeration (ACR) copper tubing of equal internal diameter, ASTM B280. Steel piping for modifications to existing systems: Schedule 40 black steel, seamless Type S or welded Type E, Grade A or B, ASTM A53.

C. Components of different manufacturers are not interchangeable. System components must be of uniform type and manufacturer. System components being replaced must be replaced with components of the same type and manufacturer. Follow manufacturer instructions.

D. Pipe and fittings to be used in modifications, repairs, or additions must be of the same material as the tie-in points to the existing system, and must conform to the following unless otherwise indicated on the applicable contract drawings:

2.2 Pipes, Tubes, and Fittings

A. Comply with ASME B31.9, “Building Services Piping” for compressed air piping operating at 150 psig (1035 kPa) and lower.

B. For modifications to existing steel systems: Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade B, black or hot-dip zinc coated with ends threaded according to ASME B1.20.1. Wall thickness to match existing system, pressure class and material. Join according to existing joint method. Do not soft solder.

1. Steel Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106.
2. Malleable-Iron Fittings: ASME B16.3, Class 150 or 300, threaded.
3. Malleable-Iron Unions: ASME B16.39, Class 150 or 300, threaded.
4. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel, threaded or weld neck.
5. Wrought-Steel Butt-Welding Fittings: ASME B16.9.

C. Type 316/316L Stainless Steel.

D. Copper Tube: Cleaned, purged, and packaged for oxygen service according to CGA G-4.1, Type L, seamless, drawn-temper copper tubing, ASTM B 88 or ACR copper tubing of equal internal diameter, ASTM B280.

1. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or Manufacturers Standardization Society Standard Practice 73 (MSS SP-73), wrought copper with dimensions for brazed joints.
2. Copper Unions: ASME B16.22 or MSS SP-73.

E. CDA: Clean, purge, and package for oxygen service all piping and fittings for CDA systems according to CGA G-4.1.

F. Transition Couplings for Metal Piping: Metal coupling or other manufactured fitting same size as, with working pressure rating at least equal to and ends compatible with, piping to be joined.

G. Flexible Pipe Connectors

1. Bronze-Hose Flexible Pipe Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

   a. Working pressure rating: (300 psig [2068 kPa]) minimum.
   b. End Connections, NPS 2 (DN 50) and smaller: Threaded copper pipe or plain-end copper tube.
   c. End Connections, NPS 2-1/2 (DN 65) and larger: Flanged copper alloy.

2. Stainless-Steel-Hose Flexible Pipe Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

   a. Working pressure rating: 300 psig (2068 kPa) minimum.
   b. End Connections, NPS 2 (DN 50) and smaller: Threaded or socket ends. Type 321 stainless steel. MetraFlex SST.
   c. End Connections, NPS 2-1/2 (DN 65) and larger: Flanged steel nipple. Type 321 stainless steel. MetraFlex MLP or SLP.

H. Pipe-Flange Gasket Materials: Suitable for compressed-air piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-millimeter [mm]) maximum thickness unless thickness or specific material is indicated.

   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

I. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

J. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

K. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.

1. Copper-to-copper joints must be brazed using a copper-phosphorus or copper-phosphorous-silver brazing filler metal (BCuP) without flux. Copper-to-bronze or copper-to-brass joints must be brazed using an appropriate flux with 45% silver (Bag-5 series) brazing filler metal per Copper Development Association's Copper Tube Handbook.

L. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

M. Underground Pipe and Fitting Corrosion Protection

1. Steel: Installed protective pipe coating systems must be of the same materials throughout. Protective pipe covering must be factory- or field-applied according to manufacturer's written instructions. Coatings must extend above grade at least 6 inches. Products must be Polyken No. 1027 primer and Polyken No. 930-35 tape coating, 35 mil, 21 kilovolts (kV) dielectric strength, as manufactured by Tyco adhesives, Corrosion Protection Group. Minimum 1-inch overlap required. Epoxy Coatings: 3M epoxy coatings may be used in place of the Polyken pipe coatings. 3M Scotchkote 6233, Fusion-Bonded Epoxy Coating, must be facility-specified and applied at 15 mils thickness for pipe and fittings. Epoxy coatings must be applied according to manufacturer's written instructions.
2. Copper: Installed protective pipe coating systems must be of the same materials throughout. Protective pipe covering must be factory- or field-applied according to manufacturer's written instructions. Coatings must extend above grade at least 6 inches. Products must be Polyken No. 1027 primer and Polyken No. 930-35 tape coating, 35 mil, 21 kV dielectric strength, as manufactured by Tyco adhesives, Corrosion Protection Group. Minimum 1-inch overlap required.

N. Wrought copper and bronze braze joint, ASME B16.22, ASTM B88. Threaded brass fittings and nipples, ASTM B 43, ASTM B 687. For modifications to existing steel systems: Class 150 banded malleable iron, screwed, ASME B16.3; Schedule 40 wrought-steel butt-weld fittings, ASME B16.9.

O. Flanges: Flanges must be Class 150 bronze flanges, ASME B16.24, or for a modification to an existing steel system, Class 150 forged-steel flanges conforming to ASME B16.5.

P. Fittings: Two ferrule compression-type tube fittings, Swagelok or Parker A-lock® series. Tube fittings must be compatible with pipe material.

2.3 Valves

A. Gate:

1. 3 inches and smaller: Class 150, threaded ends, bronze body, rising stem, union bonnet and solid wedge. Nibco T-134.

2. 4 inches and larger: Class 150, flanged ends, outside stem and yoke (OS&Y), cast steel or ductile iron body, bronze trim, bolted bonnet, rising stem. Nibco F-637-31 or equivalent.

B. Ball: Two-piece or three-piece bronze or stainless steel

1. 2 inches and smaller: 600 psi Cold Working Pressure (CWP), bronze body, blow-out-proof captive stainless-steel stem, double Teflon seals and seats, full-ported stainless-steel ball. Nibco T-585, 2-piece and threaded ends or Nibco S-595-Y-66, 3-piece and solder ends.

2. 2½ inches and larger: Class 150, flanged ends, carbon steel body with 316 stainless steel trim, blow-out-proof captive stainless-steel stem and ball, double Teflon seals and seats. Nibco F510 Series.

C. Needle:

1. 1 inch and smaller: Rated at 600 psi and 300ºF, positive shut-off for gauges, brass. Weiss Instruments 25NVBR.

D. Globe:

1. 2 inches and smaller: Class 125, screwed ends, bronze body, inside screw, screw-in bonnet, renewable seat and disc. Nibco T-211.
2. 2½ inches and larger: Class 125, iron body conforming to ASTM A126 Class B, bronze trim, flanged ends, bolted bonnet, bronze disc, replaceable seats. Nibco F- 718-B.

E. Safety Valves:

1. ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels" construction; National Board certified, labeled, and factory sealed; constructed of bronze body with poppet-type safety valve for compressed-air service.
2. Pressure Settings: Higher than discharge pressure and same or lower than receiver working pressure rating, or any device installed in the system.

F. Pressure Regulators:

1. Bronze or stainless-steel body and trim.
2. Spring-loaded, diaphragm-operated, relieving type.
3. Manual pressure-setting adjustment.
4. Rated for 250-psig (1725-kPa) minimum inlet pressure.
5. Capable of controlling delivered air pressure within 0.5 psig for each 10-psig inlet pressure.

2.4 Joining Materials

A. Aboveground:

1. Copper: All copper joints between the air compressor and its receiver, or within underground piping, or in any piping subject to service temperatures greater than 200ºF, or within piping systems with designed operating pressures of greater than 150 psi, must be brazed or threaded. All aboveground copper joints in clean dry air systems must be brazed or threaded.

B. Underground:

1. Copper: All joints must be brazed with an argon or nitrogen purge applied. The installation of flanges or unions underground is prohibited.

2.5 Specialties

A. Air-Main Pressure Regulators: Bronze or stainless-steel body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 250-psig (1725-kPa) inlet pressure, unless otherwise indicated.

1. Type: Pilot operated.

B. Air-Line Pressure Regulators: Diaphragm or pilot operated, bronze or stainless-steel body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 200-psig (1380-kPa) minimum inlet pressure, unless otherwise indicated.

C. Zero Loss Condensate Drain Valves: Aluminum body and internal parts, rated for 200-psig (1380-kPa) minimum working pressure, capable of automatic discharge of collected condensate.

D. Coalescing Filters: Coalescing type with activated carbon capable of removing water and oil aerosols; with color-change dye to indicate when carbon is saturated and warning light to indicate when selected maximum pressure drop has been exceeded.

E. Mechanical Filters: Two-stage, mechanical-separation-type, air-line filters. Equip with deflector plates, resin-impregnated-ribbon-type filters with edge filtration and drain cock.

F. Air-Line Lubricators: With drip chamber and sight dome for observing oil drop entering air stream; with oil-feed adjustment screw and quick-release collar for easy bowl removal.

1. Provide with automatic feed device for supplying oil to lubricator.

2.6 Quick Couplings

A. General Requirements for Quick Couplings: Assembly with locking-mechanism feature for quick connection and disconnection of compressed-air hose. Assemblies must be from the same manufacturer and type.

B. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and stainless-steel or nickel-plated-steel operating parts.

1. Socket End: With one-way valve and threaded inlet for connection to piping or threaded hose fitting.
2. Plug End: Straight-through type with barbed outlet for attaching hose.

2.7 Hose Assemblies

A. Description: Compatible hose, clamps, couplings, and splicers suitable for compressed-air service, of nominal diameter indicated, and rated for 300-psig (2070-kPa) minimum working pressure, unless otherwise indicated.

1. Hose: Reinforced single- or double-wire-braid, corrosion-resistant-covered hose for compressed-air service.
2. Hose Clamps: Stainless-steel clamps or bands.
3. Hose Couplings: Two-piece, straight-through, threaded brass or stainless-steel O-ring or gasket-seal swivel coupling with barbed ends for connecting two sections of hose.
4. Hose Splicers: One-piece, straight-through brass or stainless-steel fitting with barbed ends for connecting two sections of hose.

PART 3 - Execution

3.1 Piping Applications

A. Compressed-Air Piping between Air Compressors and Receivers; Low or High-Pressure Piping: Use one of the following piping materials for each size range:

1. NPS 2 (DN 50) and smaller: Schedule 40, black-steel pipe; threaded, malleable-iron fittings; and threaded joints.
2. NPS 2 (DN 50) and smaller: Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.
3. NPS 2 (DN 50) and smaller: Type K, copper tube; wrought-copper fittings; and brazed joints.
4. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.
5. NPS 2-1/2 to NPS 4 (DN 65 to DN 100)>: Type K, copper tube; wrought-copper fittings; and brazed joints.
6. NPS 5 (DN 125) and larger: Schedule 40, black-steel pipe; threaded, malleable-iron fittings; and threaded joints
7. NPS 5 (DN 125) and larger: Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.

B. Drain Piping: Use the following piping materials:

1. NPS 2 (DN 50) and smaller: Type L copper tube; wrought-copper fittings; and brazed or soldered joints.

3.2 Piping Installation

A. General

Piping installation must be coordinated, with respect to space available, with heating, ventilating, and electrical installation. In every instance where there is a conflict in the routing of the piping and the ducting, the routing of the ducting must govern. Installed piping must not interfere with the operation or accessibility of doors or windows; must not encroach on aisles, passageways, and equipment; and must not interfere with the servicing or maintenance of equipment. Pipe must be cut accurately to measurements established at the construction site and must be worked into place without springing or forcing, properly clearing all openings and equipment. Cutting or weakening of structural members to facilitate piping installation is not permitted. Pipes must have burrs removed by reaming and must be so installed as to permit free expansion and contraction without damage to joints or hangers. Aboveground piping must be run parallel with the lines of the building unless otherwise noted on the drawings. Unless otherwise shown on the drawings, horizontal piping must pitch down in the direction of flow with a grade of not less than 1 inch in 40 feet. Service pipe, valves, and fittings must be located a sufficient distance from other work to permit the installation of the finished covering not less than ½" from such other work, and not less than ½" between the finished covering on the different services.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping concealed from view and protected from physical contact by building occupants, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.

E. Install piping to permit valve servicing.

F. Install unions in copper compressed-air tubing adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.

G. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.

H. Install air and drain piping with 1 percent slope downward in direction of flow.

I. Install nipples, flanges, unions, transition and special fittings, and valves with working pressure ratings same as or higher than system working pressure rating, unless otherwise indicated.

J. Equipment and Specialty Flanged Connections:

1. Use steel companion flange with gasket for connection to steel pipe.
2. Use cast-copper-alloy companion flange with gasket and brazed or soldered joint for connection to copper tube. Do not use soldered joints for connection to air compressors or to equipment or machines producing shock or vibration.

K. Flanged joints may be used instead of specified joint for any piping or tubing system.

L. Install eccentric reducers where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

M. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

N. Install thermometer and pressure gauge on discharge piping from each air compressor and on each receiver. Install piping to permit valve servicing.

O. Install piping free of sags and bends.

P. Install fittings for changes in direction and branch connections.

3.3 Joint Construction

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints for Steel Piping: Join according to AWS D10.12/D10.12M.

E. Brazed Joints: Join copper tube and fittings according to Copper Development Association's "Copper Tube Handbook," "Brazed Joints" chapter. Continuously purge joint with inert gas during brazing.

F. Flanged Joints: Use asbestos-free, nonmetallic gasket suitable for compressed air. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

G. Dissimilar Metal Piping Material Joints: Refer to 3.6 Dielectric Fitting Installation.

3.4 Valve Installation

A. General-Duty Valves: Comply with requirements in Section 23 00 50, “Basic Mechanical Materials and Methods.” Install shutoff valves and unions or flanged joints at compressed-air piping to air compressors.

B. Install shutoff valve at inlet to each automatic drain valve, filter, lubricator, and pressure regulator.

C. Install check valves to maintain correct direction of compressed-air flow to and from compressed-air piping specialties and equipment.

D. Valves must be installed at the locations shown on the drawings and where specified. All valves must be installed with their stems orientated horizontal or vertical and with sufficient clearance to allow for full-stem travel and the repair of two-piece or three-piece valves in place.

E. Install pressure regulators on compressed-air piping where reduced pressure is required.

F. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor.

3.5 Reducers

Reduction in pipe sizes must be made with one-piece reducing fittings. Forged bushings are acceptable only with the approval of the Sandia Mechanical Construction Observer (SCO), and when there is no room for reducing couplings, and the reduction is less than two pipe sizes. Cast bushings are not acceptable.

3.6 Dielectric Fitting Installation

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. NPS 2 (DN 50) and smaller: Use dielectric nipples, dielectric couplings, brass nipples, brass valves, or brass unions between copper and steel piping.

C. NPS 2-1/2 (DN 65) and larger: Use dielectric flange kits.

D. Dielectric unions must not be used to join two dissimilar metals (ferrous and nonferrous metallic piping).

3.7 Flexible Pipe Connector Installation

A. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor. Comply with SNL Specification 23 05 48, “Vibration and Limit Control,” Part 3, Execution Section, 3.1.A “Installation.”

B. Install bronze-hose flexible pipe connectors in copper compressed-air tubing.

C. Install stainless-steel-hose flexible pipe connectors in steel compressed-air piping.

3.8 Specialty Installation

A. Install safety valves on receivers in quantity and size to relieve at least the capacity of connected air compressors.

B. Install air-main pressure regulators in compressed-air piping at or near air compressors.

C. Install air-line pressure regulators in branch piping to equipment and tools.

D. Install zero-loss automatic drain valves on aftercoolers, receivers, and dryers. Discharge condensate through condensate management system and route effluent to nearest floor drain.

E. Install coalescing filters in compressed-air piping at or near air compressors and upstream from mechanical filters.

F. Install mechanical filters in compressed-air piping at or near air compressors and downstream from coalescing filters.

G. Install air-line lubricators in branch piping to machine tools.

H. Install quick couplings at piping terminals for hose connections.

I. Install hose assemblies at hose connections.

3.9 Connections

A. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment and machine.

B. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment and machine.

3.10 Hanger and Support Installation

A. Comply with requirements in Section 23 05 48, “Vibration Limits and Controls,” and Section 23 00 50, “Basic Mechanical Materials and Methods.”

B. Vertical Piping: MSS Type 8 or 42, clamps.

C. Individual, Straight, Horizontal Piping Runs:

1. 100 feet (30 m) or less: MSS Type 1, adjustable, steel clevis hangers.
2. Longer than 100 feet (30 m): MSS Type 43, adjustable roller hangers.

D. Multiple, Straight, Horizontal Piping Runs 100 feet (30 m) or longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

E. Base of Vertical Piping: MSS Type 52, spring hangers.

F. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

G. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

H. Install hangers for Schedule 40, steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1/4 to NPS 1/2 (DN 8 to DN 15): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
2. NPS 3/4 to NPS 1 (DN 20 to DN 32): 72 inches (1830 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/4 (DN 32): 10 feet (3.7 m) with 3/8-inch (10-mm) rod.
4. NPS 1-1/2 (DN 40): 10 feet (3.7 m) with 3/8-inch (10-mm) rod.
5. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
6. NPS 2-1/2 (DN 65): 10 feet (.3 m) with 1/2-inch (13-mm) rod.
7. NPS 3 (DN 80): 10 feet (3 m) with 1/2-inch (13-mm) rod.
8. NPS 4 (DN 100): 10 feet (3 m) with 5/8-inch (16-mm) rod.
9. NPS 5 (DN 125): 10 feet (3 m) with 5/8-inch (16-mm) rod.
10. NPS 6 (DN 150): 10 feet (3 m) with 3/4-inch (19-mm) rod.
11. NPS 8 (DN 200): 10 feet (3 m) with 7/8-inch (19-mm) rod.
12. NPS 10 (DN 250): 10 feet (3 m) with 7/8-inch (22-mm) rod.
13. NPS 12 (DN 300): 10 feet (3 m) with 7/8-inch (22-mm) rod.

I. Install supports for vertical, Schedule 40, steel piping every 10 feet (3 m).

J. Install hangers for copper piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1/4 and NPS 3/8 (DN 8 and 10): 48 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS ½ through NPS 1-1/4 (DN 15 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
4. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
5. NPS 2-1/2 (DN 65): 10 feet (4 m) with 1/2-inch (13-mm) rod.
6. NPS 3 (DN 80): 10 feet (3 m) with 1/2-inch (13-mm) rod.
7. NPS 4 (DN 100): 10 feet (3 m) with 5/8-inch (13-mm) rod.
8. NPS 5 (DN 125): 10 feet (3 m) with 5/8-inch (13-mm) rod.
9. NPS 6 (DN 150): 10 feet (3 m) with 3/4-inch (16-mm) rod.
10. NPS 8 (DN 200): 10 feet (3 m) with 7/8-inch (19-mm) rod.

K. Install supports for vertical copper piping every 10 feet (3 m).

3.11 Labeling and Identification

A. Install identifying labels and devices for general-service compressed-air piping, valves, and specialties. Comply with requirements in Section 23 00 50, “Basic Mechanical Materials and Methods.”

3.12 Field Quality Control

A. Perform field tests and inspections.

B. Testing Agency: Engage qualified testing agency to perform tests and inspections of compressed-air piping in nonmedical laboratory facilities and to prepare test and inspection reports.

C. Tests and Inspections:

1. Piping Leak Tests for Metal Compressed-Air Piping: Test new and modified parts of existing piping. Test to 250 psig or 1.5 times working pressure, whichever is greater. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen to pressure of 100 psig (690 kPa) for 0–30 psig (0–207 kPa) compressed air and 300 psig (2070 kPa) for 30–200 psig (207–1380 kPa) compressed air. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
2. Repair leaks and retest until no leaks exist.
3. Inspect filters, lubricators and pressure regulators for proper operation.

D. Remove and replace components that do not pass tests and inspections and retest as specified above.

E. Prepare and submit test reports.

END OF SECTION 22 15 13

Exceptional service in the national interest

Sandia National Laboratories

Section 22 15 19 – General-Service Packaged Air Compressors and Receivers

February 2018

Effective Date: 02/19/2018
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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 22 15 19 – General-Service Packaged Air Compressors and Receivers

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to fit new Masterspec format.
2/19/18	Tim Peterson	None	3-year review was completed and no changes are required.

Section 22 15 19 – General-Service Packaged Air Compressors and Receivers

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section Includes:

1. Lubricated, reciprocating air compressors.
2. Oil-free, reciprocating air compressors.
3. Oil-less, reciprocating air compressors.
4. Oil-free, rotary-screw air compressors.
5. Oil-flooded, rotary-screw air compressors.
6. Oil-free, rotary, sliding-vane air compressors.
7. Oil-sealed, rotary, sliding-vane air compressors.
8. Inlet-air filters.
9. Air-cooled, compressed-air aftercoolers.
10. Water-cooled, compressed-air aftercoolers.
11. Refrigerant compressed-air dryers.
12. Desiccant compressed-air dryers.
13. Computer interface cabinet.

1.3 Definitions

A. Actual Air: Air delivered from air compressors. Flow rate is delivered compressed air measured in acfm.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

C. Standard Air: Free air at 68 degrees F and 1 atmosphere (29.92 in. Hg) before compression or expansion and measured in scfm.

1.4 Performance Requirements

A. Seismic Performance: Compressed-air equipment shall withstand the effects of earthquake motions determined according to **SEI/ASCE 7**.

1.5 Action Submittals

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1. Wiring Diagrams: For power, signal, and control wiring.

1.6 Closeout Submittals

A. Operation and Maintenance Data: For compressed-air equipment to include in emergency, operation, and maintenance manuals.

1.7 Quality Assurance

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.

1.8 Project Conditions

A. Interruption of Existing Compressed-Air Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify the SDR (Sandia Delegated Representative) no fewer than twenty-one (21) days in advance of proposed interruption of compressed-air service.
2. Do not proceed with interruption of compressed-air service without SDR's written permission.

1.9 Coordination

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - Products

2.1 General Requirements for Packaged Air Compressors and Receivers

A. Equipment required for installation on this contract must be as specified on the applicable contract drawings and must be furnished complete with all accessories normally supplied with the catalog item listed and all other accessories necessary for a complete and satisfactory operating system.

B. General Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.

C. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.

1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
2. Motor Controllers: Full-voltage, combination magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
3. Control Voltage: 120-V ac or less, using integral control power transformer.
4. Motor Overload Protection: Overload relay in each phase.
5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
6. Automatic control switches to alternate lead-lag compressors for duplex air compressors. Refer to sequence of operation on the Drawings.
7. Instrumentation: Include discharge-air pressure gage, air-filter maintenance indicator, hour meter, compressor discharge-air and coolant temperature gages, and control transformer.

D. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

Prior to installation and acceptance, a pressure vessel operated at pressures of 15 psig or greater furnished under this contract must be stamped with an ASME Boiler and Pressure Vessel Code Symbol and a National Board of Boiler and Pressure Vessel Inspector's number. This certifies that the vessel has been fabricated and tested per the provisions of the ASME *Boiler and Pressure Vessel Code*. Manufacturers' data reports (unless exempted by the ASME Code) are filed with the National Board in Columbus, Ohio. Two copies of these data reports must be submitted to Sandia National Laboratories. Testing, certification, and registration are at the expense of the Contractor. ASTM A-515- and ASME SA-515-type steels must not be used in the fabrication of pressure vessels.

1. Pressure Rating: At least as high as highest discharge pressure of connected compressors, and bearing appropriate code symbols.
2. Interior Finish: Corrosion-resistant coating.
3. Accessories: Include shut-off valve, properly sized ASME certified pressure relief valve, pressure gage, drain, and pressure-reducing valve.

E. Mounting Frame: Fabricate mounting and attachment to pressure vessel with reinforcement strong enough to resist packaged equipment movement during a seismic event when base is anchored to building structure.

2.2 Lubricated, Reciprocating Air Compressors

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Atlas Copco.
2. Curtis-Toledo.
3. Gardner Denver, Inc.
4. General Air Products, Inc.
5. Ingersoll-Rand; Air Solutions Group.
6. Quincy Compressor; an EnPro Industries company.
7. Saylor-Beall Manufacturing Company.

C. Compressor(s): Lubricated, reciprocating-piston type with lubricated compression chamber and crankcase.

1. Submerged gear-type oil pump.
2. Oil filter.
3. Combined high discharge-air temperature and low lubrication-oil pressure switch.
4. Belt guard totally enclosing pulleys and belts.

D. Capacities and Characteristics:

1. Air Compressor(s): Refer to Equipment Schedule on Drawings.
2. Intercooler between stages of two-stage units.
3. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

E. Receiver: ASME construction steel tank.

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

2.3 Oil-Free, Reciprocating Air Compressors

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Gast Manufacturing Inc.
2. Ingersoll-Rand; Air Solutions Group.
3. Quincy Compressor; an EnPro Industries company.

C. Compressor(s): Oil-free, reciprocating-piston type with nonlubricated compression chamber, lubricated crankcase, and of construction that prohibits oil from entering compression chamber.

1. Submerged gear-type oil pump.
2. Oil filter.
3. Combined high discharge-air temperature and low lubrication-oil pressure switch.
4. Belt guard totally enclosing pulleys and belts.

D. Capacities and Characteristics:

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

E. Receiver: ASME construction steel tank.

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

2.4 Oilless, Reciprocating Air Compressors

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Curtis-Toledo.
2. Gast Manufacturing Inc.
3. General Air Products, Inc.
4. Ingersoll-Rand; Air Solutions Group.
5. Quincy Compressor; an EnPro Industries company.

C. Compressor(s): Oilless (nonlubricated), reciprocating-piston type, with sealed oil-free bearings, that will deliver air of quality equal to intake air.

1. High discharge-air temperature switch.
2. Belt guard totally enclosing pulleys and belts.

D. Capacities and Characteristics:

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

E. Receiver: ASME construction steel tank.

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

2.5 Oil-Free, Rotary-Screw Air Compressors

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Atlas Copco.
2. Gardner Denver, Inc.
3. Ingersoll-Rand; Air Solutions Group.

C. Compressor(s): Oil-free, rotary-screw type with nonlubricated helical screws and lubricated gear box, and of construction that prohibits oil from entering compression chamber.

1. Coupling: Nonlubricated, flexible type.
2. Cooling/Lubrication System: Unit-mounted, air-cooled exchanger package pre-piped to unit; with air pressure circulation system with coolant stop valve, full-flow coolant filter, and thermal bypass valve.
3. Air Filter: Dry type, with maintenance indicator and cleanable replaceable filter element.
4. Air/Coolant Receiver and Separation System: 150-psig-rated steel tank with ASME safety valve, coolant-level gage, multistage air-coolant separator element, minimum pressure valve, blowdown valve, discharge check valve, coolant stop valve, full-flow coolant filter, and thermal bypass valve.
5. Capacity Control: Capacity modulation between zero and 100 percent air delivery, with operating pressures between 50 and 100 psig. Include necessary control to hold constant pressure. When air demand is zero, unload compressor by using pressure switch and blowdown valve.

D. Capacities and Characteristics:

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

E. Receiver: ASME construction steel tank.

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

2. Enclosure: Steel with sound-attenuating material lining.

2.6 Oil-Flooded, Rotary-Screw Air Compressors

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Atlas Copco.
2. Gardner Denver, Inc.
3. Ingersoll-Rand; Air Solutions Group.
4. Quincy Compressor; an EnPro Industries company.
5. Sullair Corporation.

C. Compressor(s): Oil-flooded, rotary-screw type with lubricated helical screws and lubricated gear box.

1. Coupling: Nonlubricated, flexible type.
2. Cooling/Lubrication System: Unit-mounted, air-cooled exchanger package pre-piped to unit; with air pressure circulation system with coolant stop valve, full-flow coolant filter, and thermal bypass valve.
3. Air Filter: Dry type, with maintenance indicator and cleanable replaceable filter element.

4. Air/Coolant Receiver and Separation System: 150-psig-rated steel tank with ASME safety valve, coolant-level gage, multistage air-coolant separator element, minimum pressure valve, blowdown valve, discharge check valve, coolant stop valve, full-flow coolant filter, and thermal bypass valve.
5. Capacity Control: Capacity modulation between zero and 100 percent air delivery, with operating pressures between 50 and 100 psig. Include necessary control to hold constant pressure. When air demand is zero, unload compressor by using pressure switch and blowdown valve.

D. Capacities and Characteristics:

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

E. Receiver: ASME construction steel tank.

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

2. Enclosure: Steel with sound-attenuating material lining.

2.7 Oil-Free, Rotary, Sliding-Vane Air Compressors

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Gast Manufacturing Inc

C. Compressor(s): Oil-free, nonpulsating, rotary, sliding-vane type with nonlubricated sliding vanes.

1. Cleanable inlet screens.
2. Outlet silencers on discharge connections.

D. Capacities and Characteristics:

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

E. Receiver: ASME construction steel tank.

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

2.8 Oil-Sealed, Rotary, Sliding-Vane Air Compressors

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Davey Compressor Company.

2. Gast Manufacturing Inc.

C. Compressor(s): Nonpulsating, rotary, sliding-vane type with oil-sealed sliding vanes.

1. Cleanable inlet screens.
2. Outlet silencers and oil-mist separators on discharge connections.

D. Capacities and Characteristics:

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

E. Receiver: ASME construction steel tank.

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

2.9 Inlet-Air Filters

A. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.

1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
2. Capacity: Match capacity of air compressor, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

B. Description: Combination inlet-air filter-silencer, suitable for remote installation, for multiple air compressors.

1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
2. Capacity: Match total capacity of connected air compressors, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

2.10 Air-Cooled, Compressed-Air Aftercoolers

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Arrow Pneumatics, Inc.
2. Hankison International.
3. Ingersoll-Rand; Air Solutions Group.
4. Saylor-Beall Manufacturing Company.
5. Van Air Systems, Inc.
6. Zeks Compressed Air Solutions

C. Description: Electric-motor-driven, fan-operation, finned-tube unit; rated at 250 psig and leak tested at 350-psig minimum air pressure; in capacities indicated. Size units to cool compressed air in compressor-rated capacities to 10 degrees F above summertime maximum ambient temperature. Include moisture separator and automatic drain.

D. Capacities and Characteristics:

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

2.11 Water-Cooled, Compressed-Air Aftercoolers

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Arrow Pneumatics, Inc.
2. Hankison International.
3. Ingersoll-Rand; Air Solutions Group.
4. Saylor-Beall Manufacturing Company.
5. Van Air Systems, Inc.
6. Zeks Compressed Air Solutions.

C. Description: Shell and tube unit, rated at 250 psig and leak tested at 350-psig minimum air pressure, in capacities indicated. Include moisture separator and automatic drain.

D. Capacities and Characteristics:

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

2.12 Refrigerant Compressed-Air Dryers

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Arrow Pneumatics, Inc.
2. Atlas Copco.
3. Curtis-Toledo.
4. Donaldson Company, Inc.; Donaldson Ultrafilter Co.
5. Hankison International.
6. Ingersoll-Rand; Air Solutions Group.
7. Van Air Systems, Inc.
8. Wilkerson Operations; Pneumatic Division.
9. Zeks Compressed Air Solutions.

C. Description: Noncycling, air-cooled, electric-motor-driven unit with steel enclosure and capability to deliver 35 degrees F, 100-psig air at dew point. Include automatic ejection of condensate from airstream, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.

D. Capacities and Characteristics:

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

2.13 Desiccant Compressed-Air Dryers

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Air/Tak, Inc.
2. Donaldson Company, Inc.; Donaldson Ultrafilter Co.
3. Hankison International.
4. Ingersoll-Rand; Air Solutions Group.
5. Van Air Systems, Inc.
6. Wilkerson Operations; Pneumatic Division.
7. Zeks Compressed Air Solutions.

C. Description: Twin-tower unit with purge system, mufflers, and capability to deliver plus 10 degrees F**,** 100-psig air at dew point. Include dew point controlled purge, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.

D. Capacities and Characteristics:

1. Capacities, Performance and Arrangement: Refer to Equipment Schedule on Drawings.

2.14 Motors

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 00 50, Section 2.5, “Motors.”

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

PART 3 - Execution

3.1 Equipment Installation

A. Equipment Mounting: Install air compressors on concrete bases using elastomeric pads. Comply with requirements in Section 03 30 00 "Cast in Place Concrete." Comply with requirements for vibration isolation devices specified in Section 23 05 48 “Vibration Limits and Control.”

1. Minimum Deflection: 1/4 inch.

B. Install compressed-air equipment anchored to substrate.

C. Arrange equipment so controls and devices are accessible for servicing.

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Install the following devices on compressed-air equipment:

1. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
2. Pressure Regulators: Install downstream from air compressors and dryers.
3. Automatic Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

3.2 Connections

A. Comply with requirements for piping specified in Section 22 15 13 "General Service Compressed Air Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

3.3 Identification

A. Identify general-service air compressors and components. Comply with requirements for identification specified in Section 23 00 50 “Basic Mechanical Materials and Methods.”

3.4 Startup Service

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check for lubricating oil in lubricated-type equipment.
3. Check belt drives for proper tension.
4. Verify that air-compressor inlet filters and piping are clear.
5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.

6. Check safety valves for correct settings. Ensure that settings are higher than air-compressor discharge pressure but not higher than rating of system components.
7. Check for proper seismic restraints.
8. Drain receiver tanks.
9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
10. Test and adjust controls and safeties.

3.5 Demonstration

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air compressors, aftercoolers, and air dryers.

END OF SECTION 22 15 19

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Section 22 30 00 – Plumbing

November 2019

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 22 30 00 – Plumbing

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to new Master spec style.
5/31/16	Tim Peterson	Subst	Updated *Section 2.5, I. Drinking Fountains, Electric*.
11/13/19	Tim Peterson	Subst	3-year review performed; updated references; added to Section 2.3F, 2.3G2c, 2.5A, 2.5C–2.5H; removed information on hangars and rods
12/10/19	Tim Peterson	Admin	Corrected needle information under Section 2.3F

Section 22 30 00 – Plumbing

PART 1 - General

1.1 Summary

A. This specification, in conjunction with the design drawings and other contract documents, specifies materials and operations required for installation of interior plumbing systems. Systems covered by this document are domestic hot and cold water, nonpotable water, sanitary waste, drain and vent, laboratory waste, roof drains, and indirect or special drains. Operations include the specification of piping, fittings, valves, joints, fixtures, equipment, tests, and disinfection.

B. Pipe and fittings used for modifications or additions must be the same material (such as copper or galvanized steel) as the existing systems being modified, and must conform to the following unless otherwise indicated on the applicable contract drawings.

1.2 References

A. The current editions of the following standards are to be considered a part of this specification:

1. Sandia National Laboratories (SNL) Standard Specifications

Number	Title
Section 01 33 00	Submittals
Section 31 20 00	Earthwork
Section 09 90 00	Painting
Section 22 07 16	Plumbing Equipment Insulation
Section 22 07 19	Plumbing Piping Insulation
Section 23 00 50	Basic Mechanical Materials and Methods
Section 23 05 29	Hangers and Supports for Piping and Equipment

2. American Society of Mechanical Engineers (ASME)

Number	Title
B1.20.1	Pipe Threads, General Purpose (Inch)
B16.3	Malleable Iron Threaded Fittings Classes 150 and 300
B16.5	Pipe Flanges and Flanged Fittings
B16.12	Cast Iron Threaded Drainage Fittings
B16.18	Cast Copper Alloy Solder Joint Pressure Fittings
B16.22	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
B16.23	Cast Copper Alloy Solder Joint Drainage Fittings
B16.24	Bronze Pipe, Flanges and Flanged Fittings (Class 150 and 300)
B16.29	Wrough Copper and Wrough Copper Alloy Solder-Joint Drainage Fittings--DWV
B31.9	Building Services Piping
ASME BPVC	Boiler and Pressure Vessel Codes

3. American National Standards Institute (ANSI)

Number	Title
NSF/ANSI 42	Drinking Water Treatment Units – Aesthetic Effects
NSF/ANSI 53	Drinking Water Treatment Units – Health Effects
NSF/ANSI 61	Drinking Water System Components – Health Effects
NSF/ANSI 372	Drinking Water System Components – Lead Content
Z21.10.3	Gas Water Heaters Volume III, Storage Water Heaters With Input Ratings Above 75,000 BTUh Circulating and Instantaneous
Z358.1	Emergency Eyewash and Shower Equipment

4. American Society for Testing and Materials (ASTM)

Number	Title
A53	Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless
A74	Standard Specification for Cast Iron Soil Pipe and Fittings
A126	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
B88	Standard Specification for Copper Water Tube
C1540	Standard Specification for Heavy Duty Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings
D3222	Standard Specification for Unmodified Polyvinylidene Fluoride (PVDF) Molding Extrusion and Coating Materials
D3311	Standard Specification for Drain, Waste and Vent (DWV) Plastic Fittings Patterns
D4101	Standard Specification for Propylene Plastic Injection and Extrusion Materials
E84	Standard Test Method for Surface Burning Characteristics of Building Materials
F1412	Standard Specification for Polyolefin Pipe and Fittings for Corrosive Waste Drainage Systems
F1673	Standard Specification for Polyvinylidene Fluoride (PVDF) Corrosive Waste Drainage Systems

5. American Welding Society (AWS)

Number	Title
A5.8	Specification for Brazing Filler Metal
B2.2	Specification for Brazing Procedure and Performance Qualification

6. Cast Iron Soil Pipe Institute (CISPI)
   - 301 Cast Soil Pipe and Fittings for Hubless Cast Iron Sanitary Systems

7. American Waterworks Association (AWWA)
   - AWWA C651 Disinfecting Water Mains

8. International Underwriters Laboratories, Inc. (UL)

9. International Code Council
   - International Plumbing Code® (IPC)

10. Americans With Disability Act (ADA) – Title 28 Code of Federal Regulations (CFR) Part 36 – ADA Standards for Accessible Design

1.3 Submittals

A. General

Submittals must be per SNL Construction Standard Specification Section 01 33 00, "Submittals." Where specific manufacturer or model numbers are mentioned in these specifications, proposed substitutions must be included in the submittal package.

B. Submittal Data Required

1. Pipe materials, valves, equipment, and accessories not listed in this specification under Part 2, "Products," must be submitted for approval.
2. Relief valves require submittals for approval.
3. Backflow preventers require submittals for approval.
4. All certifications for welders, brazers, and fusion-welded-plastic-pipe-installers must be submitted to the Sandia-Delegated Representative (SDR) for verification of quality assurance requirement Standard Specification 22 30 00, "Plumbing," before starting work.

C. Sustainability Submittal Data

1. Water Efficiency: Submit manufacturer's product data indicating flush and flow rates for each plumbing fixture.
2. Energy Efficiency: Submit manufacturer's product data indicating thermal efficiency for all domestic water heater units.

1.4 Quality Assurance

A. Welding Materials

1. Welding materials must conform to ASME code for Pressure Piping and ASME B31.9, Building Services Piping.

B. Welding, Brazing, or Soldering:

1. Welders shall be certified in accordance with ASME Boiler and Pressure Vessel Code, as modified by ASME B31.9, Building Services Piping.
2. Brazing: Certify brazing procedures, brazers, and operators in accordance with ASME B31.9, Building Services Piping, for shop and jobsite brazing of piping work.
3. Qualify welding/brazing processes and welder/brazer performance in accordance with AWS B2.2, Standard for Brazing Procedure and Performance Qualification, or ASME Boiler and Pressure Vessel Code, Section IX. Certify that each welder/brazer has satisfactorily passed AWS or an ASME qualification test for the welding/brazing processes involved and, if pertinent, has undergone recertification.
4. Certification of procedures and operators applies for both shop and jobsite welding and brazing of pipe work.

5. Performance qualification of welders/brazers must remain in effect indefinitely unless the welder/brazer does not weld or braze with the qualified procedure for a period exceeding six months, or if there is a specific reason to question the ability of the welder/brazer.
6. Welder/brazers must comply with SNL Construction Specification 01065, "ES&H for Construction and Service Contracts," Section 3.4F, "Hot Work Permit."
7. Soldering: Conform to ASME B31.9, Building Services Piping and Copper Development Association recommended practices.

C. Laboratory, Process, Acid Waste, and Vent-Piping Installers

1. Must be product-manufacturer-representative certified for the specific product/piping being installed.

D. Copper or Bronze Pressure Sealed Joints

1. Installers of Copper or Bronze Pressure-Sealed Joints: Pipefitters must be certified by the pressure-joint fitting manufacturer as having been trained and qualified to join copper pipe with pressure-seal fittings.
2. Copper pressure-seal fittings must be installed using the proper tool, actuator, jaws, and rings as instructed by the press-fitting manufacturer.

PART 2 - Products

2.1 Acceptable Manufacturers

The following products and materials must be used unless shown otherwise on the drawings. Other manufacturers of products of equal or better quality and characteristics may be submitted in addition to those listed in this specification. The manufacturers listed under this section supply products of acceptable type, quality, and performance.

2.2 Plumbing Materials

A. Potable Piping

1. Plumbing for potable systems must be lead-free per Public Law 99-339, Safe Drinking Water Act.
2. Lead-free is defined as:

   a. No more than 0.2% lead when used with respect to solder and flux.
   b. Not more than a weighted average of 0.25% lead when used with respect to the wetted surfaces of pipes, pipe fittings, plumbing fittings, and fixtures.

B. Domestic Hot and Cold Water, Nonpotable Water, and Pressure Drain Piping

1. Above Grade: Piping must be Type L hard drawn copper tubing, ASTM B88, with wrought copper solder type fittings conforming to ANSI B16.22, or cast copper alloy solder joint fittings conforming to ANSI B16.18, or cast copper alloy flanged fittings

Class 150 conforming to ANSI B16.24. Screwed joints in piping are restricted to pipe sizes 2" and smaller.

2. Copper or Bronze Pressure-Seal Fittings: Copper or bronze housing, factory-installed Ethylene Propylene Diene Terpolymer sealing element, 200 pounds per square inch (psi) working pressure with a 0 to 250°F temperature rating. ASME B16.18 and B16.22, ASTM B88, and D 2000. Rigid ProPress™, or Stadler-Viega, or NIBCO® INC.

   a. Exception: Modifications to existing steel systems may use schedule 40, galvanized steel pipe, ASTM A53, Grade A or B, with 150-pound galvanized malleable iron screwed fittings conforming to ANSI B16.3.

3. Below Grade: Type K copper tubing must be used. When piping is installed within a building and within or under a concrete slab, it must be installed without joints. Where joints are unavoidable, they must be brazed.

   a. Protective pipe covering must be factory- or field-applied according to manufacturer's written instructions.
   b. 2-1/2 Inches and Larger: Products must be Polyken® No. 1027 primer and Polyken No. 930-35 tape coating, 35 mil, 21kV dielectric strength, as manufactured by Berry Plastics Corporation, Corrosion Protection Group. Minimum one-inch overlap required.
   c. 2 Inches and Smaller: Products must be 27 MIL plastic sleeve-protector. LSP® Products Group, Plasti-Sleeve, or equivalent.

C. Soil, Waste, Drain, and Vent Piping: Cast iron soil pipe, fittings, and connections must comply with Cast Iron Soil Pipe Institute (CISPI) guidelines.

1. Below Grade: Piping must be service weight hub and spigot (with gasket) coated cast iron and must conform to ASTM A74, or hubless cast iron pipe and fittings with heavy-duty couplings; Husky brand or equivalent.
2. Above Grade: Piping must be Schedule 40, galvanized steel pipe, ASTM A53, with threaded, galvanized cast iron Durham drainage fittings, ANSI B16.12; or drain-waste-vent (DWV) copper pipe with solder joint DWV wrought copper fittings; or service weight hub-spigot (with gasket) coated cast iron pipe and fittings conforming to ASTM A74; or hubless cast iron pipe and fittings conforming to CISPI 301.

D. Laboratory/Process/Acid Waste and Vent Piping: For acid and caustic resistant drains.

1. From lab waste to neutralizing tank and vent piping: Pipe and fittings must be flame retardant Schedule 40 Polypropylene (George Fischer “Fuseal II” PPFR Group 1 63153, or Enfield “Enfusion” Type II-37206), or PVDF (Fuseal 25/50 PVDF), or Spears® Labwaste™ chlorinated polyvinyl (CPVC). Polypropylene pipe must conform to ASTM F1412, ASTM D3311, and ASTM D4101. The PVDF pipe must conform to ASTM F1673, ASTM E84, and ASTM D3222. Joints and fittings must be DWV electric fusion or solvent welded and made of the same material as the piping. From neutralizing tank to sewer main: Pipe and fittings must be per “Soil, Waste Drain, and Vent Piping” above.
2. Connection to equipment and fixtures in accessible locations must be made with mechanical joints.
3. Connection to existing systems of different materials must be made with the appropriate adapter provided by the contractor.

E. Roof Drain Leaders:

1. Below Grade: Leaders must be service weight hub and spigot coated cast iron and must conform to ASTM A74, or hubless cast iron pipe and fittings with heavy-duty couplings; Husky brand or equivalent.
2. Above Grade: Schedule 40 galvanized steel pipe, ASTM A53, with galvanized cast iron screwed drainage fittings, ANSI B16.12; or service weight hub-spigot coated cast iron pipe and fittings conforming to ASTM A74; or hubless cast iron pipe and fittings conforming to CISPI 301.

F. Equipment Drains and Indirect Waste:

1. Piping must be Schedule 40 galvanized steel pipe, ASTM A53, with galvanized cast iron screwed drainage fittings conforming to ANSI B16.12 or DWV copper pipe with DWV wrought copper fittings in compliance with ANSI B16.29.

2.3 Valves

A. Gate

1. 2 Inches and Smaller: Class 125, solder or threaded ends, bronze body, rising stem, screwed bonnet, and solid wedge. NIBCO S-111 or NIBCO T-111 or equivalent.
2. 2-1/2 Inches and Larger: Class 125, flanged ends, outside stem and yoke, iron body, bronze trim, rising stem, and solid wedge. NIBCO F-617-0 or equivalent.

B. Ball

1. 2 Inches and Smaller: Bronze body, blow-out proof captive stem, double Teflon (TFE) seats, full ported, stainless steel or chrome plated brass ball, two-piece, threaded or soldered ends. NIBCO T- or S-585-66-LF, or a three-piece bronze body, full port, stainless steel trim, with a blowout-proof stem. NIBCO T or S-595-Y-LF or equivalent. Pressure-seal ends: Nibco PC-585-80-LF.
2. 2-1/2 Inches to 3 Inches: Two or three-piece bronze body, blow-out proof captive stainless steel stem, double Teflon seals and seats, full ported, stainless steel or chrome plated brass ball and threaded ends. NIBCO T-595-Y-LF.
3. 4 Inches and Larger: Class 150, flanged ends, carbon steel body with 316 stainless steel trim, unibody design, full ported, blow-out proof captive stainless steel stem and ball, and seat. NIBCO F-510-CS-R-66-FS.

C. Globe

1. 2 Inches and Smaller: Class 125, screwed ends, bronze body, inside screw, screw-in bonnet, renewable seat and disc. NIBCO T-211 or equivalent.
2. 2-1/2 Inches and Larger: Class 125, iron body conforming to ASTM A126 Class B, bronze trim, flanged ends, bolted bonnet, bronze disc, replaceable seats. NIBCO F-718-B or equivalent.

D. Butterfly

1. 2-1/2 Inches through 6 Inches: 200 psi working pressure, ductile iron body, aluminum/bronze disc, stainless steel shaft, resilient seat, O-ring seals, lug type for dead-end service, lever operator. NIBCO LD2000 series.
2. 8 Inches and Larger: 150 or 200 working pressure, ductile iron body, aluminum/bronze disc, stainless steel shaft, resilient seat, O-ring seals, lug type for dead-end service, gear operator. NIBCO LD1000 or LD2000 series dependent on the application.

E. Check Valve:

1. 2 Inches and Smaller: Class 125, threaded ends, bronze body, Y pattern, renewable seat and disk, and screw cap. NIBCO T-413 or equivalent.
2. 2-1/2 Inches and Larger: Class 125, iron body, silent check, flanged ends, globe style, spring actuated, renewable seats and disc, bronze trim or 316 stainless steel trim. NIBCO F-910 or equivalent.

   a. Vertical Check: 2 Inches and Smaller: Class 125, threaded ends, bronze body, spring actuated, inline vertical lift type, TFE seat ring. NIBCO T-480-Y or equivalent.

F. Needle:

F. 1 Inch and Smaller: Rated at 600 psi and 300°F, positive shut-off for gauges, brass. Weiss Instruments BTC-14 or equivalent.

G. Strainers, Flanges, and Unions

1. Strainers

   a. 2 Inches and Smaller: Threaded ends, cast bronze body with screwed cap, and 20-mesh 304 stainless steel screen for water service. Watts series LF777S.
   b. 2-1/2 Inches and Larger: Flanged ends, cast iron body and bolted cap, 20-mesh stainless steel screen for water service. Watts series 77F-CSI.

2. Flanges

   a. Class 150, forged steel, threaded, ANSI B16.5
   b. Copper Systems: Class 150, Cast Copper or Bronze, ANSI B16.23 or ANSI 16.24
   c. Pressure connection: Class 150, Copper or Bronze, ANSI/ASME 16.24, ProPress Nibco or Viega. Maximum Test Pressure: 600 psi, Maximum Working Pressure: 200 psi

3. Unions

   a. Piping unions must be of the ground joint type constructed from materials equivalent in alloy composition and strength to other fittings prescribed with which they are used. Union pressure classes and end connections must be the same as the fittings used in the lines with the unions.
   b. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

c. Dielectric unions must not be used to join two dissimilar materials (ferrous and non-ferrous metallic). Use brass fittings, valves, or unions to join dissimilar materials.

2.4 Cleanouts

A. Floor Cleanout:

1. Fully adjustable, coated cast iron body with nickel bronze scoriated top. Zurn ZN-1400 (Normal Traffic) or ZN-1400-HD (Heavy Traffic)

B. Wall Cleanouts:

1. Coated cast iron body with Acrylonitrile-Butadiene-Styrene plug and smooth stainless steel access cover. Zurn Z-1441 or Z-1445.

2. Acid Resistant Cleanouts:

a. Cleanouts for acid-resistant waste lines must be of the same material as the connecting waste pipes or approved equal.

2.5 Plumbing Fixtures

Unless specified otherwise on the contract drawings, provide plumbing fixtures as listed below. Ordinary plumbing fixtures are specified here. Refer to the contract drawings for laboratory and special equipment. Fixtures must be white and furnished with all trim and accessories required for a complete installation. Fixtures must be provided with stop valves on both hot and cold water supplies. Metal trimmings on fixtures and exposed piping to fixtures, unless otherwise noted, must be chromium plated with chromium-plated escutcheons. Toilets and lavatories must be mounted on approved carriers or as indicated on the drawings.

Flushometer valves must be sensor operated when called out on drawings as such and must be manufactured by Sloan® or Zurn. Battery powered, sensor operated fixtures are not allowed. No substitutions allowed. If different manufactures are specified on the contract drawings, an equivalent Sloan or Zurn must be supplied.

A. Toilets

1. All new and replacement toilets shall be installed with a Pressure Assist Tank Vessel. Sloan FLUSHMATE for 1.6 gallons per flush (GPF) and lower.
2. Floor Mounted, Tank Type: American Standard elongated "Cadet3", High Efficiency (1.28 GPF) No. 710AB.101, right height, or No. 3379.128ST, standard height, elongated bowl, siphon jet closet, Olsonite® #95 open front seat.
3. Floor Mounted, Flush Valve Type: American Standard "Madera", No. 2854.128, water saver, siphon jet closet, elongated bowl with Sloan Royal Optima # 111-ES-S sensor operated flush valve or Sloan Royal #111 flush valve or Zurn ZEMS6000AV-IS-WS1 sensor operated flush valve or Zurn Z6000AV-WS1 and Olsonite #95 white open front seat.

4. Wall Hung, Flush Valve Type: American Standard “Afwall”, No. 2257.101, water saver, top spud, siphon jet closet, elongated bowl with Sloan Royal Optima #111-ES-S sensor operated flush valve or Sloan Royal #111 flush valve or Zurn ZEMS6000AV-IS-WS1 sensor operated flush valve or Zurn Z6000AV-WS1 and Olsonite #95 white open front seat.

   NOTE: Retrofitting toilets requires both flush valve and fixture to be rated for 1.6 GPF. Replacing an existing standard or full flush (3.5 or 4.5 GPF) valve with a 1.6 GPF flush valve without also replacing the fixture is prohibited.

B. Urinal

American Standard “WASHBROOK® FloWise®”, No. 6590.001, 0.125 GPF application, wall hung and approved wall hanger with Sloan ECOS® 186-0.125 HEU HW, High Efficiency (0.125 GPF) sensor operated flush valve or Sloan Royal Model 186-0.125 (0.125 GPF) manual operated flush valve or Zurn ZEMS6003AV-ULF-IS (0.125 GPF) sensor operated flush valve, or Zurn Z6003AV-ULF (0.125 GPF) manual operated flush valve.

NOTE: Retrofitting urinals requires both flush valve and fixture to be rated for 0.125 GPF. Replacing an existing 1.0 GPF flush valve with a 0.125 GPF flush valve without also replacing the fixture is prohibited.

C. Lavatories

1. Top-mount applications on existing laboratory countertops: Kohler “Farmington”, No. K2905-4, drop-in counter mount self rimming, white enameled cast iron oval bowl, 4-inch faucet centers.
2. Kohler “Hudson”, No. K2861, wall-mount, white enameled cast iron bowl, 4-inch faucet centers.
3. Undermount applications: Kohler “Canvas” K-2874, white enameled cast iron oval bowl.
4. For new construction or replacing countertops: sinks shall be replaced with integral solid surface. Reference Specification Section 12 36 61.16 “Solid Surface Material Countertops.”

D. Lavatory Faucets

1. Manual; Single-lever faucet: Delta Faucet 583LF-WF Chrome C-spout, single hole with 3 hole cover plate option, 0.5 gallons per minute (GPM).
2. Automatic, when specifically called out for on drawings: Sloan Faucet No. SF-2400-PLG-BDM-CP-00.5 GPM-MLM-IR-FCT, 4-inch center electronic lavatory faucet, ADA-compliant, sensor activated, 24 volts alternating current, chrome plated cast brass, 0.5 GPM vandal resistant spray head, plug-in transformer, below deck manual mixing valve.

E. Kitchen/Pantry/Mothers’ Room/Bar Sink

1. Elkay Crosstown Stainless Steel 25"x2"x6", single bowl dual mount, with ADA kit.

F. Kitchen/Pantry/Bar/Break Area/Mothers’ Room Faucets

1. Kitchen-type faucets installed in nursing mothers’ rooms, lunch rooms, break rooms, or pantry areas shall not exceed 1.5 GPM. Must be ADA-compliant.

2. Kohler Simplice, Bar Sink Faucet Swing Spout K-22034, polished chrome, single hole, single lever.

G. Showerheads

1. Showerheads shall comply with flow rate criteria established by the U.S. Environmental Protection Agency’s WaterSense® program, 2.0 GPM or less.
2. Delta 9-Spray Shower Mount Hand Shower, Model #54424-PK, Chrome. ADA-compliant. WaterSense certified.

H. Janitor/Equipment Room Service Sink

1. Kohler, “Whitby”, No. K-6710, floor-mounted, white enameled cast iron, with K8940 sink rim guard, chrome faucet with lever handles, vacuum breaker, rubber hose and wall hook, with No. K9146-CP perforated strainer.

I. Wall Hydrant

1. Walls with Exposed Finished Interior – Zurn No. Z-1333-C, moderate climate, 3/4" hose connection, with anti-siphon, automatic draining, polished brass with operating key.
2. Walls at Partitions or with Unfinished Interior – Zurn No. Z1310, exposed, non-freeze, anti-siphon, automatic draining, polished bronze face, 3/4" hose connection, and operating key.

J. Drinking Fountains, Electric

1. Wall-Mounted: New drinking fountains shall be electric water coolers with bottle filling station, stainless steel trim, 115V/60Hz. Units shall deliver 8 gallons per hour (GPH) of 50°F drinking water at 90°F ambient and 80°F inlet water. Cooler shall have push bar activation. Bottle filling unit shall include an electronic sensor for touchless activation. Bottle filler shall provide 1.1 GPM flow rate with laminar flow to minimize splashing. Filter shall be certified to National Sanitation Foundation (NSF)/ANSI 42 and 53 with visual monitor to indicate when replacement is necessary. Unit shall meet ADA guidelines. Unit shall be lead-free design certified to NSF/ANSI 61 & 372. Unit shall be certified to UL399. Unit shall utilize an in-wall carrier mounting system constructed of heavy gauge steel and support up to 500 lbs. Single fountain is not allowed; must be ADA bi-level. Versatile Bi-level Filtered Water Cooler, Elkay Model No. LZSTL8WSSK.

K. Emergency Shower and Eyewash

1. Inside: Emergency showers and eyewash stations are to be barrier-free. Bradley, Model No. S19314BFSS stainless steel or S19314SBFW plastic bowl and Face Spray Ring. Provisions for vertical or horizontal supply. Shower valve to be 1" iron pipe size (IPS) stay-open ball valve. Eyewash valve to be 3/4" IPS stay open hand-operated ball valve. Units must meet ANSI Z358.1.
2. Outside: Emergency showers and eyewash stations are to be frost proof. Bradley® Model No. S19-304, stainless steel bowl and face spray ring. Provisions for top or bottom supply. Shower valve to be 1" National Pipe Thread (NPT) stay-open ball valve. Eyewash valve to be 1/2" NPT stay open hand-operated ball valve. Units must meet ANSI Z358.1.

2.6 Equipment

Equipment required for installation on this contract must be as specified and as shown on the applicable contract drawings. It must be furnished complete with accessories normally supplied with the catalog item listed and other accessories necessary for a complete and satisfactory operating system.

A. Domestic Water Heaters

1. Domestic water heaters must be commercial grade, stock catalog items of standard manufacturer, glass lined, and unconditionally guaranteed for a minimum of 10 years. Must be insulated with a minimum R-value of 12.5. Tank must be nameplate rated for 150 psig (minimum working pressure). For input ratings 200,000 British Thermal Units per hour (BTUH) and above, must be certified and stamped to meet ASME Boiler and Pressure Vessel Code.
2. Domestic water heaters shall meet the U.S. Department of Energy Federal Energy Management Program designated products performance requirements.

   a. Gas, storage-type units with input ratings of 75,000 BTUH or above shall have a thermal efficiency greater than or equal to 94%, as measured by the thermal efficiency test procedure in ANSI Z21.10.3.

3. Manufacturer's ASME data sheets must be submitted per SNL Construction Specification 01 33 00, “Submittals.”
4. Dip tubes, hot and cold water supply nipples, and baffles or heat traps used in the tank must be made to withstand a temperature of 400°F without deteriorating in any manner.
5. Gas burners must be of the high-recovery type and American Gas Association and UL listed. Electric water heaters must be UL listed.
6. Water heaters must be provided with ASME Boiler and Pressure Vessel Code certified and stamped combination temperature and pressure relief valves with test lever.

B. Domestic Hot Water Storage Tanks

1. Tanks must be constructed, certified, and stamped to meet ASME Boiler and Pressure Vessel Code for potable water storage. Tanks must be glass-lined and have a thermometer and thermometer well installed at the points where the water enters and leaves the tank.
2. Tanks 80 gallons and larger must have a 12" x 16" manhole.
3. Tanks, regardless of size, must be provided with an ASME combination temperature and pressure relief valve with test lever.
4. Tanks must be insulated with a minimum R-value of 12.5.
5. Manufacturer's ASME data sheets must be submitted for approval and record keeping according to SNL Construction Specification 01 33 00, “Submittals.”

C. Temperature and Pressure Relief Valves

1. All temperature and pressure relief valves must be in compliance with IPC.
2. Relief valves must be factory set, ASME listed, certified, and stamped.
3. Relief valves must be sized to relieve the unregulated capacity of the pressure regulating valve, burner, or heating element.

PART 3 - Execution

3.1 Plumbing Installation

A. Contamination Prevention

1. Pipe interiors must be kept free of debris.
2. Interior surfaces of potable water pipes, valves, and fittings must be protected against contamination, as well as debris. All openings in pipelines must be closed with watertight plugs when work is halted on the system. Sealing and packing materials must not support the growth of bacteria. Trenches that become wet must be treated with calcium hypochlorite granules to prevent bacterial growth.

B. General

1. Plumbing accommodations in government facilities must conform to 28 CFR Part 36, Nondiscrimination on the Basis of Disability by Public Accommodations in Commercial Facilities.
2. The installation of the plumbing systems must conform to the IPC and this specification.
3. Plumbing installation must be coordinated with respect to space available for heating, ventilating, and electrical installation. In case of conflict in the routing of the piping and the ducting, the routing of the ducting must govern. Installed piping must not interfere with the operation or accessibility of doors or windows; must not encroach on aisles, passageways, and equipment; and must not interfere with the servicing or maintenance of equipment. Pipe must be cut accurately to measurements established at the construction site and must be worked into place without springing or forcing, properly clearing all openings and equipment. Pipe must not be bent. Cutting or weakening of structural members to facilitate piping installation is not permitted.
4. Plumbing installation must maintain the working spaces around electrical equipment as required by National Electric Code® section 110.26 F1, "Spaces About Electrical Equipment." Replacement of existing metal water piping must not occur without first ascertaining how the electrical ground system is configured.
5. Pipes must have burrs removed by reaming and must be installed to permit free expansion and contraction without damage to joints or hangers. Piping above ground must be run parallel with the lines of the building unless otherwise noted on the drawings. Unless otherwise shown on the drawings, horizontal piping must pitch down in the direction of flow with grade of not less than 1" in 40 feet. Piping connections to equipment must be in accordance with details shown on the drawings. Service pipe, valves, and fittings must be kept a sufficient distance from other work to permit finished surface not less than 1" from such other work.
6. Protect chrome or special finishes. Do not install such with abrasive tools.

C. Reducers

1. Reduction in pipe sizes must be made with one-piece reducing fittings. Forged bushings reducing at least two pipe sizes will be acceptable only when there is no room for manufactured reducing couplings or swaged nipples. Cast bushings are not acceptable.

D. Unions or Flanges

1. Unions or flanges must be installed whenever threaded connections are used on equipment, instruments, or relief valve discharge lines.

E. Installation of Valves

1. Valves must be installed at the locations shown on the drawings and where specified. All valves must be installed with their stems between the horizontal and the 90◦ vertical. Provide access to all concealed valves by means of access doors furnished and installed by the contractor.

F. Hangers and Supports: Refer to Specification Section 23 05 29, "Hanger and Supports for Piping and Equipment."

G. Joints

1. Cast iron pipe joints must be made in accordance with the IPC.

a. Compression joints for bell and spigot pipe must have flexible, compression factory-fabricated joints composed of a neoprene gasketing system in accordance with IPC.
b. No-Hub joints must conform to ASTM C-1540 Standard Specification for Heavy Duty Shielding Couplings in above ground systems.

2. Flanged Joints

a. All flanged joints must be face matched. Raised-face flanges must not be mated to flat-faced cast-iron flanges on valves or equipment. The raised face must be machined flush. All flange bolt holes must straddle the horizontal and vertical centerlines unless otherwise noted. Bolting must comply with ANSI/ASME B31.9, Building Services Piping.
b. Install insulating kits on flanges connecting dissimilar metals (such as steel to copper) to prevent electrolytic action.
c. When making final assembly of a bolted flange joint, the following steps must be performed:

Step	Action
1	Place the gasket on the gasket seating surface and bring the cover flange in contact with the gasket. Do not glue the gasket in place.
2	Install all bolts, making sure they are free of dirt and grit, and are well lubricated.
3	Run-up all nuts finger tight.
4	Develop the required bolt stress in a minimum of four steps: (1) stress the bolts to about 30% of their required stresses, tightening one bolt after another according to the cross bolting pattern of the flange type, (2) stress to about 60%, tightening each bolt one after another according to the cross bolting pattern of the flange type, (3) tighten to 100%, tightening each bolt one after another according to the cross bolting pattern of the flange type, and (4) perform final full pass at 100% torque in a clockwise direction on adjacent bolts

3. Screwed Joints

Screwed pipe joints must have Pipe Threads, General Purpose (Inch), ASME B1.20.1. Burrs formed when cutting pipe must be removed by reaming. Care must be taken that the inside of the pipe is thoroughly clean and free of cutting oil and foreign matter before installation. The joints must be made perfectly tight by the use of Teflon tape or approved Teflon thread sealing and lubricating compound. Use Teflon tape or pipe joint sealant on plastic screwed pipe, never both.

4. Brazed or Soldered Joints

   a. Cut tube ends square. Ream, remove burrs, and size.
   b. All joints in piping systems with pressure above 100 psig or service temperatures above 200°F must be brazed.
   c. Brazed copper-to-copper joints must be made with a silver-brazing alloy conforming to AWS A5.8, BCuP-5 (15% silver). Joints must comply with ANSI/ASME B31.9 Building Services Piping.
   d. Brazed copper to brass, or copper to stainless steel joints, must be made with a silver-brazing alloy conforming to AWS A5.8, BAg-5 (45% silver). Joints must comply with ANSI/ASME B31.9 Building Services Piping.
   e. All solder joints, for copper tubing, must conform to recommended practices of the Copper Development Association, and must be made with 95-5 tin-antimony solder with the following exception:
      1) Solder containing antimony must not be used to join metals containing zinc (e.g., galvanized iron, galvanized steel, and brass).
   f. Use sand cloth or a steel wire brush to clean surfaces to be joined. Steel wool is not permitted.

5. Spears Labwaste (CPVC) Joints

   a. Spears Labwaste must be solvent welded per manufacturer's written instructions.

H. Cross-Connection Control

1. A reduced pressure backflow prevention assembly (RPBFP) must be installed to prevent cross-connection contamination between potable water systems and nonpotable or potentially polluted, or contaminated, systems, such as drainage systems, soil lines, fire-protection lines, or chemical lines.
2. All potable water fixture outlets with hose attachments, such as hose bibbs, yard hydrants, janitor sinks, and lab sinks, must be protected by an approved vacuum breaker device.
3. Backflow prevention RPBFP assemblies must be approved by the Foundation for Cross Connection Control and Hydraulic Research, University of Southern California (USC-FCCCHR).
4. Backflow prevention assemblies used or installed under this contract must be tested by a “Certified Backflow Control Assembly Tester” who possesses a current (within three years from date of issuance) certificate that confirms successful completion of an approved (USC-FCCCHR or Colorado Environmental Training Center, Golden, Colorado) training course.
5. The contractor must perform an operational test on any new or relocated backflow prevention assemblies used or installed under this contract. Passing backflow preventers must be labeled with a tag indicating test performed, tester's initials, and date. Testing documentation must be submitted per Specification 01 33 00, “Submittals.”

6. Repairs to backflow preventer (BFPs) must be made with original manufacturer's parts.
7. Piping downstream of BFPs must be labeled "Nonpotable" or "NPW" in accordance with Section 23 00 50, "Basic Mechanical Materials and Methods."
8. RPBFP devices must be installed at a maximum distance of five feet from finished floor with a one-foot clearance maintained on all sides for ease of maintenance.
9. Adequate drainage must be provided for the RPBFP and must meet the following:

   a. Discharge must be piped full size (of the relief valve) and extend to a drain.
   b. Discharge piping must be sloped a minimum of 1/8" per foot.

I. Drains

1. Drains indicated on the drawings in connection with water distribution systems must be 3/4" hose bib with integral vacuum breaker, unless otherwise noted.

J. Equipment Connections

1. All piping connections to pumps and other equipment must be installed without strain at the pipe connection of the equipment.

   a. The contractor must, as directed by the SDR, remove the bolts in flanged connections or disconnect piping to demonstrate that the piping has been so connected.

2. Pipe connections to equipment must be made with unions, flanged fittings.
3. Eccentric reducers are required at pumps and other equipment for air removal.
4. Install water heaters per IPC.

K. Water Hammer Arrestors

1. Sizes and locations of water hammer arrestors must be as indicated on the drawings and must be installed in an easily accessible location.

L. Joining Dissimilar Materials (Copper to Steel)

1. Use brass nipples, brass valves, or brass unions between copper and steel piping 2" and smaller. Use dielectric flanges on larger piping. Dielectric unions must not be used.

M. Insulation

1. Insulation of all pipes, valves, fittings, and equipment must be in accordance with Section 22 07 16 "Plumbing Equipment Insulation," and Section 22 07 19 "Plumbing Piping Insulation," unless noted otherwise on the drawings.

N. Identification and Labels

1. All plumbing systems must be labeled and identified in accordance with Section 23 00 50, "Basic Mechanical Materials and Methods."

O. Chlorine Injection Port

1. A 3-way ball valve or an approved cleanout port must be installed on the new line directly off of the existing main to aide in the sterilization tests of new water lines.

P. Relief Valves

a. Discharge from relief valves located inside buildings must be piped full size and extended to a floor sink or to the outside of the building. Potable water lines must be either turned down toward the ground and terminated 6" above the ground, or piped to a drain. Piping must not have any trapped sections and must be sloped 1/8" per foot.
b. No valves of any type must be placed between the relief valve and the equipment to be protected.
c. Install a union on the discharge of relief valves with threaded connections.

Q. Escutcheons

1. See Spec Section 23 00 50, “Basic Mechanical Materials and Methods” regarding requirements for wall, ceiling, and floor penetrations of piping in occupied areas.

R. Access doors

1. See Spec Section 23 00 50, “Basic Mechanical Materials and Methods” regarding requirements where maintenance access is required (at shut-off valves, trap primers, shock absorbers, BFPs, etc).

3.2 Soil, Waste, and Vent Piping Installation

A. Soil, Waste, and Vent Piping

1. Must be installed in accordance with the IPC.
2. All excavation and backfill must be in accordance with Section 31 20 00, “Earthwork.”

3.3 Polypropylene and PVDF Piping Installation

A. General

1. Fusion and mechanical joints must be installed by manufacturer certified experienced pipe fitters and as according to the manufacturer's instructions. The contractor must provide all tools and equipment necessary for proper installation. The contractor must provide for supports and thermal expansion to meet the manufacturer's recommendations.

B. Horizontal Piping

1. Support horizontal piping at end of branches and at change of direction or elevation. Clamp piping to control thermal expansion according to manufacturer's installation instructions.

C. Vertical Piping

1. Support risers with standard riser clamp or wall brackets.

D. Air Plenums

1. Piping installed in air plenums must be installed with piping materials that have a flame/smoke rating of 25/50 or less per ASTM E84, or piping must be wrapped with 3M Fire Barrier Plenum wrap to meet a flame/smoke rating of 25/50 or less per ASTM E84.

3.4 Fixture and Equipment Installation

A. General:

1. All fixtures and equipment must be installed complete with all accessories and trim required for proper installation.

B. Fixtures:

1. Fixtures must be firmly bolted to wall, floors, or carriers in accordance with the manufacturer's rough-in and setting requirements and drawings. The contractor must make proper provision for hanging and setting fixtures and accessories during building construction. Where “rough-in only” is specified, rough-in must include stop valves on all service lines and waste line must be capped, ready for installation of trap by others. All fixtures must be installed square with the wall, in line, and level to provide a skillful and uniform appearance.

C. Equipment

1. Equipment must be installed in accordance with the manufacturer's directions and must be supported and fastened in a satisfactory manner.

D. Traps

1. Each fixture and piece of equipment connecting to the drainage system must be equipped with a trap. Each trap must be placed as near to the fixture as possible and there must be no double-trapped fixtures.

3.5 Tests

A. General

1. All plumbing, piping, equipment, and fixtures installed under this contract must be inspected and tested by the contractor before insulation is installed, in the presence of the Sandia Construction Observer (SCO), and approved before acceptance. The contractor must furnish all labor, material, and equipment required for testing. The contractor must be responsible for all repairs and retesting as required. All instruments and other equipment whose safe pressure range is below that of the test pressure must be removed from the line or blanked off before applying the tests. Prior to performing hydrostatic tests (see below), all lines must be “blown” free of all loose dirt and foreign particles. The lines must then be thoroughly flushed with potable water at a sufficient flow rate and period to ensure complete cleaning of the lines of all dirt, scale, and foreign matter. Satisfactory cleaning and flushing of the lines must be subject to approval by the SCO.

a. For tests, the contractor must provide a calibrated 4-inch diameter pressure gauge of maximum 1% full-scale accuracy, maximum 200 psig range, and maximum 2 psig graduations.

B. Water System

1. Upon completion of the rough-in and before setting fixtures, the entire hot and cold water piping systems installed under this contract must be hydrostatically tested at a pressure of no less than 150 psig and must show no drop in pressure in a two-hour period. Where a portion of the water piping system is to be concealed before completion, this portion must be hydrostatically tested separately in the same manner as prescribed for the entire system.

C. Sanitary System

1. The sanitary soil, waste, and vent piping installed under this contract must be tested by plugging all outlets and filling the lines with water to the level of the highest vent stack above the roof. The system must hold this water for one hour without showing a drop in level. Where only a segment of the system is to be tested, the test must be conducted in the same manner as prescribed for the entire system, except that a vertical stack supplying at least 10-foot head of water pressure must be installed above the highest horizontal line to be tested. The contractor must install suitable fittings, such as plugged tees, if such fittings are required to isolate portions of the system for the test. The segment of the system being tested must hold this water pressure for one hour without showing a drop in level. All joints must be inspected for visible leaks, and all leaks must be repaired before the placing of the system into service. All soil or waste piping located underground must be tested before backfilling.

D. Final Plumbing Fixture Test

1. Upon installation of the plumbing fixtures, appurtenances, or appliances having water and/or waste connections, and before the general use thereof, all water and waste connections must have been proved tight, without defects or leaks, by such operating tests as directed by the SCO.

3.6 Disinfection

Potable water piping installed under this contract must be disinfected before it is placed in operation. Piping must be disinfected after testing and flushing is performed per section 3.5A.

A. SNL-Performed Work

1. Quality Testing:

a. SNL will perform water quality testing of water samples taken from piping systems for chlorine concentrations and bacteriological quality. SNL will approve use of disinfected piping when test results demonstrate compliance with water quality requirements of the Safe Drinking Water Act.

b. Notify the SDR at least 48 hours in advance to arrange for a bacterial quality or free total chlorine concentration test.

c. Requirements for demonstration of compliance with the Maximum Containment Level of the Safe Drinking Water Act:

1) Total-chlorine-concentration of less than 1 milligram per liter (mg/L) (1 parts per million [ppm]).
2) The absence of any coliform bacteria.
3) Less than 200 non-coliform bacteria per 100 mL.

B. Chlorination of Piping

1. Inject sodium hypochlorite solution (bleach) containing 5% to 6% available chlorine, or 50,000 to 60,000 ppm into down stream of the main valve with a high pressure, low volume metering pump while the water is flowing at a given flow rate. After a chlorine residual of 25 ppm minimum is detected at each faucet of fixture (using a high-range chlorine test kit), the chlorine is allowed to remain in the pipes for at least 24 hours.
2. At the end of a 24-hour period, treated water in all portions of piping must have a free chlorine concentration of no less than 10 ppm. If the chlorine residual is less than 10 ppm, repeat the entire procedure. After residual free chlorine concentration test has been completed, flush the entire system with potable water until total chlorine concentration at all faucets and fixtures is less than 1 ppm.
3. Dispose of or neutralize heavily contaminated water under the direction of SNL Pollution Prevention and Environmental Monitoring Department.
4. After flushing, contact the SDR to arrange for final total chlorine concentration and bacteriological quality test.

C. Repairing or Cutting into Existing Mains

1. New interior piping surfaces must be swabbed with a 1% hypochlorite solution. The section being modified must be subjected to a high chlorine disinfection process per AWWA C651, section 9. The concentration must be a minimum of 300 mg/l for 15 minutes. At the end of the prescribed time period, flush affected piping with potable water until total chlorine concentration is less than 1 ppm.
2. After flushing, contact the SCO to arrange for final total chlorine concentration and bacteriological quality tests. Water systems affected by chlorination may not be returned to service until test results have been reviewed and potability has been proven.

END OF SECTION 22 30 00

Exceptional service in the national interest

Sandia National Laboratories

Section 22 63 13 – Gas Piping for Laboratory Facilities

August 2019

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

SECTION 22 63 13 – GAS PIPING FOR LABORATORY FACILITIES

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to fit new Masterspec format.
10/26/16	Russ Matheson; Jennifer Sawayda	Admin	1.4 - Quality Assurance; added reference to 230050 in ASME compliance; spelled out acronyms
06/19/19	Jennifer Sawayda	Subst	Three-year review performed; updated References section (mainly formatting); several changes to Section 2.1 (including deletion of #4-7; deletions under Section 3., including table, and Section 3.3; deletion of some of the compressed gas systems under 3.5C; removed disclaimer

SECTION 22 63 13 – GAS PIPING FOR LABORATORY FACILITIES

PART 1 - General

1.1 Summary

A. This section includes materials and operations required for the installation of interior, low-pressure (below 150 pounds per square inch gauge [psig]) compressed gas piping systems, including argon, helium, nitrogen, and oxygen, piping, fittings, valves, equipment, joints, and tests.

1.2 References

Related Sections: Refer to the following sections for related work:

A. Section 23 05 29, "Hangers and Supports for Piping and Equipment"

B. Sandia National Laboratories (SNL) Construction Standards and Specifications

C. American Society of Mechanical Engineers (ASME)

Number	Title
B1.1	Unified Inch Screw Threads
B2.1	Pipe Threads (Except Dryseal)
B16.18	Cast Copper Alloy Solder Joint Pressure Fittings
B16.22	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
B31.1	Power Piping
B31.3	Process Piping

D. American Society for Testing and Materials (ASTM)

Number	Title
BPVC	Section IX, Welding and Brazing Qualifications
A269	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
A307	Standard Specification for Carbon Steel Bolts and Studs 60,000 psi Tensile Strength
A632	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small Diameter) for General Service
B280	Copper Tube for Air Conditioning and Refrigeration - ACR - Dimensions and Working Pressures
B819	Standard Specification for Seamless Copper Tube for Medical Gas Systems
G93	Standard Practice for Cleaning Methods and Cleanliness Levels for Materials and Equipment Used in Oxygen-Enriched Environments

E. American Welding Society (AWS)

Number	Title
	Brazing Manual, 3rd Edition, 1976
A5.8	Specification for Filler Metals for Brazing and Braze Welding
B2.1-8-005	Standard Welding Procedure Specification (SWPS) for Gas Metal Arc Welding (Short Circuit Transfer Mode) of Austenitic Stainless Steel (M-8, P-8, or S-8), 18 through 10 Gauge, in the As-Welded Condition, with or without Backing
B2.2	Specification for Brazing Procedure and Performance Qualifications

F. National Fire Protection Association (NFPA)

Number	Title
50	Standard for Bulk Oxygen Systems

G. Copper Development Association

1.3 Submittals

A. General: Submit the following in accordance with Conditions of Contract documents and Section 01 33 00, "Submittal Procedures:"

B. Product Data: Submit product data for products used in Interior Compressed Gas Piping. Product data must indicate the maximum allowable operating pressure and temperature of each component and any related manufacturing standard.

C. As-Built Drawings

1. On completion of the work, the Contractor must revise all drawings with a red marker to agree with the construction materials, capacities, locations, and routing as actually accomplished. The notation "As-Built" must be entered in the revision block, dated, and initialed.

D. All certifications for welders and brazers, and welding and brazing procedures, must be submitted for verification of quality assurance at least two weeks before starting any work. The procedures and certifications are reviewed by the SNL-designated certified welding inspector. Retain paragraph below if project includes vacuum systems for healthcare facilities.

1.4 Quality Assurance

A. Qualify welding/brazing processes and welder/brazer performance in accordance with AWS B2.2 or ASME Boiler and Pressure Vessel Code, Section IX. Certify that each welder/brazer has satisfactorily passed AWS or ASME qualification tests for welding/brazing processes involved and, if pertinent, has undergone recertification.

B. Welding and brazing procedures must address cleaning, joint clearance, overlaps, internal purge gas, purge gas flow rate, and filler metal.

C. ASME compliance:

1. Welded pipe shall comply with the guidelines as specified in 23 00 50 – "Basic Mechanical Materials and Methods," part 1; section 1.5; paragraph C.

D. Certification of procedures and operators applies for both shop and job site welding and brazing of pipe work.

E. Soldering is to conform to ANSI/ASME B31.1, Power Piping, and the Copper Development Association recommended practices.

F. Operators must have completed the SNL Welding Safety Class.

G. Performance qualification of welders/brazers must remain in effect indefinitely unless the welder/brazer does not weld or braze with the qualified procedure for a period exceeding 12 months by proof of continuity logs, or there is a specific reason to question the ability of the welder/brazer.

1.5 Delivery, Storage, and Handling

A. Deliver materials to the job site in good condition and properly protected against damage to finished surfaces.

1. Storage on Site: Store materials in a location and in a manner to avoid damage. Stacking must be done to prevent bending.

B. Store metal components and materials in a clean, dry location. Cover with waterproof paper, tarpaulin, or polyethylene sheeting to permit circulation of air inside the cover.

C. Keep handling onsite to a minimum. Exercise care to avoid damage to material finishes.

D. Pipe, fittings, and valves specified for "Cleaned and Packaged for Oxygen Service" must be capped and bagged until use.

PART 2 - Products

2.1 Materials

A. General: Materials must be as follows unless otherwise indicated on the applicable contract drawings (materials and fittings of equal quality and characteristics may be substituted for those listed in this specification):

1. Piping, fittings, valves, and other components that are required to be "Cleaned and Capped/Packaged for Oxygen Service" must be per ASTM G93.
2. Pipe and fittings to be used for modifications or additions must be the same material (steel or copper) as the existing systems being modified but must conform to the following unless otherwise indicated on the applicable contract drawings:

   a. Argon, Helium, and Nitrogen Systems (150-psig and under) Stainless Steel or ½-inch copper tube (⅝-inch O.D.) and larger:

1) Piping: Cleaned for oxygen service, Type L, hard drawn copper tubing, ASTM B280 or ASTM B819, and conforming to ANSI/ASME B31.3. Seamless, Type 304 stainless steel, ASTM A269, fully annealed with a hardness of Rockwell b (Rb 80 or less, cleaned and capped for oxygen service). Minimum tube wall thickness must be ⅛-inch outside diameter (O.D.) – 0.028-inch wall thickness (w.t.), ¼-inch O.D. – 0.035-inch w.t., ⅜-inch O.D. – 0.035-inch w.t., ½-inch O.D. – 0.035-inch w.t.
2) Fittings: Wrought-copper brazed-joint, ANSI/ASME B16.22. Cast copper fittings in sizes over 3-inch diameter (where wrought copper is not available), ASTM B16.18. Use brass-threaded adapters on brazed joints to minimize distortion of threads. All fittings must be cleaned and packaged for oxygen service. Two ferrule compression-type tube fittings, Swagelok or Parker A-lock® series. Tube fittings must be compatible with pipe material.
3) Ball Valves: Whitey® Series 60, brass body, stainless steel ball and stem, Teflon® seat, cleaned and packaged for oxygen service, 250-psig maximum working pressure.

3. Argon, Helium, and Nitrogen Systems (150-psig and under) ½-inch O.D. and smaller:

a. Piping: Seamless, Type 304 stainless steel, ASTM A269, fully annealed with a hardness of Rockwell b (Rb 80 or less, cleaned and capped for oxygen service). Minimum tube wall thickness must be ⅛-inch outside diameter (O.D.) – 0.028-inch wall thickness (w.t.), ¼-inch O.D. – 0.035-inch w.t., ⅜-inch O.D. – 0.035-inch w.t., ½-inch O.D. – 0.035-inch w.t.
b. Fittings: Two ferrule compression-type tube fittings, Swagelok or Parker A-lock® series. Tube fittings must be compatible with pipe material.
c. Ball Valves: Whitey 60 Series, 316 stainless steel body with stainless steel ball and stem and Teflon seat, cleaned and packaged for oxygen service.

4. Oxygen Systems (50-psig and under):

a. Piping: Type L hard drawn copper tubing, ASTM B280 or ASTM B819; cleaned and packaged for oxygen service. Seamless, Type 304 stainless steel, ASTM A269, fully annealed with a hardness of Rockwell b (Rb 80 or less, cleaned and capped for oxygen service). Minimum tube wall thickness must be ⅛-inch outside diameter (O.D.) – 0.028-inch wall thickness (w.t.), ¼-inch O.D. – 0.035-inch w.t., ⅜-inch O.D. – 0.035-inch w.t., ½-inch O.D. – 0.035-inch w.t.
b. Fittings: Wrought copper and bronze brazed-joint, ANSI/ASME B16.22, cleaned and packaged for oxygen service. Two ferrule compression-type tube fittings, Swagelok or Parker A-lock® series. Tube fittings must be compatible with pipe material.
c. Ball Valves: Whitey Series 60, brass body, stainless steel ball and stem, Teflon seat, cleaned and packaged for oxygen service, 250-psig maximum working pressure.

Note: Oil and oxygen may combine with explosive force. Comply with NFPA 50 and ASTM G93.

2.2 Equipment

A. All major items of equipment required for installation on this contract must be as specified on the applicable contract drawings and must be furnished completely with all accessories normally supplied with the catalog item listed and all other accessories necessary for a complete and satisfactory operating system.

B. Relief Valves: Shall be ASME constructed and stamped. Size, capacity, and setting must be as indicated on the drawings. Discharge from relief valves must be piped full size and extended to the outside where required by code, standard, or drawings.

C. Identification and Labels: All piping systems must be labeled and identified. Reference Section 23 00 50, "Basic Mechanical Materials and Methods"

D. Gauges: Gauges must be safety-type with rear blowout plug or panel, clear plastic cover, and sides and front consisting of one integral part. Range must be at least 1.2 times the system relief pressure. Gauges must be installed with snubbers and ¼-inch bronze needle valves. All gauges must be rated for the specific gas, pressure rating, and ambient conditions.

PART 3 - Execution

3.1 Preparation

A. On-site cleaning of the interior surfaces of materials in copper and stainless piping systems must be limited to recleaning surfaces in the immediate vicinity of the joints that have become contaminated prior to brazing or welding.

1. Surfaces must be cleaned by washing in a clean, hot water/alkaline solution of 1-pound tri-sodium phosphate to 3 gallons of water (protective gloves required). Scrubbing must be employed as required to ensure removal of dirt, metal filings, oil, and grease. After washing, materials must be rinsed in clear, hot water. Dry using Argon purge to <10 parts per billion (ppb) moisture level. After drying, materials must be plugged or capped until assembly.

3.2 Installation – General

A. General: Piping installation must be coordinated with all trades with respect to space available with heating, ventilating, and electrical installation. In every instance where there is a conflict in the routing of the piping and the ducting, the routing of the ducting must govern. Installed piping must not interfere with the operation or accessibility of doors or windows; must not encroach on aisles, passageways, or equipment; and must not interfere with the servicing or maintenance of equipment.

1. Pipe must be cut accurately to measurements established at the construction site and must be worked into place without springing or forcing, properly clearing all openings and equipment.
2. Cutting or weakening of structural members to facilitate piping installation is not permitted.

3. Pipes must have burrs removed by reaming and must be so installed as to permit free expansion and contraction without damage to joints or hangers.
4. Piping above ground must be run parallel with the lines of the building unless otherwise noted on the drawings. Piping connections to equipment must be in accordance with details shown on the drawings. Service pipe, valves, and fittings must be kept a sufficient distance from other work to permit finished covering not less than ½-inch from such other work, and not less than ½-inch between finished covering on the different services.
5. Any penetrations through fire walls should be firestopped in accordance with Section 07 84 13, "Penetration Firestopping."

B. Reducers: Reduction in pipe sizes must be made with one-piece reducing fittings. Bushings reducing at least two pipe sizes will be acceptable only when there is no room for reducing couplings or swaged nipples.

C. Unions: All piping unions must be of the ground joint type constructed from materials equivalent in alloy composition and strength to other fittings specified with which they are used. Union pressure classes and end connections must be the same as the fitting used in the lines with the unions. Steel unions must have hardened stainless steel seating surfaces on both faces.

D. Valves: Valves must be installed at the locations shown on the drawings and where specified. All valves must be installed with their stems horizontal or above.

3.3 Joints

A. Screwed Joints: Screwed pipe joints must have American Standard Taper Pipe Threads ANSI/ASME B1.2. Burrs formed when cutting pipe must be removed by reaming. Care must be taken that the inside of the pipe is thoroughly clean and free of cutting oil and foreign matter before installation. Joints must be made perfectly tight using Teflon tape or approved Teflon thread sealing and lubricating compound.

B. Brazed Joints: New copper systems must be installed per ASTM G93, with brazed socket type fittings and with an argon or nitrogen purge applied. Flux must not be used except where joining specialty items and fittings that are not available in copper. Brazing filler metals must comply with ANSI/AWS A5.8, Specification for Filler Metals for Brazing. Copper-to-copper joints must be brazed using a copper-phosphorus or copper-phosphorous-silver brazing filler metal (BCuP) without flux. Dissimilar metals, such as copper and bronze or brass, must be brazed using an appropriate flux with a silver brazing filler metal, AWS BAg series.

1. Tube ends must be cut square using a sharp tubing cutter. The wheel must be free of grease, oil, or other lubricant not suitable for oxygen service. The cut end of the tubing must be deburred with a sharp, clean deburring tool, taking care to prevent chips from entering the tube or pipe.
2. The surfaces to be brazed must be mechanically cleaned with a stainless-steel wire brush. The use of steel wool is prohibited due to the possible presence of oil. After mechanical cleaning, the surfaces must be wiped using a clean, lint-free white cloth. Joints must be recleaned if contaminated prior to brazing. Joints must be brazed within 1 hour of being cleaned.
3. Where dissimilar metals, such as copper and bronze or brass, are being brazed, flux must be applied sparingly to minimize contamination of the inside of the tube with flux. Where possible, short sections of copper tube must be brazed to the noncopper components and

the interior of the subassembly must be cleaned of the flux prior to installation in the piping system. Flux-coated brazing rods may be used in lieu of the application of flux to the surfaces to be joined for tubes ¾-inch size and smaller.

4. While being brazed, joints must be continuously purged with oil-free dry nitrogen or argon to prevent the formation of copper oxide on the inside surface of the joint. The flow of the purge gas must be maintained until the joint is cool to the touch.
   Exception: A final connection to an existing system must be permitted to be made without the use of a purge gas.
5. During and after installation, openings in the piping system must be kept capped or plugged to avoid unnecessary loss of purge gas and to prevent contamination. While brazing, a discharge opening must be provided on the opposite side of the joint from where the purge gas is introduced. During brazing, the purge gas flow rate must be maintained at a level that will not produce a positive pressure in the piping system. While welding, the minimum purge rate must be 15 standard cubic feet per hour (scfh) for ¼-inch tubing, and 25 scfh for all tubing ⅜-inch and larger.
6. After brazing, the outside of all joints must be cleaned by washing with water and a stainless-steel brush to remove any residue and permit clear visual inspection of the joint. Where flux has been permitted and used, hot water must be used.

C. Swagelok® Compression Fittings: Follow the manufacturer's installation instructions for assembly tubing and tube fittings. Use a sharp, clean, tube-cutter wheel to cut tubing. Remove burrs, chips, and scratches from the end of the tubing. Ensure that the tubing is fully bottomed in the fitting before final tightening. After assembly, check that the fitting is properly tightened by using a gap inspection gauge.

D. Welded Joints: Joints between sections of pipe and between pipe and fittings may be welded using either gas or electric welding equipment. Stainless steel welding must conform to ANSI/AWS B2.1-8-005. All pipe surfaces must be thoroughly cleaned before welding. Each joint, except socket-weld joints, must be beveled before being welded. The Contractor must provide a nonflammable mat or blanket to protect the structure and adequate fire protection equipment at all locations where welding is done. All elbows must be long radius where space conditions allow. Wherever tee connections are made to piping systems on the main run, welding sockets or weld-o-lets may be used in lieu of reducing outlet tees for branch connections up to one-half the size of the main run. On connections larger than one-half the size of the main run, welding tees must be used. The use of fittings formed from welded pipe sections will not be permitted.

E. Any welding work requires the following:

1. A Hot Work Permit from Fire Protection Engineering, located in MO119.
2. A dedicated fire watch during work through thirty (30) minutes after operation.
3. A minimum 2-A rated fire extinguisher located near the welding site.
4. Any other requirements listed on the permit.

3.4 Field Quality Control

A. General: All piping, equipment, and accessories installed under this contract must be inspected and tested by the Contractor in the presence of the Inspector and approved before acceptance. The Contractor must furnish all labor, material, and equipment required for testing. The Contractor must be responsible for all repairs and retesting as required. All instruments and other equipment whose safe pressure range is below that of the test pressure must be removed from the line or blanked off before applying the tests.

B. Brazed Joints: Each brazed joint must be visually examined after cleaning of the outside of the joint. The following conditions must be considered unacceptable:

1. Flux or flux residue
2. Excessive oxidation of the joint
3. Presence of unmelted filler metal
4. Failure of the filler metal to be clearly visible all the way around the joint at the interface between the socket and the tube
5. Cracks in the tube or component
6. Cracks in the braze filler metal
7. Failure of the joint to hold test pressure

Brazed joints that are found to be defective under conditions 1, 3, 4, 6, and 7 must be permitted to be repaired, except that no joint must be repaired more than once. Brazed joints that are defective under 2 and 5 must be replaced.

C. Blow Down and Purge Test: In order to remove particulate matter in the pipelines, a heavy, intermittent purging of each outlet must be performed with oil-free nitrogen. The outlet must be allowed to flow until the purge produces no discoloration in a white cloth.

D. Pressure Tests: Compressed gas piping must be tested at the test pressures specified and must not exceed the following drop in pressure (temperature compensated) in a 4-hour period. All system leaks must be located by soap testing.

Compressed Gas	Test Pressures	Test Gas	Max. Pressure Drop (4 Hrs)
Nitrogen Systems	225 psig	Nitrogen	0 psi
Argon Systems	225 psig	Nitrogen	0 psi
Helium Systems	225 psig	Nitrogen	0 psi
Oxygen Systems	150 psig	Nitrogen	0 psi

1. The pressure test must be conducted as follows:

   a. Equipment that is not to be tested such as relief valves and gauges must be removed and the openings plugged or capped.
   b. The system must be filled with the test gas to 25 psig and held while all joints are visually inspected for leaks.
   c. The pressure must be slowly increased to 150 psig and held while all joints are soap tested.
   d. The system must be increased to the test pressure and held for 4 hours and the pressure drop recorded for acceptance.
   e. Pressure must be relieved from the system and equipment that was removed must be reinstalled. The system must be pressurized to the operating pressure and joints at previously removed equipment must be soap tested.
   f. Leaks, if any, must be located, repaired, and retested.
   g. For the test, the contractor must provide a calibrated 4-inch diameter pressure gauge of maximum 1% full scale accuracy, maximum 300 psig range, and maximum 2 psig graduations. A digital pressure gauge of similar accuracy may also be used. If the

system is in an area where the temperature will fluctuate more than 10°F over the test period, then the contractor must also furnish an 8-inch temperature chart recorder or a combination temperature/pressure chart recorder or digital data logger. The pressure gauge must be calibrated annually.

END OF SECTION 22 63 13

Exceptional service in the national interest

Sandia National Laboratories

Section 23 00 50 – Basic Mechanical Materials and Methods

June 2017

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 23 00 50 – Basic Mechanical Materials and Methods

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to new Master spec style.
10/26/16	Russ Matheson; Jennifer Sawayda	Admin	Corrected reference to ANSI/ASME B31.1 in Quality Assurance 1.5 : C.; spelled out acronyms
06/26/17	Jennifer Sawayda	Admin	Reviewed as part of 3-year cycle, no changes required
01/03/19	Jennifer Sawayda	Admin	Changed title of reference document; in Section 1.7, changed location to “site location”; added G to 2.3; added

			stenciled design information to A1 under Section 3.3; clarified 3.3B; added sentence to end of Section 3.6A; basic editing and updated numbers of referenced specs

Section 23 00 50 – Basic Mechanical Materials and Methods

Part 1 – General

1.1 Summary

Section includes the following basic mechanical materials and methods to complement other Division 22 and 23 Sections:

1. Manufacturer's directions
2. Altitude Ratings
3. Welding Requirements
4. Motor Efficiencies
5. Access Doors
6. Interruption of utilities
7. Cooperation with other trades
8. Cutting and patching
9. Mechanical sleeve seals
10. Escutcheons
11. Protection of materials and equipment
12. Roof curbs and bases
13. Concrete base construction requirements
14. Nonshrink grout for equipment installations
15. Special openings
16. Welding foundations
17. Alteration and removal work
18. Tools
19. Protection from rotating parts
20. Shaft alignment
21. Belts and pulleys
22. Cleaning
23. Identification tags and labels
24. Metal and Wood Equipment Supports
25. Pressure vessels
26. Final adjustments
27. Touchup painting and finishing.

A. Nonexistent Conditions or Requirements:

These specifications are general in scope and may contain provisions or requirements that are not applicable to this construction project. Any provision or requirement of this specification which pertains to a nonexistent condition or requirement shall have no meaning in the contract and shall be disregarded.

1.2 References

A. American Standards Institute, ANSI

A13.1, "Scheme for Identification of Piping Systems"
B31.9, "Building Services Piping"

B. American Society of Mechanical Engineers, ASME

"Boiler and Pressure Vessel Code"

C. American Society of Heating, Refrigeration, and Air-Conditioning, ASHRAE

Std. 90.1, “Energy Standard for Buildings except Low Rise Residential Buildings”

D. American Welding Society, AWS

D1.1, "Structural Welding Code -- Steel"

E. American Society of Testing and Materials, ASTM

A515, "Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service"

A53, "Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless"

C1107, "Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)"

D709, "Standard Specification for Laminated Thermosetting Materials"

1.3 Definitions

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoors' ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.4 Submittals

A. All material and equipment lists submitted for approval shall conform to the requirements of Section 01 33 00, "Submittal Procedures."

1.5 Quality Assurance

A. Pressure Vessels: Prior to installation and acceptance, any power boiler, low-pressure heating boiler, or unfire pressure vessel operated at pressures of 15 pounds per square inch or greater, furnished under this contract will be stamped with ASME Boiler and Pressure Vessel Code Symbol and a National Board of Boiler and Pressure Vessel Inspector's number. This will certify that the vessel has been fabricated and tested per the provisions of the ASME Boiler and Pressure Vessel Code. Manufacturers' data reports (unless exempted by the ASME Code) will be filed with the National Board in Columbus, Ohio. Two copies of these data reports shall be submitted to Sandia National Laboratories (SNL). Testing, certification, and registration will be at the expense of the Contractor. ASTM A-515 and ASME SA-515 type steels shall not be used in the fabrication of pressure vessels.

B. Any boilers or pressure vessels operated at pressures stated above, utilized by the Contractor in his performance of the work, will be similarly tested and certified before being brought on the project and annually thereafter so long as they are used on the project site.

C. Welding: All welding on pressure piping shall conform with the requirements of the American National Standards Institute, Code for Pressure Piping, ASME B31.9, "Building Services Piping." The examination method employed will be as prescribed by the Sandia Delegated Representative (SDR). The SDR shall have the right to inspect all welds by any nondestructive examination method of choice or by removing welds and subjecting them to mechanical tests. The inspection may be made during or after the weld has been completed. The acceptance criteria for nondestructive evaluation (NDE) will be as specified in B31.9 under the NDE method used. The frequency of inspection shall be as specified by the SDR but at a minimum 5% of welds will be inspected with additional welds inspected at the discretion of the SDR if defects are found. Faulty welds shall be removed at no additional cost to SNL. NDE shall be performed by others at no additional cost to the Contractor. Any costs for re-test of failed welds that have been repaired will be borne by the contractor and not be accepted until all welds meet the requirements of ASME B31.9, "Building Services Piping." All re-tests shall employ the same NDE method that originally exposed the defect.

D. Equipment Selection: Equipment of different type, electrical characteristics, physical dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical and electrical services, circuit breakers, conduits, motors, bases, and equipment spaces are increased. All related modifications necessary to allow for changes shall be at the contractor's expense. If minimum energy ratings or efficiencies of equipment are specified, equipment must meet design and commissioning requirements.

1.6 Delivery, Storage, and Handling

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and prevent entrance of dirt, debris, and moisture.

B. Protect stored pipes, tubes, and equipment from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

D. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

E. Equipment shall be tightly covered and protected against dirt, water, and chemical or mechanical injury. At completion of all work, the materials and equipment shall be thoroughly cleaned.

F. Cover the ends of ducts stored outdoors with plastic to prevent contamination by dirt, debris, and moisture.

1.7 Project Conditions

A. Altitude Ratings: Unless otherwise noted, all specified equipment capacities, air quantities are for an altitude of the site location. Adjustments to manufacturers' ratings must be made accordingly.

1.8 Sequencing and Scheduling

A. Coordinate mechanical equipment installation with other building components.

B. The contractor shall refer to other parts of these specifications covering the work of other trades, which must be carried on in conjunction with the mechanical work, so that the construction operations can proceed without interference or delay.

C. Arrange for pipe spaces, duct spaces, chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.

D. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components, as they are constructed.

E. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning before closing in building.

F. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services.

G. Coordinate requirements for access panels and doors if mechanical items requiring access are concealed behind finished surfaces. Access panels and doors are specified in Section 08 11 13 "Steel Doors and Frames."

H. Coordinate installation of identifying devices after completing covering and painting, if devices are applied to surfaces. Install identifying devices before installing acoustical ceilings and similar concealment.

I. Interruption of Mechanical Utilities: The Contractor shall not interrupt any main interior or exterior mechanical utility without written request for an outage and a subsequent approval by SNL personnel, nor shall he/she interrupt any branch line to an outlet or item of equipment without verbal approval from the Sandia Construction Observer (SCO).

1. Written request for outages shall be submitted using the Outage Request Worksheet, according to the instructions and advance notice requirements on the Worksheet.
2. Unless otherwise noted on the drawings, or directed, any tie-ins or connections to existing utilities or equipment that necessitate interruptions of service shall be performed during non-standard hours.
3. The work to be performed during the interruption will be preceded by all possible preparation and will be carefully coordinated to minimize the duration of the interruption. Work will proceed continuously until the system is restored to normal.
4. Unless otherwise directed, the manipulation of existing main valves to isolate piping, the shutdown of fans, pumps, and other equipment will be done by SNL maintenance personnel.

Part 2 – Products

2.1 Mechanical Sleeve Seals

A. Description: Modular design, with interlocking rubber links shaped to continuously fill annular space between pipe and sleeve. Include connecting bolts and pressure plates. Seals shall be insulating type and rated for the temperature service of the pipe system.

2.2 Piping Specialties

A. Sleeves: The following materials are for wall, floor, slab, and roof penetrations:

1. Steel Sheet Metal: 24 gauge minimum thickness, galvanized, round tube closed with welded longitudinal joint.
2. Steel Pipe: ASTM A 53, Type E, Grade A, Standard, Black Pipe, plain ends.
3. Cast Iron: ASTM A74

B. Escutcheons: Manufactured wall, ceiling, and floor plates; deep-pattern type if required to conceal protruding fittings and sleeves.

1. Inside Diameter: Closely fit around pipe, tube, and insulation of insulated piping.
2. Outside Diameter: Completely cover opening.
3. Cast Brass: One piece, with setscrew.

    a. Finish: Polished chrome-plate.

4. Cast Brass: Split casting, with concealed hinge and setscrew.
    a. Finish: Polished chrome-plate.
5. Stamped Steel: One piece, with setscrew and chrome-plated finish.
6. Stamped Steel: One piece, with spring clips and chrome-plated finish.
7. Stamped Steel: Split plate, with concealed hinge, setscrew, and chrome-plated finish.
8. Cast-Iron Floor Plate: One-piece casting.

2.3 Identifying Devices and Labels

A. General: Manufacturer's standard products of categories and types required for each application as referenced in other Division 22 and 23 Sections. If more than one type is specified for application, selection is Installer's option, but provide one selection for each product category.

B. Equipment Nameplates: Metal nameplate with operational data engraved or stamped; permanently fastened to equipment. Shall be installed by the manufacturer or contractor.

1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliance, and similar essential data.
2. Location: Accessible and visible location.

C. Stencils: Standard stencils, prepared for required applications with letter sizes complying with recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4-inch high letters for ductwork and not less than 3/4-inch high letters for access door signs and similar operational instructions.

1. Stencil Paint: Standard exterior-type stenciling enamel; black, unless otherwise indicated; either brushing grade or pressurized spray-can forms and grade.

D. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, permanent adhesive, color-coded, pressure-sensitive vinyl, complying with ASME A13.1.

E. Engraved Plastic-Laminate Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated.

1. Fabricate in sizes required for message.
2. Engraved with engraver's standard letter style, of sizes and with wording to match equipment identification.
3. Punch for mechanical fastening.
4. Thickness: 1/8 inch, unless otherwise indicated.
5. Fasteners: Self-tapping stainless-steel screws or contact-type permanent adhesive.

F. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated on the drawings. Use numbers, lettering, and wording indicated for proper identification and operation/maintenance of mechanical systems and equipment.

G. Metal tags for outside piping/valves and inside valves shall be 1½″ round nonferrous metal with ½″ stamp numbers. Hung with chain length as needed. Valve schedule shall be posted in mechanical rooms

2.4 Grout

A. Epoxy Grout for Equipment Bases: Loctite Fixmaster Deep Pour Grout, Product No. 99545.

2.5 Motors

A. Unless stated otherwise on the drawings, the minimum efficiency of motors shall comply with Table 10.2 of ASHRAE 90.1 – 2013.

Part 3 – Execution

3.1 Piping and Duct Systems – Common Requirements

A. General: Install piping and duct work as described below, unless piping Sections specify otherwise. Individual Division 22 and 23 piping Sections specify unique piping installation requirements.

B. General Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and duct systems. Indicated locations and arrangements were used to size pipe and ducts and calculate friction loss, expansion, pump/fan sizing, and other design considerations. Install piping and ducts as indicated, unless deviations to layout are approved by the SCO.

C. Install components with pressure rating of 1.5 times or greater than system operating pressure.

D. Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.

E. Install piping to allow application of insulation plus 1-inch clearance around insulation.

F. Install pipe escutcheons in finished spaces for pipe penetrations of concrete and masonry walls, wall board partitions, and suspended ceilings according to the following:

1. Bare Piping Wall and Ceiling Escutcheons: Cast brass or stamped steel one piece, with setscrew, and polished chrome-plated finish. Use split-casting escutcheons if required, for existing piping.
2. Insulated Piping: Cast brass or stamped steel; with concealed hinge, spring clips, and chrome-plated finish.
3. Uninsulated Piping Floor Plates: Cast-iron floor plates.

G. Install sleeves for pipes passing through interior concrete and masonry walls, fire rated gypsum-board partitions and walls, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Build sleeves into new walls and slabs as work progresses.
3. Install sleeves large enough to provide a minimum 1/2-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

   a. Steel Pipe Sleeves: For pipes smaller than 6-inch Nominal Pipe Size (NPS).
   b. Steel, Sheet-Metal Sleeves: For pipes 6-inch NPS and larger, penetrating gypsum-board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Section 07 62 00, "Sheet Metal Flashing and Trim" for flashing.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using elastomeric joint sealants. Refer to Section 07900, "Joint Sealants" for materials.
5. Use Type S, Grade NS, Class 25, Use O, neutral-curing silicone sealant, unless otherwise indicated.

H. Aboveground, Exterior-Wall, Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches in diameter and larger.
3. Assemble and install mechanical sleeve seals according to manufacturer's written instructions. Tighten bolts that cause rubber sealing elements to expand and make watertight seal.

I. Underground, Exterior-Wall, Pipe Penetrations: Install steel pipe sleeves furnished with continuously welded water stop and anchor plate. Core drilled openings are permitted if approved ahead of time by the SCO. Seal pipe penetrations using mechanical sleeve seals. Size sleeve to meet the requirements of the mechanical seal manufacturer.

J. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestopping materials. Refer to Section 07 84 13, "Penetration Firestopping" for materials.

K. Verify final equipment locations for roughing-in.

3.2 Equipment Installation – Common Requirements

A. The Contractor shall install equipment in strict accordance with the directions and recommendations furnished by the manufacturer. Prior to installation of equipment, the contractor shall have on-site the original equipment manufacturer's (OEM's) installation requirements for the particular equipment for reference by the installing trade and the SNL inspector (SCO). This working copy of the installation instructions is in addition to any installation instructions required in the submittal list. Where such directions are in conflict with the plans and specifications, the Contractor shall inform the SCO of such conflict before proceeding with the work.

B. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

3.3 Labeling and Identifying

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.

1. Self-sticking vinyl pipe markers (internal) or stenciled painted signs (external), with application systems and flow direction arrows. Install on insulation segment if required for hot, uninsulated piping.
2. Locate pipe markers as follows if piping is exposed in finished spaces, machine rooms, and accessible maintenance spaces, such as shafts, tunnels, plenums, and exterior nonconcealed locations:

   a. At each valve and control device.
   b. At each branch, excluding short takeoffs for fixtures and terminal units. Mark each pipe at branch, if flow pattern is not obvious.
   c. Near locations if pipes pass through walls, floors, ceilings, or enter nonaccessible enclosures.
   d. At access doors, manholes, and similar access points that permit view of concealed piping.
   e. Near major equipment items and other points of origination and termination.
   f. Spaced at maximum of 25-foot intervals along each run. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

B. Equipment: Install engraved plastic-laminate sign or equipment marker for internal installations or a corrosive resistant metal sign for external installations on or near each major item of mechanical equipment.

1. Lettering Size: Minimum 1/4-inch high lettering for name of unit if viewing distance is less than 24 inches, 1/2-inch high lettering for distances up to 72 inches, and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
2. Text of Signs: Provide name of identified unit. Include text to distinguish between multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Duct Systems: Identify air supply, return, exhaust, intake, and relief ducts with duct markers; or provide internal/external stenciled painted signs and arrows, showing duct system service and direction of flow.

1. Location: In each space, if ducts are exposed or concealed by removable ceiling system, locate signs near points where ducts enter into space and at maximum intervals of 50 feet.

D. Controls: All automatic controls, control panels, zone valves, pressure electric, electric pressure switches, relays, and starters shall be clearly tagged and identified. Wording shall be identical to that on the control diagram in the contract drawings.

E. Valves: All main service valves, including fire protection and all fuel valves located inside the building, shall be tagged and identified as to the type of service. All gate valves or stop cocks controlling branch mains or risers to various portions of the building shall be tagged and identified as to the areas served.

F. Adjusting: Relocate identifying devices as necessary for unobstructed view in finished construction.

3.4 Access Doors for Walls and Ceilings

A. Provide access doors in walls and rigid ceilings to access concealed valves, instruments, controls, and equipment. Unless shown otherwise on the drawings, the doors shall be minimum 16 gauge, galvanized steel with a prime coat finish suitable for painting, and compatible for the type of wall/ceiling system to be installed. The hinge shall be concealed, pivoting rod or piano hinge. The latch shall be screwdriver operated. Doors in fire rated walls and ceiling shall be Underwriters Laboratory (UL) rated and meet ANSI-UL 10B consistent with the rating for the wall/ceiling to be installed. Doors shall be sized to provide access for both operations and maintenance of concealed items.

3.5 Painting and Finishing

A. Refer to Section 09 90 00, "Painting" for paint materials, surface preparation, color-coding, and application of paint.

B. Do not paint piping specialties, which have factory-applied finish.

C. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 Concrete Bases

A. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3,000 pounds per square inch gauge, 28-day compressive-strength concrete, and reinforcement as specified in Section 03 30 00, "Cast-in-Place Concrete." When assembly is small and will be mixed by hand, use 5,000 pounds per square inch gauge, 28-day compressive-strength concrete.

3.7 Erection of Metal Supports and Anchorage

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Field Welding: Comply with AWS D1.1, "Structural Welding Code—Steel."

3.8 Erection of Wood Supports and Anchorages

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage to support and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.9 Demolition

A. All alteration and removal work, when required or specified, shall be as indicated in the applicable contract drawings or in the "Special Conditions." Work shall conform to the "Environment, Safety and Health for Construction and Maintenance Service Contracts" in Division 1 and the Section 02 41 13, "Selective Site Demolition" specification of SNL Specifications.

B. Disconnect and remove equipment and materials as specified in Division 15 Sections. Removal shall be done in a manner to protect the salvage value of the equipment or materials.

C. Construction affecting existing equipment containing chloroflourocarbons (CFC) refrigerants shall be done in accordance with the requirements in Division 22 and 23 Sections.

D. If pipe, ductwork, insulation, or equipment to remain is damaged or disturbed, remove damaged portions and install new products of equal capacity and quality.

E. Accessible Work: Remove indicated exposed pipe and ductwork in its entirety.

F. Work Abandoned in Place: Cut and remove underground pipe a minimum of 2 feet beyond face of adjacent construction unless indicated otherwise on the drawings. Cap and patch surface to match existing finish.

G. Removal: Remove indicated equipment from Project site. Unless indicated otherwise, equipment that is removed shall be delivered to Sandia Reclamation Yard (the Reapplication Yard is located south of Hardin Blvd., east of Wyoming Blvd.)

H. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.

3.10 Cutting and Patching

A. Cutting the work installed by other trades shall not be done without approval. Where cutting becomes necessary, the Contractor shall employ the trade, who originally installed the work to do the cutting and to restore such cutwork.

B. The cutting of structural members for the passage of ductwork, piping, or for hangar fastenings will not be permitted, except by prior written approval.

C. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of trades involved.

D. Repair cut surfaces to match adjacent surfaces.

3.11 Grouting

A. Install epoxy grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's written instructions.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placing of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases to provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout according to manufacturer's written instructions.

3.12 Adjustment and Cleaning

A. Shaft Alignment after Grouting: All motors and pumps (or drives) connected by a shaft coupling, whether factory or field assembled, shall be aligned during installation using a dial indicator or laser alignment tool applied to both ends of both shafts for a full 360 degrees prior to operation. Alignment of the shafts shall be less than the maximum allowable tolerances as recommended by the coupling or equipment manufacturer. Alignment of shafts shall be rechecked after several hours of operation and equipment has reached operating temperature.

B. Belts and Pulleys: All equipment 5 horsepower and over and all equipment with multi-belt drives shall be furnished with fixed sheaves. The Contractor shall make any changes or replacements of pulleys and belts required for correct balance of the system.

C. Protection from Rotating Parts: All belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts shall be fully enclosed or properly guarded.

D. Final Adjustments: The Contractor shall adjust all new heating, cooling, and plumbing equipment for proper operation, including calibration of all new control equipment and existing equipment as noted on the contract drawings.

E. Cleaning: At the completion of the work, all parts of the installation shall be thoroughly cleaned. All equipment, pipe, valves, and fittings shall be cleaned of grease, metal cuttings, and sludge, which may have accumulated by operation of the system before and after the testing. Any stoppage or discoloration, or other damage to parts of the building, its finish, or furnishings, due to the Contractor's failure to properly clean the system, shall be repaired by the Contractor.

3.13 Systems and Equipment Start-Up and Checkout

A. The contractor is responsible for the start-up and checkout of all systems and equipment. Start-up of equipment shall be in accordance with the manufacturer’s requirements and shall be performed by individuals knowledgeable with the equipment and its requirements. Provide start-up and checkout by manufacturer’s certified technicians when required by the manufacturer or as noted in the specifications and drawings. Prior to start-up of equipment, the contractor shall have on-site the OEM’s Operations and Maintenance (O&M) requirements for the particular equipment for reference by start-up personnel and the SCO. This working copy of the O&M instructions is in addition to any O&M manuals required in the submittal list.

B. The contractor shall operate systems and equipment at full and part load conditions to prove capability to meet specified requirements.

C. The contractor is responsible for coordinating all start-up activities and making systems and equipment ready for use. The contractor shall provide a start-plan two weeks prior to start-up of a system or equipment. The plan shall include:

1. Cleaning, filling, testing, and venting for piping and ductwork.
2. Adjustment, alignment, and calibration of equipment, instruments, hangers, and braces.
3. Scheduling of start-up personnel.
4. Start-up and functional performance testing.
5. Support for Test and Balance activities.
6. Training for SNL maintenance and operations personnel.

3.14 Special Tools

A. All special tools for the proper operation and maintenance of each system and major items of equipment shall be identified and installed in an acceptable location.

END OF SECTION 23 00 50

SPECIAL SPECIFICATION

SECTION 230533S

PIPING, EQUIPMENT AND GAS HEATING SYSTEMS

Page

SPECIAL SPECIFICATION

SECTION 230533S

PIPING, EQUIPMENT AND GAS HEATING SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings, equipment schedule and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. 230533S – Molten Salt Valves – Special Specification

C. 230719S – Piping Insulation – Special Specification

D. 232125S – Molten Salt Piping – Special Specification

1.02 SUMMARY

A. This Section includes pipe and equipment heating systems for pipe, salt tank immersion heaters, heat exchanger, expansion tanks and nitrogen (ullage) gas in-line heaters. Also included is industrial water piping heat trace heaters.

1. Molten salt piping and ullage gas piping shall be preheated to a minimum 500°C (932°F) using heat tape prior to flowing salt that has a freeze point of 400-440°C. The salt vapors have a freeze point of 480°C (896°F).
2. One immersion heater is required for the cold salt storage tank that operates at 500°C (932°F) and one immersion heater for the hot salt storage tank that operates at 720°C (1328°F). The nominal heater length is 20'-6" (after heater thermal growth). The minimum salt level (heel height) is 3'-9".
3. In-line nitrogen gas heaters are required for various functions such as preheating the nitrogen (ullage) gas from ambient temperature to 500°C (932°F). The ullage gas is used for creating a gas barrier in the salt pumps, salt flow control valves, expansion/surge tanks, and for back filling the salt distribution piping system when the system is drained down each late afternoon day.
4. The molten salt flow control valves shall be preheated using ceramic fiber heaters (clamshell style) to 500°C (932°F) normally. Each valve will have six heating control zones. There is a possibility that the salt could freeze in the

flow control valve; therefore, the maximum operating condition for the ceramic fiber heater shall be 720°C (1328°F).

5. The sodium to salt shell and tube heat exchanger shall be preheated using ceramic fiber heaters (clamshell style) to 500°C - 720°C (932°F - 1328°F) normally. The heat exchanger is approximately 19’-8” in length by 11” in diameter. The heat exchanger shall have 4 heating zones (2 zones 50% area on top and 2 zones on bottom 50% area). An illustration of the ceramic fiber heater application for the heat exchanger is found under Part 3 Execution of this specification.
6. The Hot and Cold Salt Pumps (Vertical Turbine) each have a bellows section between the pump sole plate and the salt storage tank nozzle. The bellows is 36-inches in diameter and 36-inches in length. The bellows section is to be heat tape. In addition the Hot and Cold vertical turbine pump discharge head is also to be heat taped per the requirements of the hot and cold salt piping.
7. Domestic water piping to the emergency shower/eyewash outdoor station and makeup water to the acid scrubber shall be freeze protected with self-regulating heat trace.

1.03 CODES, APPROVALS, AND STANDARDS

A. American National Standards Institute

B. FM Approvals

C. Institute Of Electrical and Electronics Engineers

D. National Electrical Code (NFPA 70)

E. National Electrical Manufacturers Association

F. National Electrical Safety Code

G. Underwriters’ Laboratories, Inc.

1.04 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.

1. Schedule indicating heating capacity, length of cable, length of lead, spacing, and electrical power requirement for each electric heating cable required. This is to be determined by the manufacturer/supplier based on the approved piping shop drawings and installed wattage amounts indicated in 3.03 of this specification.

2. Control Panel
   a) Layout drawing indicating description of major components, the location of the components, terminal blocks, wiring, etc.
   b) Wiring diagram indicating the manufacturer wiring and field wiring.
   c) Installation, start up and operation instructions.

B. Shop Drawings:

1. Electric heating cable.
   a) Include plans, sections, details, and attachments to other work.
   b) Layout drawing indicating the cable designation and the location of the cable.
   c) Wiring Diagrams: Power, signal, and control wiring.
   d) Installation instructions indicating the bending radius, spacing, attachment method, etc that applies to the specific product submitted.

1.05 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

B. Warranty: warranty specified in this Section.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.

1.07 QUALITY ASSURANCE

A. Electrical Panels, Control Panels, Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.08 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: 3 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 HIGH TEMPERATURE HEAT TAPE

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:
   1. HTS / Amptek, Industrial, Heavy Insulated Duo-Tape.

B. Maximum Maintain Operating Temperature (Energized): 650 deg. Celsius (1200 deg F). Maximum de-energized exposure temperature 760 deg. Celsius (1400 deg F).

C. Capacities and Characteristics:

   1. Heat Output: 104 W/ft
   2. Tape width: 1 inch
   3. Maximum Watt Density: 8.67 W/in²
   4. Operating Voltage: 277V
   5. Phase: Single
   6. Hertz: 60
   7. Two (2) wire.
   8. Knitted, serpentine construction yields maximum flexibility: 2 layers of braided AMOX™ yarn.
   9. High Temperature Lead Wires: 48 inches length on each end, multiple strand, nickel alloy conductor is covered with two layers of braided AMOX™ yarn.

D. Each cable shall be factory-terminated to the required length, consisting of the lengths required for the pipe or equipment, plus an allowance for areas of additional heat loss such as valves, flanges, fittings, supports, and the like, plus a reasonable excess to allow for field variations.

E. Heat tape shall be spiral wrapped around piping per manufacturer's installation instructions. Utilize Aremco Pyro-Tape 682, 1" wide wrapped around heat tape to hold position.

F. Each cable shall be shipped with the catalog number marked on the outside of the package, and a permanent metallic cable tag containing the heating cable Manufacturer, model number, length, wattage, voltage, and current draw and circuit number. See drawings for heat schedule and preliminary zoning layout.

G. A warranty against manufacturing defects for a period of 3 years shall be available.

H. The manufacturer/supplier of the heat trace shall determine the proper cables based on the approved piping shop drawings, the installed wattage amounts indicated in 3.03 A of this specification and the cable requirements indicated in section 2.01 of this specification.

2.02 IN-LINE NITROGEN GAS HEATERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:
1. Micropyretics Heaters International (MHI): Air Torch Model LTA.

B. See drawing equipment schedule for specific model number, sizes and capacity.

C. Maximum Continuous Operation: 900°C (1652°F).

D. Built-in Type “K” thermocouple.

E. Provided with BPAN power controller.

F. Install unit per manufacturer’s installation instructions.

2.03 IMMERSION TANK HEATER

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:

B. Wattco: Flanged Immersion Heater.

C. Properties:
1. Quantity: 1-2 heaters per cold tank and hot tank for a total of 2-4 heaters.
2. ANSI Class 150 RTJ flange heater, size 12-inch diameter.
3. Terminal Box Housing: NEMA 4X Water Proof.
4. Expanded Length: 20’-6” (Approximately, to be finalized after receipt of final approved salt tank shop drawings).
5. Chloride Salt: 40MgCl / 20 NaCl / 40KCl (molar weight)
6. Hot Storage Tank Operating Conditions: 720°C - 740°C (1328°F - 1364°F)
7. Cold Storage Tank Operating Conditions: 500°C - 520°C (932°F - 1428°F)
8. MAWP (Nitrogen Gas Blanket): 0.5 psig

D. Heating Power Requirements: 50 kW per tank

E. Available Electrical: 480V/3ph/60Hz

F. Minimum Tank Heel (Fluid) Height: 3’-9” from top of refractory to minimum salt level.

G. Maximum Tank Fluid Height: 14’-8” from top of refractory to normal operating salt level.

H. Heating Element: Inconel

I. Extra Heavy Duty Sheath: Hastelloy C-276, minimum wall thickness 0.065” thick.

J. Passivation: Chemically passivated sheaths.

K. Welded Elements: Hastelloy C-276.

L. Temperature Controls:
1. Factory manufactured control panel with SCR controllability.
2. Built-in Thermocouples: Type “K” or Type “E”.
3. Built-in High Limits

M. Stand-off terminal housing may be used to protect wire connections from excessive high temperature exposure.

2.04 CERAMIC FIBER HEATER

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:
1. DS Fibertech Corporation: Model CF-200 vacuum formed ceramic fiber.

B. Properties:
1. Continuous Energized Limit: 1000°C (1832°F)
2. Melting Point: 1790°C (3260°F)
3. Nominal Density: 288 kg/m³ (18 lb/ft³)
4. Dielectric Strength: 27 Volts/mil
5. Specific Heat: 1130 J/kg C at 1093°C (2000°F)
6. Maximum Allowable Shrinkage: 2% after 100 hours of firing
7. Electrical: 240V/1PH
8. Controllability: Separate SCR for each of the six heating zones.
9. Thermocouples: Type “E” or Type “C” Pyromation for each zone.

C. Resistance Heating Wire:
1. Acceptable Manufacturer: Kanthal
2. Model: A-1
3. Material: ferritic iron-chromium-aluminium alloy
4. Maximum Temperature: 1400°C (2552°F)

5. Creep Strength: 1.2 MPA (170 psig) at 800°C (1472°F) (1% Elongation in 1000 hr)
6. Electrical Resistivity: 1.4 ohm mm²/m
7. Young's Modulus: 150 GPa (22 Msi) at 800°C (1472°F)
8. Thermal Conductivity: 22 W/(m °K) at 800°C (1472°F)
9. Specific Heat: 800°C (1472°F) is 0.17 Btu/(lb. °F)
10. Melting Point: 1500°C (2732°F)
11. Emissivity (fully oxidized): 0.70

D. Heater shall be custom formed for the molten salt flow control valves and the sodium to salt heat exchanger. The valve body and bellows section shall be preheated to 500°C (932°F) minimum. See Part 3 Execution of this specification for valve zoning and drawing equipment schedule for additional information. The sodium to salt shell and tube heat exchanger shall be preheated using ceramic fiber heaters (clamshell style) to 500°C - 720°C (932°F - 1328°F) normally. The heat exchanger is approximately 19'-8" in length by 11" in diameter. The heat exchanger shall have 4 heating zones (2 zones 50% area on top and 2 zones on bottom 50% area).

E. Each flow control valve will having the following configuration for zone control:
1. Valve Body: 3 heating control zones
2. Bellows Section: 2 heating control zones
3. Bellows Purge Port: 1 heating control zone
   Extended Bonnet: No heating.

2.05 CONTROLS

A. The process-temperature maintenance system's control/distribution panels shall consist of an NEMA 1 enclosure including a panelboard with a main circuit breaker, zone circuit breakers, contactors, current switches, SCRs, current transmitters, and door mounted Hand-Off-Auto switches for each contactor. The individual zone overcurrent devices shall be bolt-in circuit breakers with ground-fault protection (30mA trip level). The entire control panel shall be UL listed as a unit.

B. Each heat trace leg connected to the piping system or valve bodies shall be switched by an external solid-state or mechanical contactor with a maximum rating of 60 Amps at voltages up to 600V installed in the panel. The coil voltage for these contactors shall be 24 VAC. Each contactor shall have an associated door mounted Hand-Off-Auto switch which will allow control of the contactor to be overridden locally. Control of the contactors shall be through the facility Process Equipment Control System (PECS) through the Auto side of the switch.

C. Each heat trace leg connected to a contactor shall be provided with a current switch to monitor when current is flowing to the heat trace leg. The currents switch shall have an adjustable switch setting to allow it to be set for the active current setpoint. Each current switch shall be connected to the PECS.

D. Each heat trace leg connected to a valve bonnet shall be provided with modulating SCR controls. The SCRs shall be controlled by the PECS through a 0-10 VDC signal and a contact closer to enable/disable.

E. Each heat trace leg connected to an SCR shall be provided with a current transmitter to monitor the current flowing to the heat trace. The current transmitters shall output a 0-10 VDC signal to the PECS.

2.06 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Comply with IEEE 515.1.

B. Heating Element: Pair of parallel No. 18 AWG, nickel-coated, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: Stainless-steel braid[and polyolefin outer jacket with ultraviolet inhibitor.

E. Maximum Operating Temperature (Power On): 150 deg F (65 deg C.)

F. Maximum Exposure Temperature (Power Off): 185 deg F (85 deg C).

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Capacities and Characteristics:

1. Maximum Heat Output: 10 W/ft. (32.8 W/m).
2. Piping Diameter: See drawings.
3. Number of Parallel Cables: 1.
4. Electrical Characteristics for Single-Circuit Connection:

    a. Volts: 120.
    b. Phase: single.
    c. Hertz: 60.

2.07 ACCESSORIES

A. Additional Gland fittings: Additional 10% of the total installed gland fittings shall be provided.

B. Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, installation clips, etc. as required by the manufacturer's installation instructions shall be supplied for a complete installation.. Materials shall be furnished by the manufacturer and shall be the product listed for the supplied cable and application.

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils (0.08 mm) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches : 3/4 inch minimum.

2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions. Coordinate with the pipe installers.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATIONS

A. Install the following types of electric heating cable for the applications described:

1. Temperature maintenance for solar salt process piping: Two wire Mineral insulated heat trace cable.

3.03 INSTALLATION

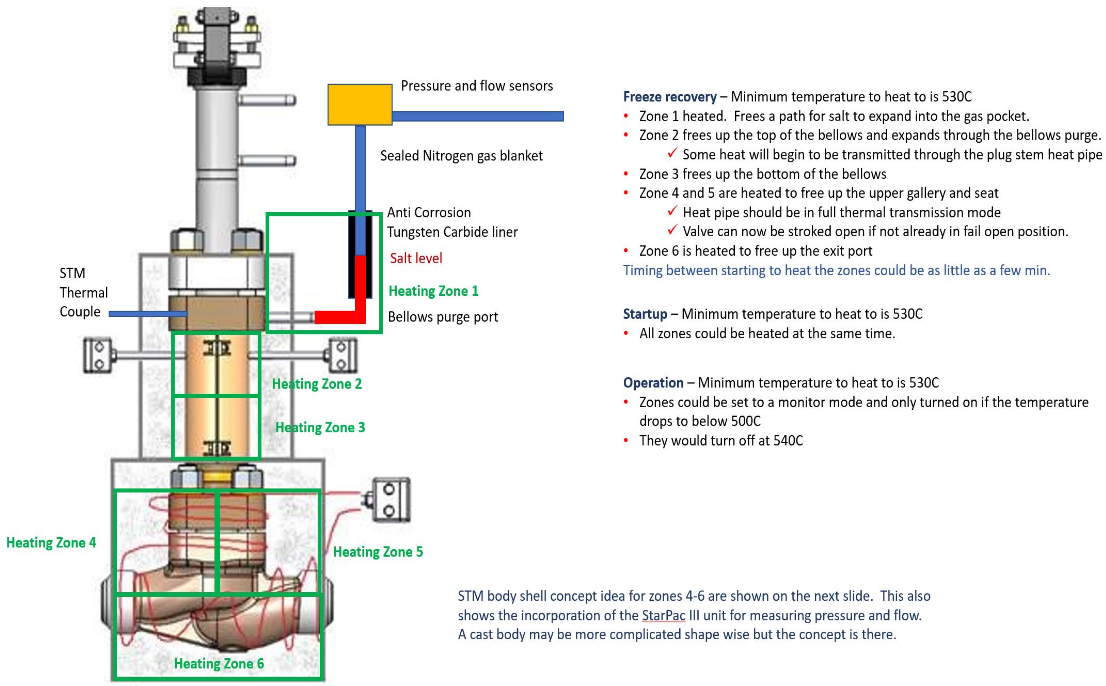
A. Electric Heating Cable Installation:

1. Install electric heating cables after piping has been tested and before insulation is installed.
2. Install electric heating cables according to IEEE 515.1.
3. Heat trace tape shall be installed in a spiral manner per manufacture's installation instruction.
4. See drawing equipment schedule for heat tape lengths, power and voltage requirements.
5. All hot to cold junctions and all hot to hot junctions shall be made outside of the insulation.
6. Coordinate the heat trace exiting the insulation to the hot to cold junctions and hot to hot junctions (heat trace flower) with insulator, heat trace installer, and pipe fitter so there are no hot spots.
7. Coordinate the cold lead placement for ease of connection and maintenance. Place the cold lead circuit connection so that rain and snow does not accumulate (the bottom one third of the piping).
8. Install the cables according to the manufactures recommended methods, bending radius and spacing.
9. Install cable with the manufacturers recommended attachment materials and according to the recommended attachment distances.
10. Install electric heating cables after piping has been tested and before insulation is installed.
11. Install electric heating cables according to IEEE 515.1.
12. Install insulation over piping with electric cables according to Section 230719S - Piping Insulation – Special Specification.
13. Install warning tape on piping insulation where piping is equipped with electric heating cables.
   a. Set field-adjustable switches and circuit-breaker trip ranges.

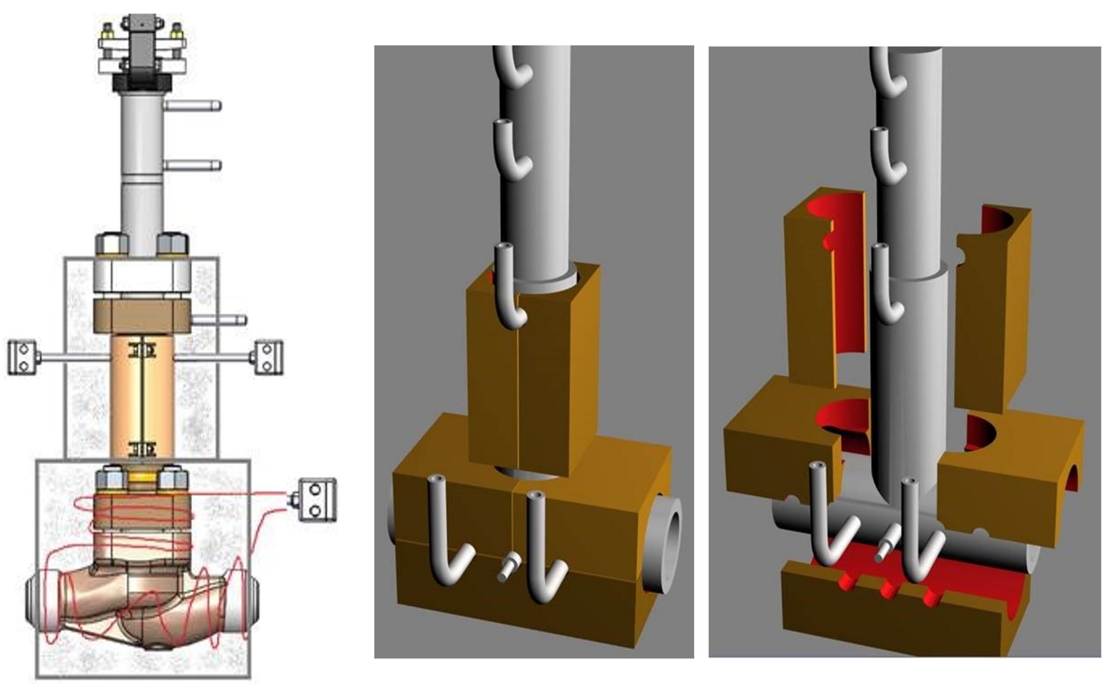
B. Protect installed heating cables, including non-heating leads, from damage.

3.04 SALT FLOW CONTROL VALVE HEATERS

A. The ceramic fiber heaters shall be cable of multi-zone control per the illustration below.

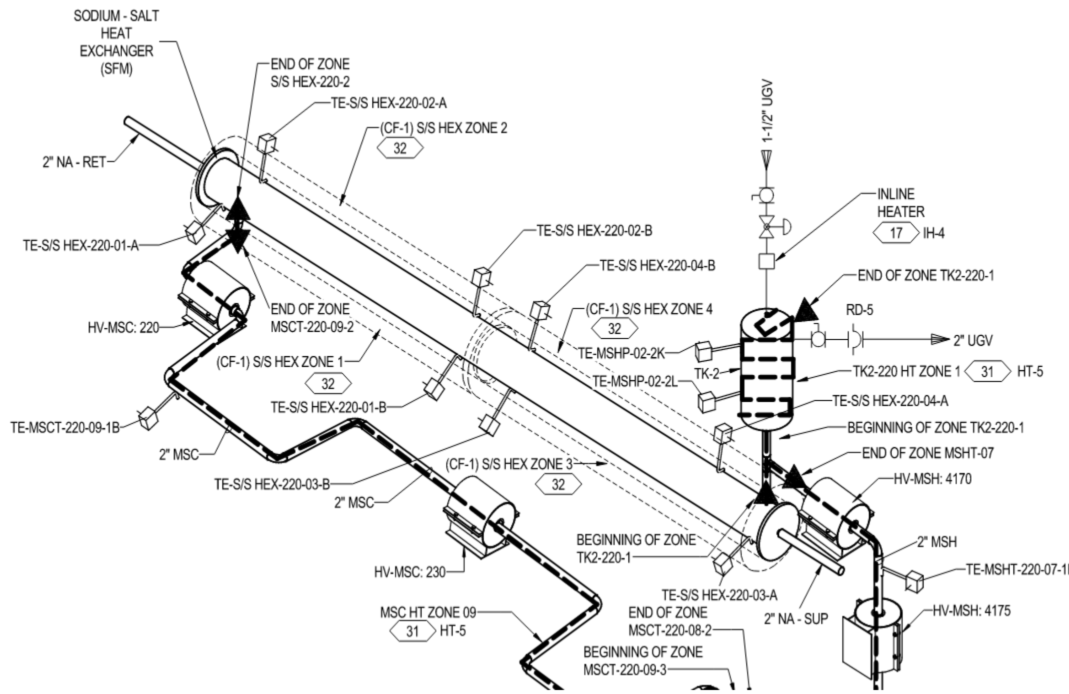


B. The following illustration is the layout of ceramic fiber heaters and the interface the heaters must have with the nitrogen gas barrier tubing to the valve body and valve bellows section.



C. The illustrations are only preliminary. The design of the ceramic fiber heaters will be based on final approved flow control valve shop drawings.

D. The following illustration is the layout of ceramic fiber heaters for the sodium-to-salt heat exchanger using ceramic fiber heaters (clamshell style) to heat 500°C - 720°C (932°F - 1328°F) normally. The heat exchanger is approximately 19’-8” in length by 11” in diameter. The heat exchanger shall have 4 heating zones (2 zones 50% area on top and 2 zones on bottom 50% area). The heater has an additional capacity of 50% for melting salt in the heat exchanger if this was to occur. The size of the heaters is found in the Mechanical Equipment Schedule on the drawings.



E. The illustration is only preliminary. The design of the ceramic fiber heaters will be based on final approved sodium-to-salt heat exchanger shop drawings.

3.05 CONNECTIONS

A. Ground equipment according to Specification 260526 – Grounding & Bonding for Electrical System.

B. Connect wiring according to Specification 262726 – Wiring Devices.

C. Provide over current protection per Specification 260574 – Overcurrent Protective Device Arc-Flash Study

D. Heater control panels shall meet Specification 262816 – Enclosed Switches and Circuit Study Breakers.

E. Provide surge protection per Specification 264313 – Surge Protective Devices for Low Voltage Electrical Power Circuits.

3.06 FIELD QUALITY CONTROL

Inspections and tests for the heat tape, immersion heaters, in-line gas heaters, and ceramic fiber heaters shall include but are not limited to the following:

1. Testing shall be done per the latest IEEE Std. 515 test section and applicable manufacturer's standards. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

2. All heater cables shall be tested with a meg ohm meter in the field. The following separate field meg ohm meter readings shall be taken on each heater type:
   a. Heater cable shall be meg ohm tested when received at jobsite before installation.
   b. Heater cable shall be meg ohm tested after installation, but before insulation is applied.
   c. Heater cable shall be meg ohm tested after insulation has been installed.

3. All three of the above field meg ohm meter readings shall be greater than 20 meg ohms. Otherwise, the heater cable is not acceptable and shall be replaced

4. Field meg ohm meter tests shall be recorded for each heater cable, and certified reports (test log) shall be submitted to the user

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounting cables.

C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

Exceptional service in the national interest

Sandia National Laboratories

Section 23 05 48 – Vibration Limits and Control

April 2016

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U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration
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Section 23 05 48 – Vibration Limits and Control

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to new Master spec style.

Section 23 05 48 – Vibration Limits and Control

Part 1 – General

1.1 Summary

Section includes types of vibration isolators required for different systems, and establishes maximum acceptable limits for vibration of machines with five horsepower or greater, in terms of:

Balance level in displacement (mils) as filtered measurement at rotating speed.

Overall velocity (in/sec) in 10 – 1,000 Hz band.

Bearing quality or condition by measuring overall acceleration in 0 – 5,000 Hz band, which indicates severity of metal-to-metal contact by detecting shock pulses. This measurement is normalized to speed.

1.2 References

American National Standards Institute (ANSI)

S2.2-1959 (R1990) Methods for the Calibration of Shock and vibration Pickups

1.3 Submittals

General: Submit the following items in accordance with the Conditions of Contract and Section 01330, "Submittal Procedures."

Vibration Report: Submit in accordance with specified requirements of Part 3.

1.4 Quality Assurance

Contractor is required to demonstrate to Sandia that equipment complies with requirements of this specification. Measurements can be taken elsewhere, and documents submitted as evidence of passage; but final acceptance judgement shall be made from measurements taken on site in equipment's final, installed location and operating configuration. Equipment shall not be accepted until fully compliant with specified requirements.

Part 2 – Products

2.1 Vibration Isolators

Spring and Resilient Pad Hangars: Stable steel spring and neoprene isolator placed in series, and encased in welded steel bracket, with allowance for rod misalignment up to 15 degrees without short-circuiting. Provide Mason Industries, Inc., Model PC30N, or approved equal.

2.2 Vibration Measurement Device

A. General

1. Capable of filtered displacement readings at rotational speed.

   a. Provide separate speed-measuring device, such as strobe light, photo tachometer, or mechanical tachometer, to measure rotating speed of belt-driven or variable-speed machines.
   b. Displacement Readings: Mils (0.001 inch), peak-to-peak.
   c. Filter Bandwidth: Sufficiently narrow to achieve accuracy of ± 10 percent from absolute value.

2. Velocity Measurement: Overall in 10 to 1,000 Hz bandwidth, readings in inches per second, peak.
3. Acceleration Measurement: Overall in 0 to 5,000 Hz bandwidth, readings in g, peak.

   a. Capability to record and plot waveform with 100-microsecond resolution (5,000-Hz frequency span and 500 lines with Fast Fourier Transform (FFT) analyzer).
   b. Record and plot waveform for acceleration level failures to aid analysis.

4. FFT analyzer with accelerometer can meet the above requirements.

B. Calibration of Complete Instrumentation System: Includes transducer, signal conditioning, cable, and readout instrument. Calibrate in accordance with one of the methods in ANSI S2.2.

1. Comparison calibration is acceptable.
2. Calibration of transducer alone is unacceptable; final reading is dependent on settings in readout instrument (like windows, filters, averaging method, calibration constants, and frequency span).

C. Frequency Response: Linear (within ± 10 percent) in 1 to 5,000 Hz range.

Internally generated noise or external signals that are not vibration, shall be less than 1 percent of upper limit under test (signal-to-noise ratio shall be 100 to 1). Noise is defined as any signal level displayed that is not vibration.

D. Recording and Plotting Capability: Capable of recording frequency spectrum and time plot, and plotting on paper.

1. Both plots unfiltered below 5,000 Hz.
2. Spectrum Frequency Resolution: No coarser than 1/200 of full span frequency (200-line spectrum analyzer or finer is suitable).
3. Digital integration of accelerometer signal to velocity or displacement is acceptable.

Part 3 – Execution

3.1 Installation

A. Piping Systems: Connect refrigerant piping to compressors with refrigerant-rated, flexible metallic sections, oriented parallel to crankshaft.

1. Use flexible connections parallel to crankshaft to connect building air piping to air compressors.
2. When piping vibration hangars are specified, provide spring hanger isolators as described in Part 2.

B. Ductwork: Attach to fans with weatherproof, flame-retardant flexible connections.

When duct vibration hangars are specified, provide spring hanger isolators described in Part 2.

3.2 Vibration Testing

A. Perform vibration testing after equipment alignment and balance.

B. Obtain vibration measurements after Test and Balance is complete. The machines shall be at their normal operating conditions (such as normal speed, normal loading, and producing flow or energy) for which the system was designed.

C. Determine and record equipment operating speeds with tachometer or strobe. Indicate both driving and driven speeds.

D. Check isolation system for proper operation, if applicable:

1. Visually inspect equipment installation. Verify that isolators supporting piece of equipment have approximately the same deflection.
2. Apply unbalanced load and verify that system moves freely.
3. Determine actual isolator deflection and compare to specified value.

E. Vibration Measurements: Obtain at each bearing, or as close to bearing on structure as practical. For machines housed in rigid casing, such as electric motors or vaneaxial fans, obtain measurements at each end of machine.

1. Obtain three orthogonal measurements at each bearing, typically in horizontal, vertical, and axial directions. For unusual configurations, three orthogonal measurements in other orientations are allowed.
2. Hand-held probing is allowed. Magnetic mounting of transducers is preferred. Adjust magnet on rough surfaces so that it is stable and does not rock.

F. Safety: Exercise extreme caution when obtaining vibration measurements on operating machinery.

1. Measurement points may be deleted if it poses unnecessary risk, in the opinion of person taking measurements.

2. Judgement of equipment's vibration acceptability will be made from pattern of remaining measurements by the Sandia Delegated Representative (SDR).
3. If necessary, machine may be stopped to attach transducers and secure cables, and this stop-start pattern repeated for each measurement point.
4. Obtain SDR's approval prior to deleting measurement points, and stopping and starting equipment.

G. Operate variable-speed machines throughout their entire range, at each measurement point, and observe for resonance. Measure and record vibration at minimum of three operating speeds. Vibration levels must be acceptable at all three test speeds.

1. Maximum speed.
2. Speed which produces highest reading at each measuring point.
3. Expected normal operating speed.

H. It is acceptable to take measurements over a period of time and statistically average the readings. It is recognized that vibration is mostly steady state, but it is also dynamic, changes with time, and external transients can influence readings.

Digital and analog readings can be averaged visually. Summation averaging with FFT analyzer is acceptable. Time period of observation, or averaging, shall be minimum of 10 seconds.

3.3 Vibration Limits

A. Maximum allowable measurements for various pieces of equipment are shown below:

Table 1
Vibration Limits

Equipment	Balance Condition Displacement (mils, P-P at 1X rpm)	Overall Velocity (in/sec, Peak 10 - 1,000 Hz)	Overall Acceleration (g, Peak 0 - 5,000 Hz)
Electric Motors:			
1,000 - 2,000 rpm	2.0	0.2	0.5
> 2,000 rpm	1.0	0.2	1.0
VSD Driven Motors:			
1,000 - 2,000 rpm	2.0	0.2	0.5*
> 2,000 rpm	1.0	0.2	1.0*
Generators	2.0	0.2	0.5
Centrifugal Fans			
< 600 rpm	4.0	0.3	0.5
600-1,000 rpm	3.0	0.3	1.0
1,000-2,000 rpm	2.0	0.3	1.5
> 2,000 rpm	1.0	0.3	2.0
Vaneaxial Fans	1.0	0.2	0.5
Blowers	1.0	0.3	0.5
Pumps			
1800 rpm	2.0	0.2	0.5
3600 rpm	1.0	0.2	1.0

Centrifugal Compressors	1.0	0.2	3.0
Cooling Tower Gearboxes	3.0	0.4	2.0
Reciprocating Engines Gas or Diesel	5.0	1.0	10.0
Turbines	1.0	0.2	0.5
Gearboxes	1.0	0.4	2.0
Twin Screw Compressors	1.0	1.0	15.0

*High reading is acceptable if due to electronic noise as determined by adjusting vibration analyzer to view time waveform. Equipment is non-compliant if high reading is due to bearing shock pulse.

B. Displacement measurements at operating speeds shall not exceed values in Table 1, or reduced values if equipment is mounted on inertia block. Values in Table 1, multiplied by displacement ratio will give maximum allowable peak-to-peak displacements for equipment on inertia blocks.

$$\text{Displacement Ratio} = \frac{1}{((MB/M) + 1)}$$

where:

M = Supported equipment and fluid weight

MB = Inertia base weight

C. Machines driven by reciprocating engines, such as pumps or generators, shall only be required to pass higher limits of reciprocating engines.

D. Non-Compliance: Equipment that does not comply with specified vibration tolerances shall be corrected at manufacturer's expense. Retest equipment and submit measurement results report in accordance with requirements of following article.

3.4 Vibrations Measurement Report

A. Submit written report that includes the following:

1. Description of instruments used, their last calibration date, and calibration method.
2. Actual vibration measurements and rotating speed at each point in tabular form. Table 2 is a sample report.
3. State whether each machine passes or fails based upon vibration limits listed in Table 1. Analysis of defective condition and recommendations for corrective action are optional.
4. See Table 2 for sample report.

B. Vibration Spectrum Plots: Include with written report minimum of plots for each machine (in velocity units); one plot for driver machine and another for driven machine.

For machines that pass, choice of which point to plot is at discretion of analyst. Plots are intended to serve as evidence of passing, and as baseline data for future analysis.

Table 2
Sample Vibration Report

Equipment	Location	Balance Displacement (mil, P-P)	Overall Velocity (in/sec Peak 10-10,000 Hz)	Overall Acceleration (g, Peak 0 - 5,000 Hz)	Pass or Fail
MAU-1 Opposite Drive End Bearing 1,200 rpm	Horizontal Vertical Axial	1.2 0.9 0.4	0.09 0.12 0.08	0.8 0.7 0.8	Pass
Drive End Bearing 1,200 rpm	Horizontal Vertical Axial	1.1 0.8 0.6	0.13 0.15 0.10	0.9 1.0 0.9	
Motor Drive End 1,770 rpm	Horizontal Vertical Axial	0.9 0.7 0.5	0.10 0.12 0.09	0.2 0.3 0.1	Pass
Opposite Drive End 1,770 rpm	Horizontal Vertical Axial	1.0 0.8 0.2	0.09 0.11 0.09	0.2 0.15 0.11	

3.5 Resonance

A. Resonating components on machines or other supplied equipment, such as pipes, panels, or ducts, are equipment flaws. Contractor shall bear full burden of stiffening components or other corrective action, until vibration measurements at bearings pass balance limits listed in Table 1.

B. If equipment vibration testing failures are related to foundation or building resonance, Contractor shall demonstrate this basis to SDR. SDR shall do one of the following:

1. Accept the vibration.
2. Require additional corrective work on Contractor's part to compensate, such as better balancing or alignment, or softer springs.
3. Move the machine.
4. Stiffen the structure.

END OF SECTION 23 05 48

Exceptional service in the national interest

Sandia National Laboratories

Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC

Table of Contents

aChange Log

Date	Changes Made By	Type	Change Description
11/09/2017	Tim Peterson	Subst	New spec that will replace 23 05 94

Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC

PART 1 - General

1.1 Summary

A. Section includes:

1. Balancing Air Systems:

   a. Constant-volume air systems.
   b. Dual-duct systems.
   c. Variable-air-volume systems.
   d. Multizone systems.
   e. Induction-unit systems.

2. Balancing Hydronic Piping Systems:

   a. Constant-flow hydronic systems.
   b. Variable-flow hydronic systems.
   c. Primary–secondary hydronic systems.

3. Balancing steam systems.
4. Testing, Adjusting, and Balancing Equipment:

   a. Heat exchangers
   b. Motors
   c. Chillers
   d. Cooling towers
   e. Condensing units
   f. Boilers
   g. Heat-transfer coils

5. Testing, adjusting, and balancing existing systems and equipment
6. Sound tests
7. Vibration tests
8. Duct leakage tests
9. Control system verification

1.2 Definitions

A. AABC: Associated Air Balance Council

B. ASHRAE: American Society of Heating, Refrigerating, and Air Conditioning Engineers

C. Commissioning Authority: As defined in Section 01810, "Facility Commissioning Requirements," the Commissioning Authority is an Sandia National Laboratories (SNL) designated Owner Representative that observes commissioning activities (e.g., installation, field testing, equipment startup, pre-functional checklists, and functional performance testing). **If a Commissioning Authority is not identified in the contract documents, the SNL Construction Manager will designate a person or persons to serve in this capacity for the duration of the project.**

D. IESNA: Illuminating Engineering Society (of North America)

E. NEBB: National Environmental Balancing Bureau

F. TAB: Testing, adjusting, and balancing

G. TABB: Testing, Adjusting, and Balancing Bureau

H. TAB Specialist: An independent entity meeting qualifications to perform TAB work

I. TDH: Total dynamic head

1.3 Informational Submittals

A. Qualification Data: Within **30** days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within **30** days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within **30** days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article (*TAB Plan*).

D. System Readiness Checklists: Within **30** days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make
2. Serial number
3. Application
4. Dates of use
5. Dates of calibration

1.4 Quality Assurance

A. TAB Specialists Qualifications: Certified by **AABC** or **NEBB**.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by **AABC** or **NEBB**.
2. TAB Technician: Employee of the TAB specialist and certified by **AABC** or **NEBB** as a TAB technician.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2, "Air Balancing."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3, "System Balancing."

1.5 Field Conditions

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - Products (not applicable)

PART 3 - Execution

3.1 Examination

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for heating, ventilating, and air conditioning (HVAC) systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in the Sheet Metal and Air Conditioning Contractors' National Association's "HVAC Systems – Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 Preparation

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.

4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include and verify, at a minimum, the following:

1. Airside:

a. Leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

a. Leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with terminals installed.
c. Water treatment is complete.
d. Systems are flushed, filled, and air purged.
e. Strainers are pulled and cleaned.
f. Control valves are functioning per the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.3 General Procedures for Testing and Balancing

A. Perform testing and balancing procedures on each system according to the procedures contained in **AABC's "National Standards for Total System Balance"** or in **NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems"** and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 33 00 "Air Duct Accessories."

3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 07 13 “Duct Insulation,” and Section 23 07 16 “HVAC Equipment Insulation.”

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in **inch-pound (IP)** units.

3.4 General Procedures for Balancing Air Systems

A. Prepare test reports for both fans and outlets. Obtain manufacturer’s outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems’ “as-built” duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 23 31 13 “Metal Ducts.”

3.5 Procedures for Constant-Volume Air Systems

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow

   a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
   b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.

c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from **commissioning authority** for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, revolutions per minute (rpms), volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.6 Procedures for Dual-Duct Systems

A. Adjust the dual-duct systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge. On systems with separate hot-deck and cold-deck fans, verify the location of the sensor on each deck.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit's hot deck and cold deck for maximum and minimum design airflow as follows:

    a. Adjust controls so that terminal is calling for full cooling. Some controllers require starting with minimum set point. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factors as required for design cold-deck maximum airflow and hot-deck minimum airflow. Record calibration factors.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for full heating.
    e. Measure airflow and adjust calibration factors as required for design cold-deck minimum airflow and hot-deck maximum airflow. Record calibration factors. If no minimum calibration is available, note any deviation from design airflow.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Set terminals for maximum airflow. If system design includes diversity (cooling coil or fan), adjust terminals for maximum and minimum airflow so that connected total matches cooling coil or fan selection and simulates actual load in the building. In systems with separate hot-deck and cold-deck fans, diversity consideration applies to each individual fan.
    c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

6. Measure the fan(s) static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.

d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan(s) while operating at maximum return airflow and minimum outdoor airflow.

   a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
   b. Verify that all terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:

   a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
   b. Re-measure and confirm that total airflow is within design.
   c. Re-measure final fan operating data, rpms, volts, amps and static profile.
   d. Mark final settings.
   e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
   f. Verify tracking between supply and return fans.

10. Record final fan-performance data.

3.7 Procedures for Variable-Air-Volume Systems

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer’s recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

   a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
   b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
   c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
   d. Adjust controls so that terminal is calling for minimum airflow.

e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

6. Measure fan static pressures as follows:

a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:

a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
b. Re-measure and confirm that total airflow is within design.
c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
d. Mark final settings.

e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
f. Verify tracking between supply and return fans.

3.8 Procedures for Multizone Systems

A. Position the unit's automatic zone dampers for maximum flow through the cooling coil.

B. The procedures for multizone systems will utilize the zone balancing dampers to achieve the indicated airflow within the zone.

C. After balancing, place the unit's automatic zone dampers for maximum heating flow. Retest zone airflows and record any variances.

D. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

   a. Set outside-air, return-air and relief-air dampers for proper position that simulates minimum outdoor air conditions.
   b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
   c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
   d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from **commissioning authority** for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

E. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

F. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

G. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.9 Procedures for Induction-Unit Systems

A. Balance primary-air risers by measuring static pressure at the nozzles of the top and bottom units of each riser to determine which risers must be throttled. Adjust risers to indicated airflow within specified tolerances.

B. Adjust each induction unit.

C. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

   a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
   b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
   c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
   d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

   a. Measure static pressure directly at the fan outlet or through the flexible connection.

b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from **commissioning authority** for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

D. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

E. Balance airflow to each induction unit by measuring the nozzle pressure and comparing it to the manufacturer's published data for nozzle pressure versus cubic feet per minute (cfm). Adjust the unit's inlet damper to achieve the required nozzle pressure for design cfm.

F. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.10 General Procedures for Hydronic Systems

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

3.11 Procedures for Constant-Flow Hydronic Systems

A. Adjust pumps to deliver total design flowrate.

1. Measure total water flow.

   a. Position valves for full flow through coils.
   b. Measure flow by main flow meter, if installed.
   c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

   a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
   b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
   c. Convert pressure to head and correct for differences in gauge heights.
   d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer’s pump curve at zero flow, and verify that the pump has the intended impeller size.
   e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.12 Procedures for Variable-Flow Hydronic Systems

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no diversity:

1. Adjust pumps to deliver total design flowrate.

   a. Measure total water flow.

      1) Position valves for full flow through coils.
      2) Measure flow by main flow meter, if installed.
      3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

   b. Measure pump TDH as follows:

      1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
      2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
      3) Convert pressure to head and correct for differences in gauge heights.
      4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

a. Measure differential pressure and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system differential-pressure set point.
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:

a. Re-measure and confirm that total water flow is within design.
b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
c. Mark final settings.

10. Verify that memory stops have been set.

D. For systems with diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
3. Adjust pumps to deliver total design flowrate.

    a. Measure total water flow.

        1) Position valves for full flow through coils.
        2) Measure flow by main flow meter, if installed.
        3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

    b. Measure pump TDH as follows:

        1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
        2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
        3) Convert pressure to head and correct for differences in gauge heights.
        4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer’s pump curve at zero flow and verify that the pump has the intended impeller size.
        5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

    c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

    a. Measure flow in main and branch pipes.
    b. Adjust main and branch balance valves for design flow.
    c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

    a. Measure flow at terminals.
    b. Adjust each terminal to design flow.
    c. Re-measure each terminal after it is adjusted.
    d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
    e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

    a. Measure differential pressure, and verify that it is within manufacturer’s specified range.
    b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

a. Re-measure and confirm that total water flow is within design.
b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
c. Mark final settings.

13. Verify that memory stops have been set.

3.13 Procedures for Primary–Secondary Hydronic Systems

A. Balance the primary circuit flow first.

B. Balance the secondary circuits after the primary circuits are complete.

C. Adjust pumps to deliver total design flowrate.

1. Measure total water flow.

a. Position valves for full flow through coils.
b. Measure flow by main flow meter, if installed.
c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
c. Convert pressure to head and correct for differences in gauge heights.
d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

D. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

E. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

F. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

G. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

H. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

I. Verify that memory stops have been set.

3.14 Procedures for Steam Systems

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

D. Check settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

3.15 Procedures for Heat Exchangers

A. Adjust water flow to within specified tolerances.

B. Measure inlet and outlet water temperatures.

C. Measure inlet steam pressure.

D. Check settings and operation of safety and relief valves. Record settings.

3.16 Procedures for Motors

A. Motors 1/2 horsepower and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number
2. Motor horsepower rating
3. Motor rpm
4. Phase and hertz
5. Nameplate and measured voltage, each phase
6. Nameplate and measured amperage, each phase
7. Starter size and thermal-protection-element rating
8. Service factor and frame size

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.17 Procedures for Chillers

A. Balance water flow through each evaporator **and condenser** to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
6. Capacity: Calculate in tons of cooling.
7. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.18 Procedures for Cooling Towers

A. Balance total condenser-water flows to towers. Measure and record the following data:

1. Condenser-water flow to each cell of the cooling tower.
2. Entering- and leaving-water temperatures
3. Wet- and dry-bulb temperatures of entering air
4. Wet- and dry-bulb temperatures of leaving air
5. Condenser-water flow rate recirculating through the cooling tower
6. Cooling-tower spray pump discharge pressure
7. Condenser-water flow through bypass
8. Fan and motor operating data

3.19 Procedures for Condensing Units

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record fan and motor operating data.

3.20 Procedures for Boilers

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Record relief valve pressure setting.

B. Steam Boilers:

1. Measure and record entering-water temperature.
2. Measure and record feed water flow.
3. Measure and record leaving-steam pressure and temperature.
4. Record relief valve pressure setting.

3.21 Procedures for Heat-Transfer Coils

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature
2. Water flow rate
3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units
4. Dry-bulb temperature of entering and leaving air
5. Wet-bulb temperature of entering and leaving air for cooling coils
6. Airflow

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data
2. Airflow
3. Entering- and leaving-air temperature at full load
4. Voltage and amperage input of each phase at full load
5. Calculated kilowatt at full load
6. Fuse or circuit-breaker rating for overload protection

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air
2. Airflow
3. Inlet steam pressure

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air
2. Wet-bulb temperature of entering and leaving air
3. Airflow

3.22 Vibration Tests

A. After systems are balanced and construction is Substantially Complete, measure and record vibration levels on equipment having motor horsepower equal to or greater than **5**.

B. Instrumentation:

1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
4. Verify calibration date is current for vibration meter before taking readings.

C. Test Procedures:

1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.
3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
4. Record cpm or rpm.
5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.

D. Reporting:

1. Report shall record location and the system tested.
2. Include horizontal-vertical-axial measurements for tests.
3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from the AABC National Standards. Acceptable levels of vibration are normally “smooth” to “good.”
4. Include in report General Machinery Vibration Severity Chart, with conditions plotted.

3.23 Duct Leakage Tests

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.24 Controls Verification

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.25 Procedures for Testing, Adjusting, and Balancing Existing Systems

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.

7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed
2. Coils are clean and fins combed
3. Drain pans are clean
4. Fans are clean
5. Bearings and other parts are properly lubricated
6. Deficiencies noted in the preconstruction report are corrected

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.26 Tolerances

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: **Plus or minus 10 percent**.
2. Air Outlets and Inlets: **Plus or minus 10 percent**.
3. Heating-Water Flow Rate: **Plus or minus 10 percent**.
4. Cooling-Water Flow Rate: **Plus or minus 10 percent**.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.27 Progress Reporting

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Advise the commissioning authority of status as required or requested by the commissioning authority. Information provided should include a list of deficiencies and problems found in systems being tested and balanced.

3.28 Final Report

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves
2. Fan curves
3. Manufacturers' test data
4. Field test reports prepared by system and equipment installers
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page
2. Name and address of the TAB specialist
3. Project name
4. Project location
5. Architect's name and address
6. Engineer's name and address
7. Contractor's name and address
8. Report date
9. Signature of TAB supervisor who certifies the report
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
    a. Indicated versus final performance
    b. Notable characteristics of systems
    c. Description of system operation sequence if it varies from the Contract Documents
12. Nomenclature sheets for each item of equipment
13. Data for terminal units, including manufacturer's name, type, size, and fittings
14. Notes to explain why certain final data in the body of reports vary from indicated values
15. Test conditions for fans and pump performance forms including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers
    b. Conditions of filters
    c. Cooling coil, wet- and dry-bulb conditions

d. Face and bypass damper settings at coils
e. Fan drive settings including settings and percentage of maximum pitch diameter
f. Inlet vane settings for variable-air-volume systems
g. Settings for supply-air, static-pressure controller
h. Other system operating conditions that affect performance

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows
2. Water and steam flow rates
3. Duct, outlet, and inlet sizes
4. Pipe and valve sizes and locations
5. Terminal units
6. Balancing stations
7. Position of balancing devices

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

a. Unit identification
b. Location
c. Make and type
d. Model number and unit size
e. Manufacturer's serial number
f. Unit arrangement and class
g. Discharge arrangement
h. Sheave make, size in inches (mm), and bore
i. Center-to-center dimensions of sheave and amount of adjustments in inches (mm)
j. Number, make, and size of belts
k. Number, type, and size of filters

2. Motor Data:

a. Motor make, and frame type and size
b. Horsepower and rpm
c. Volts, phase, and hertz
d. Full-load amperage and service factor
e. Sheave make, size in inches (mm), and bore
f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm)

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm (L/s)
b. Total system static pressure in inches wg (Pa)
c. Fan rpm
d. Discharge static pressure in inches wg (Pa)
e. Filter static-pressure differential in inches wg (Pa)
f. Preheat-coil static-pressure differential in inches wg (Pa)
g. Cooling-coil static-pressure differential in inches wg (Pa)

h. Heating-coil static-pressure differential in inches wg (Pa)
i. Outdoor airflow in cfm (L/s)
j. Return airflow in cfm (L/s)
k. Outdoor-air damper position
l. Return-air damper position
m. Vortex damper position

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification
b. Location
c. Coil type
d. Number of rows
e. Fin spacing in fins per inch (mm) on center (o.c.)
f. Make and model number
g. Face area in sq. ft. (sq. m)
h. Tube size in NPS (DN)
i. Tube and fin materials
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s)
b. Average face velocity in fpm (m/s)
c. Air pressure drop in inches wg (Pa)
d. Outdoor-air, wet- and dry-bulb temperatures in degrees F (degrees C)
e. Return-air, wet- and dry-bulb temperatures in degrees F (degrees C)
f. Entering-air, wet- and dry-bulb temperatures in degrees F (degrees C)
g. Leaving-air, wet- and dry-bulb temperatures in degrees F (degrees C)
h. Water flow rate in gpm (L/s)
i. Water pressure differential in feet of head or psig (kPa)
j. Entering-water temperature in degrees F (degrees C)
k. Leaving-water temperature in degrees F (degrees C)
l. Refrigerant expansion valve and refrigerant types
m. Refrigerant suction pressure in psig (kPa)
n. Refrigerant suction temperature in degrees F (degrees C)
o. Inlet steam pressure in psig (kPa)

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer’s factory startup equipment reports, include the following:

1. Unit Data:

a. System identification
b. Location
c. Make and type
d. Model number and unit size
e. Manufacturer’s serial number
f. Fuel type in input data

g. Output capacity in Btu/h (kW)
h. Ignition type
i. Burner-control types
j. Motor horsepower and rpm
k. Motor volts, phase, and hertz
l. Motor full-load amperage and service factor
m. Sheave make, size in inches (mm), and bore
n. Center-to-center dimensions of sheave and amount of adjustments in inches (mm)

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm (L/s)
b. Entering-air temperature in degrees F (degrees C)
c. Leaving-air temperature in degrees F (degrees C)
d. Air temperature differential in degrees F (degrees C)
e. Entering-air static pressure in inches wg (Pa)
f. Leaving-air static pressure in inches wg (Pa)
g. Air static-pressure differential in inches wg (Pa)
h. Low-fire fuel input in Btu/h (kW)
i. High-fire fuel input in Btu/h (kW)
j. Manifold pressure in psig (kPa)
k. High-temperature-limit setting in degrees F (degrees C)
l. Operating set point in Btu/h (kW)
m. Motor voltage at each connection
n. Motor amperage for each phase
o. Heating value of fuel in Btu/h (kW)

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification
b. Location
c. Coil identification
d. Capacity in Btu/h (kW)
e. Number of stages
f. Connected volts, phase, and hertz
g. Rated amperage
h. Airflow rate in cfm (L/s)
i. Face area in sq. ft. (sq. m)
j. Minimum face velocity in fpm (m/s)

2. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h (kW)
b. Airflow rate in cfm (L/s)
c. Air velocity in fpm (m/s)
d. Entering-air temperature in degrees F (degrees C)
e. Leaving-air temperature in degrees F (degrees C)
f. Voltage at each connection

g. Amperage for each phase

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification
b. Location
c. Make and type
d. Model number and size
e. Manufacturer’s serial number
f. Arrangement and class
g. Sheave make, size in inches (mm), and bore
h. Center-to-center dimensions of sheave and amount of adjustments in inches (mm)

2. Motor Data:

a. Motor make, and frame type and size
b. Horsepower and rpm
c. Volts, phase, and hertz
d. Full-load amperage and service factor
e. Sheave make, size in inches (mm), and bore
f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm)
g. Number, make, and size of belts

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm (L/s)
b. Total system static pressure in inches wg (Pa)
c. Fan rpm
d. Discharge static pressure in inches wg (Pa)
e. Suction static pressure in inches wg (Pa)

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number
b. Location and zone
c. Traverse air temperature in degrees F (degrees C)
d. Duct static pressure in inches wg (Pa)
e. Duct size in inches (mm)
f. Duct area in sq. ft. (sq. m)
g. Indicated airflow rate in cfm (L/s)
h. Indicated velocity in fpm (m/s)
i. Actual airflow rate in cfm (L/s)
j. Actual average velocity in fpm (m/s)
k. Barometric pressure in psig (Pa)

K. Air-Terminal-Device Reports:

1. Unit Data:

   a. System and air-handling unit identification
   b. Location and zone
   c. Apparatus used for test
   d. Area served
   e. Make
   f. Number from system diagram
   g. Type and model number
   h. Size
   i. Effective area in sq. ft. (sq. m)

2. Test Data (Indicated and Actual Values):

   a. Airflow rate in cfm (L/s)
   b. Air velocity in fpm (m/s)
   c. Preliminary airflow rate as needed in cfm (L/s)
   d. Preliminary velocity as needed in fpm (m/s)
   e. Final airflow rate in cfm (L/s)
   f. Final velocity in fpm (m/s)
   g. Space temperature in degrees F (degrees C)

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

   a. System and air-handling-unit identification
   b. Location and zone
   c. Room or riser served
   d. Coil make and size
   e. Flowmeter type

2. Test Data (Indicated and Actual Values):

   a. Airflow rate in cfm (L/s)
   b. Entering-water temperature in degrees F (degrees C)
   c. Leaving-water temperature in degrees F (degrees C)
   d. Water pressure drop in feet of head or psig (kPa)
   e. Entering-air temperature in degrees F (degrees C)
   f. Leaving-air temperature in degrees F (degrees C)

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

   a. Unit identification
   b. Location
   c. Service
   d. Make and size
   e. Model number and serial number

f. Water flow rate in gpm (L/s)
g. Water pressure differential in feet of head or psig (kPa)
h. Required net positive suction head in feet of head or psig (kPa)
i. Pump rpm
j. Impeller diameter in inches (mm)
k. Motor make and frame size
l. Motor horsepower and rpm
m. Voltage at each connection
n. Amperage for each phase
o. Full-load amperage and service factor
p. Seal type

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig (kPa)
b. Pump shutoff pressure in feet of head or psig (kPa)
c. Actual impeller size in inches (mm)
d. Full-open flow rate in gpm (L/s)
e. Full-open pressure in feet of head or psig (kPa)
f. Final discharge pressure in feet of head or psig (kPa)
g. Final suction pressure in feet of head or psig (kPa)
h. Final total pressure in feet of head or psig (kPa)
i. Final water flow rate in gpm (L/s)
j. Voltage at each connection
k. Amperage for each phase

N. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make
b. Serial number
c. Application
d. Dates of use
e. Dates of calibration

3.29 Verification of TAB Report

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of the **Construction Manager** and **commissioning authority**.

B. The **Construction Manager** and **commissioning authority** shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
3. If the second verification also fails, **the engineer of record** may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.30 Additional Tests

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 05 93

Exceptional service in the national interest

Sandia National Laboratories

Section 23 05 94 – System Component Checkout and Balance

April 2016

Effective Date: 04/18/2016
Review Date: 04/18/2019

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 23 05 94 – System Component Checkout and Balance

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to new Master Spec style.

Section 23 05 94 – System Component Checkout and Balance

Part 1 – General

1.1 Summary

A. Section includes Sandia National Laboratories (SNL)-furnished Heating, Ventilation, and Air Conditioning (HVAC) system balancing.

B. Contractor is responsible for the following:

1. System(s) shall be functioning prior to Test and Balance (TAB), verifiable by completed TAB readiness checklist (supplied by SNL contract TAB Agency).
2. Provide joint and cooperative effort to schedule and coordinate the test and balance.
3. Solve problems in balancing and controls in order to establish proper system performance before leaving the job.
4. Provide TAB Agency with complete set of approved submittals.
5. Provide TAB Agency with copies of Requests For Information and approved Change Orders that affect the scope of the TAB work.
6. Provide and install new sheave(s) and new belts, as required, if change in fan speed is necessary and cannot be made by adjusting originally-installed sheave.

C. SNL will provide contact information for the contract TAB Agency to the Contractor.

1.2 Submittals

A. General: Submit the following in accordance with Conditions of Contract, and Section 01330, "Submittal Procedures," and Section 01810, "Facility Commissioning Requirements."

B. HVAC equipment factory test reports and equipment start-up reports.

1.3 References

Refer to the following SNL Construction Standard Specifications and other for related work and guidance:

A. Section 01330, Submittal Procedures

B. Section 01810, Building Systems Commissioning

C. Section 230993, Facilities Control System (FCS)

D. Division 22 and 23 Sections, as previously identified and applicable to this work.

E. National Standards for Total System Balance – Associated Air Balance Council

Part 2 – Products

Not applicable.

Part 3 – Execution

3.1 Review

A. TAB Agency will be provided a set of HVAC systems drawings and applicable specifications at beginning of project by SNL. TAB Agency, when requested, will review systems plans and specifications prior to installation, and submit a report of deficiencies which could preclude proper system adjusting, balancing, and testing. SNL will take action, as required, to correct system design deficiencies.

3.2 Component Checkout

A. Contractor will coordinate with HVAC controls sub-contractor, and SNL FCS office as needed, for operational check of all modulating and balancing dampers and valves for travel and close off.

B. Operate rotating equipment to verify equipment integrity, and verify that it is the proper equipment according to approved submittals.

3.3 System Adjusting

A. Promptly correct system/equipment deficiencies identified by component checkout or by TAB agency during TAB activity.

3.4 System Testing

A. Test safety limits to ensure each performs proper function.

B. Provide support to place each system in all normal modes of operation to verify contract drawings sequence of operation.

3.5 Test Report

A. Provide and label tab in submitted Operation and Maintenance manuals for final TAB report.

END OF SECTION 23 05 94

Exceptional service in the national interest

Sandia National Laboratories

Section 23 05 95 – Mechanical Systems Demonstrations

April 2016

Effective Date: 04/16/2016
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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 23 05 95 – Mechanical Systems Demonstrations

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to fit new Masterspec format.

SECTION 23 05 95 - MECHANICAL SYSTEMS DEMONSTRATIONS

PART 1 - General

1.1 Summary

This specification covers the training requirements by the Contractor for work done in other sections of the Mechanical and Control specifications.

1.2 Submittals

Operation and Maintenance manuals shall be submitted per Section 01330, "Submittal Procedures".

A. The four complete sets of BOUND Operation and Maintenance manuals shall be submitted and approved, prior to the Field Training Session.

B. One additional bound set of the approved O&M manuals, shall be delivered to the Sandia Delegated Representative at the Field Training session (see part 3.01).

PART 2 - Products

Not used.

PART 3 - Execution

3.1 Field Training Session

A. The Sandia Delegated Representative will request the field training session and inform all involved parties by letter.

1. The letter will establish the following:

   a. The Contractor (including all necessary Subcontractors) and Sandia personnel required to attend the session.
   b. Date, time, and location of the field training.

B. The purpose of the field training session is to show Sandia personnel the location of all components, the correct operation, and the preventative maintenance requirements of all equipment.

1. The field training session will be coordinated by the SDR, who will require the Contractor and all necessary Subcontractors, including the Controls Subcontractor, to perform specific training.
2. When requested, the Contractor shall cause the equipment to cycle through each sequence the system will normally see in its lifetime.

C. <u>On occasion where a factory representative must be on hand</u> for the initial startup of a piece of equipment, in advance of the formal training session, he shall perform the training session for that piece of equipment at that time, after making appropriate arrangements with the SDR.

END OF SECTION 23 05 95

Exceptional service in the national interest

Sandia National Laboratories

Special Specification
Section 23 07 19S – Piping Insulation

June 2018

Release Date: 06/27/2018
Next Review Date: 06/27/2021

Gen 3 Liquid Pathway Edit: 12/15/20

U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 23 07 19S – Piping Insulation – Special Specification

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to new Master Spec style.
6/27/18	Tim Peterson	Admin	Removed paragraph 3.2.A.2; basic editing; 3-year review

Section 23 07 19S – Piping Insulation – Special Specification

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section includes insulating the following piping systems:

1. Condensate drain piping outdoors.
2. Process Chilled-water outdoors.
3. Molten Salt piping, indoors and outdoors.
4. Ullage Gas Equalizer and Vent piping, indoors and outdoors.
5. S-CO2 Piping, outdoors

B. Related Sections:

1. Section 23 07 13 “Duct Insulation.”
2. Section 23 07 16 “HVAC Equipment Insulation.”

C. This section includes preformed, rigid, and flexible pipe insulation; field-applied jackets; accessories and attachments; and sealing compounds for above-ground, interior, and exterior mechanical piping systems. This section also includes mechanical equipment insulation requirements.

1.3 Action Submittals

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied, if any). Provide manufacturer’s installation requirements for each type of insulation and piping. Show compliance with necessary industry standards and listing agencies.

B. Leadership in Energy and Environmental Design® (LEED) Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of volatile organic compound (VOC) content.
2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services’ “Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers.”

1.4 Informational Submittals

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 Quality Assurance

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Sandia-Delegated Representative (SDR). Use materials indicated for the completed Work.

1. Piping Mockups (Salt Piping Only):

   a. One 10-foot section of NPS 2 straight pipe.
   b. One each of a 90-degree threaded, welded, and flanged elbow.
   c. One each of a threaded, welded, and flanged tee fitting.
   d. One NPS 2 or smaller valve, and one NPS 2-1/2 or larger valve.
   e. Four support hangers, including hanger shield and insert.
   f. One thermocouple.
   g. One pressure temperature tap.
   h. One mechanical coupling.

2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
3. Notify SDR seven days in advance of dates and times when mockups will be constructed.
4. Obtain SDR’s approval of mockups before starting insulation application.

5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless SDR specifically approves such deviations in writing.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Approved mockups may become part of the completed work, if undisturbed at time of "Substantial Completion."

1.6 Delivery, Storage, and Handling

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

B. Insulation materials must be new and undamaged with the manufacturer's name and brand marking clearly displayed on all containers.

C. Insulation materials must be kept dry and protected from the weather at all times until installation is complete. Insulation material found to be wet or damaged must be replaced by the contractor at no cost to the owner.

1.7 Coordination

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

D. Coordinate with other trades to prevent delays in applying insulation; be aware of testing, painting, hanger installation, and heat-tracing requirements; coordinate clearance requirements with piping installer for insulation application.

E. Protect work of other contractors and Sandia National Laboratories (SNL) from dirt and debris caused by the insulation work; remove rubbish daily and at the conclusion of work.

F. Do not insulate over nameplates or sight/light glasses.

G. Coordinate with pump layout to ensure that pressure switches and gauges are extended outside of pump-insulation boxes.

1.8 Scheduling

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - Products

2.1 Insulation Materials

A. Comply with requirements in “Piping Insulation Schedule, General,” “Indoor Piping Insulation Schedule,” “Outdoor, Aboveground Piping Insulation Schedule,” and “Outdoor, Underground Piping Insulation Schedule” articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use Chlorofluorocarbon (CFC) or Hydrochlorofluorocarbon (HCFC) blowing agents in the manufacturing process.

F. Calcium Silicate:

1. <u>Products</u>: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. <u>Industrial Insulation Group (IIG); Thermo-12 Gold</u>.

2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
4. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” article.

1. <u>Products</u>: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. <u>Pittsburgh Corning Corporation; Foamglas</u>.

2. Block Insulation: ASTM C 552, Type I.
3. Special-Shaped Insulation: ASTM C 552, Type III.

4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
6. Preformed Pipe Insulation with Factory-Applied [**ASJ**] [**ASJ-SSL**]: Comply with ASTM C 552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

H. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Aeroflex USA, Inc.; Aerocel.
b. Armacell LLC; AP Armaflex.
c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

I. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type [**I**] [**II with factory-applied vinyl jacket**] [**III with factory-applied FSK jacket**] [**III with factory-applied FSP jacket**]. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” article.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. CertainTeed Corp.; SoftTouch Duct Wrap.
b. Johns Manville; Microlite.
c. Knauf Insulation; Friendly Feel Duct Wrap.
d. Manson Insulation Inc.; Alley Wrap.
e. Owens Corning; SOFTR All-Service Duct Wrap.

J. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Fibrex Insulations Inc.; Coreplus 1200.
b. Johns Manville; Micro-Lok.
c. Knauf Insulation; 1000-Degree Pipe Insulation.
d. Manson Insulation Inc.; Alley-K.
e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 degrees F materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied all surface jacketing, self-sealing lap (ASJ-SSL). Factory-applied jacket requirements are specified in “Factory-Applied Jackets” article.
3. Type II, 1200 degrees F materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, **with factory-applied ASJ-SSL**. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” article.

K. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory-applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Knauf Insulation; Permawick Pipe Insulation.
   b. Owens Corning; VaporWick Pipe Insulation.

L. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 degrees F is 0.29 Btu x in./h x sq. ft. x degrees F or less. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” article.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. CertainTeed Corp.; CrimpWrap.
   b. Johns Manville; MicroFlex.
   c. Knauf Insulation; Pipe and Tank Insulation.
   d. Manson Insulation Inc.; AK Flex.
   e. Owens Corning; Fiberglas Pipe and Tank Insulation.

M. Mineral fiber-board thermal insulation: Comply with ASTM C 612, type IB, for use to 450 degrees F, with a factory-applied jacket manufactured from foil, reinforcing scrim, and kraft paper (FSK). Minimum density of 3 lbs/cu. ft. Maximum conductivity of 0.40 (BTU-in./hr.-sq. ft.-degrees F) at 300 degrees F.

N. Phenolic:

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Kingspan Tarec Industrial Insulation NV; Koolphen K.
   b. Resolco International BV; Insul-phen.

2. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
3. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
4. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket: Requirements are specified in “Factory-Applied Jackets” article.

   a. Preformed Pipe Insulation: **ASJ**.

O. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

    a. Dow Chemical Company (The); Trymer 2000 XP.
    b. Duna USA Inc.; Corafoam.
    c. Dyplast Products; ISO-25.
    d. Elliott Company of Indianapolis; Elfoam.

2. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x degrees F (0.027 W/m x K) at 75 degrees F (24 degrees C) after 180 days of aging.
3. Flame-spread index shall be 25 or less, and smoke-developed index shall be 50 or less for thickness up to 1 inch (25 mm) as tested by ASTM E 84.
4. Fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" article.

    a. Pipe Applications: **ASJ-SSL**.

P. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

    a. Armacell LLC; Tubolit.
    b. Nomaco Insulation; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY.

Q. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x degrees F (0.038 W/m x K) after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

    a. Dow Chemical Company (The); Styrofoam.

2.2 Insulating Cements

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

    a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

    a. Ramco Insulation, Inc.; Thermokote V.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

    a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 Adhesives

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 degrees F (10 to 427 degrees C).

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-97.
    b. Eagle Bridges, Marathon Industries; 290.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-27.
    d. Mon-Eco Industries, Inc.; 22-30.
    e. Vimasco Corporation; 760.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 degrees F (minus 73 to plus 93 degrees C).

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

    a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Phenolic and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 degrees F (minus 59 to plus 149 degrees C).

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-33.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
   d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
   b. Eagle Bridges, Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

G. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 degrees F (minus 29 to plus 60 degrees C).

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60.

H. ASJ Adhesive, and FSK and polyvinyliedene chloride (PVDC) Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
   b. Eagle Bridges, Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

I. Polyvinyl chloride (PVC) Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Dow Corning Corporation; 739, Dow Silicone.
   b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
   c. P.I.C. Plastics, Inc.; Welding Adhesive.
   d. Speedline Corporation; Polyco VP Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 Mastics

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services when customers are not present during the duration of installation or outgassing.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
   b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 degrees F (Minus 29 to plus 82 degrees C).
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services when customers are not present during the duration of installation or outgassing.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
   b. Eagle Bridges,Marathon Industries; 501.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
   d. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
3. Service Temperature Range: 0 to 180 degrees F (Minus 18 to plus 82 degrees C).
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services when customers are not present during the duration of installation or outgassing.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
b. Eagle Bridges, Marathon Industries; 570.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 degrees F (Minus 46 to plus 104 degrees C).
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services when customers are not present during the duration of installation or outgassing.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
b. Eagle Bridges, Marathon Industries; 550.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
d. Mon-Eco Industries, Inc.; 55-50.
e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 degrees F (Minus 29 to plus 82 degrees C).
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 Lagging Adhesives

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24) when customers are not present during the duration of installation or outgassing.

2. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.

c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 degrees F (Minus 18 to plus 82 degrees C).
5. Color: White.

2.6 Sealants

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.

2. Joint Sealants for Polystyrene Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-70.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
   d. Mon-Eco Industries, Inc.; 44-05.

3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 degrees F.
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24) when customers are not present during the duration of installation or outgassing.
8. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
b. Eagle Bridges, Marathon Industries; 405.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24) when customers are not present during the duration of installation or outgassing.
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24) when customers are not present during the duration of installation or outgassing.
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 Factory-Applied Jackets

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. Foil scrim polyethylene (FSP) Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

5. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially-oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

    a. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

6. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially-oriented barrier film with a permeance at 0.01 perm (0.007 metric perm) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

    a. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

    a. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 Field-Applied Fabric-Reinforcing Mesh

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas Number 10.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.

2.9 Field-Applied Cloths

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and pre-sized a minimum of 8 oz./sq. yd.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.10 Field-Applied Jackets

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, ultraviolet-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

D. Metal Jacket:

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.

   a. **Roll stock ready for shop or field sizing to indicated sizes** or **factory cut and rolled to size**.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: **1-mil-thick, heat-bonded polyethylene and kraft paper**.
   d. Moisture Barrier for Outdoor Applications: [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].
   e. Factory-Fabricated Fitting Covers:

      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

   a. All Molten Salt Hot and Cold (MSH & MSC) Piping shall be wrapped with 3-mil stainless steel jacket.

   b. All Ullage Gas Equalizer and Vent (UGE & UGV) Piping shall be wrapped with 3-mil stainless steel jacket.

   c. **All s-CO2 Piping shall be wrapped with 3-mil stainless steel jacket.**

   d. **Sheet and roll stock ready for shop or field sizing**.
   e. Material, finish, and thickness are indicated in field-applied jacket schedules.
   f. Moisture Barrier for Indoor Applications: **1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper**.
   g. Moisture Barrier for Outdoor Applications: **3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**.
   h. Factory-Fabricated Fitting Covers:

      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Pittsburgh Corning Corporation; Pittwrap.
b. Polyguard Products, Inc.; Insulrap No Torch 125.

F. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with **white** aluminum-foil facing.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Polyguard Products, Inc.; Alumaguard 60.

G. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially-oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film.

H. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially-oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Dow Chemical Company (The); Saran 560 Vapor Retarder Film.

I. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

2.11 Tapes

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. ABI, Ideal Tape Division; 428 AWF ASJ.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
   c. Compac Corporation; 104 and 105.
   d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 11.5 mils (0.29 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. ABI, Ideal Tape Division; 491 AWF FSK.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   c. Compac Corporation; 110 and 111.
   d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. ABI, Ideal Tape Division; 370 White PVC tape.
   b. Compac Corporation; 130.
   c. Venture Tape; 1506 CW NS.

2. Width: 2 inches (50 mm).
3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.

5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. ABI, Ideal Tape Division; 488 AWF.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corporation; 120.
   d. Venture Tape; 3520 CW.

2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.

2. Width: 3 inches (75 mm).
3. Film Thickness: 4 mils (0.10 mm).
4. Adhesive Thickness: 1.5 mils (0.04 mm).
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.

2. Width: 3 inches (75 mm).
3. Film Thickness: 6 mils (0.15 mm).
4. Adhesive Thickness: 1.5 mils (0.04 mm).
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

2.12 Securements

A. Bands:

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

   a. ITW Insulation Systems; Gerrard Strapping and Seals.
   b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, **Type 304**; 0.020-inch-thick, **¾-inch-**wide with **wing seal or closed seal**.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch-thick, **¾-inch**-wide with **wing seal or closed seal**.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.

C. Wire: **0.062-inch soft-annealed, stainless steel**.

1. Manufacturers: Subject to compliance with requirements, **available manufacturers offering products that may be incorporated into the Work include but are not limited to the following**:

   a. C & F Wire.

2.13 High Temperature Piping Insulation (Piping greater than 896°F)

A. High temperature piping includes all molten salt hot and cold piping (MSH & MSC), fittings, etc.

B. High temperature piping includes all ullage gas equalizer and vent piping (UGE & UGV), fittings, etc.

C. High temperature piping includes all s-CO2 piping, fittings, etc.

D. Ceramic Blanket Insulation:

1. Blanket Insulation: The blanket performance shall meet the following requirements.

2. Certified to meet the requirements of ASTM C795 for use over stainless steel.

3. High Temperature Piping: 2 layers of 2-inch thickness for total of 4-inches of ceramic fiber insulation. Layer seams (horizontal and vertical) to be offset from one another by a minimum of 12-inches.

4. Color: White.
5. Temperature Grade: 2600°F (1427°C).
6. Maximum Operating Temperature: 2450°F (1343°C).
7. Melting Point: 3200°F (1760°C).
8. Specific Heat at 2000°F (1093°C): 0.27 Btu/lb °F.
9. Specific Gravity: 2.73 g/cm³.
10. Density: 8 lb/ft³.Standards: All thermal conductivity values measured in accordance with ASTM Test Procedure C-177.

E. Manufacturer: Unifrax Durablanket 2600.

PART 3 - Execution

3.1 Examination

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Preparation

A. Surface Preparation: Clean and prepare surfaces to be insulated. Remove materials that will adversely affect insulation application. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils- (0.127 mm-) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 degrees F (60 and 149 degrees C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 General Installation Requirements

A. Install insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties; **apply insulation with the least number of joints practical.**

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches on center (o.c.).

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at **2 inches** **(50 mm)** o.c.

   a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 Penetrations

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 07 84 13 “Penetration Firestopping” for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13 “Penetration Firestopping.”

3.5 General Pipe Insulation Installation

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe

insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word “union.” Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gauges, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 Installation of Calcium Silicate Insulation

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch soft-annealed, stainless-steel wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish. **[Apply an aluminum jacket to cover all insulation.**

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer’s written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.7 Installation of Cellular-Glass Insulation

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.8 Installation of Flexible Elastomeric Insulation

A. Follow manufacturer's written instructions for applying insulation to straight pipes, tubes, and fittings. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 Installation of Mineral-Fiber Insulation

A. Insulation Installation on Straight Pipes and Tubes: Use preformed pipe insulation when possible; use pipe and tank insulation for larger-diameter piping, if preformed insulation is not available; for required thickness, apply multiple layers of insulation with longitudinal and end seams staggered.

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, any penetrations in the insulation, and protrusions with vapor-barrier mastic and joint sealant.
3. Keep SSL adhesive and contact surfaces clean and free of dirt and moisture; seal immediately, once adhesive is exposed; seal circumferential joints with a minimum 3-inch-wide tape, and secure with two outward-clinching staples at the overlap; rub the longitudinal joints firmly with a squeegee, and secure with two outward-clinching staples evenly spaced in each 3-foot section of insulation.
4. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
5. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
6. Taper the ends of insulation at terminations; seal all raw edges of insulation with mastic.
7. Fill all voids and seal all raw edges of insulation with vapor-retarder mastic

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.10 Installation of Phenolic Insulation

A. General Installation Requirements:

1. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets with vapor retarders on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer’s written instructions.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.11 Installation of Polyisocyanurate Insulation

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o’clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer’s written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of polyisocyanurate insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.12 Installation of Polyolefin Insulation

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.13 Installation of Polystyrene Insulation

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, and make thickness same as adjacent pipe insulation, not to exceed 1-1/2-inch.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed section of polystyrene insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.14 Field-Applied Jacket Installation

A. Interior

Apply either aluminum or PVC jacketing to exposed insulated pipe, valves, fittings, and specialties, at an elevation of 8 feet or less above finished floor in mechanical/electrical rooms, penthouses, and services aisles/pipe chases; fittings of aluminum-jacketed piping may be either aluminum or standard PVC fitting covers; jacketing for piping in existing areas must match existing jacketing.

B. Exterior

Apply aluminum jacketing to all external piping that is insulated; cover all fittings, valves, and specialties with aluminum jacketing.

C. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

D. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

E. Where PVC jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

F. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints. **Secure jacket with aluminum bands or sheet-metal screws on 12-inch centers and at end joints; on piping operating below 60 degrees F, seal all screw penetrations with caulking.**

G. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-pre-sized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install pre-sized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch-circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.15 Finishes

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 99 00 “Painting” and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

   a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by the SDR. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.16 Field Quality Control

A. Testing Agency: SDR will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

1. Inspect pipe, fittings, strainers, and valves, randomly selected by SDR, by removing field-applied jacket and insulation in layers in reverse order of their installation.
2. Inspect fittings and valves randomly selected by SDR.
3. Remove fitting covers from 20 elbows or 1 percent of elbows, whichever is less, for various pipe sizes.
4. Remove fitting covers from 20 valves or 1 percent of valves, whichever is less, for various pipe sizes.

C. All insulation applications will be considered defective work if sample inspection reveals noncompliance with requirements. Remove defective work and replace with new materials according to these specifications.

D. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these specifications.

3.17 Piping Insulation Schedule, General

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor’s option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following systems, materials, and equipment:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.
4. In steam, hot water, domestic, and nonpotable service only: flexible connectors, unions, pressure-reducing valves, balancing valves, flow-control valves, steam traps, and in sizes less that 1-1/2", valves and strainers.
5. Fire-suppression piping
6. Flexible rubber connections in chilled water systems
7. Insulation of domestic cold and nonpotable water is only required in exterior walls, in ceiling spaces below roofs, and in areas subject to freezing.
8. All piping exposed to the weather, in unheated spaces or with heat tracing, must have 1" of insulation added to the values in the table. Exceptions: Refrigerant suction piping, condensate drains.

3.18 Indoor Piping Insulation Schedule

A. Condensate and Equipment Drain Water, any operating temperature:

1. All Pipe Sizes: Insulation shall be **one of** the following with vapor barrier:

   a. Cellular Glass: **1-1/2 inches (38 mm)** thick.
   b. Flexible Elastomeric: **1 inch (25 mm)** thick.
   c. Mineral-Fiber, Preformed Pipe Insulation, Type I: **1 inch (25 mm)**] <**Insert dimension**> thick.

d. Phenolic: **1 inch (25 mm)** thick.
e. Polyisocyanurate: **1 inch (25 mm)** thick.
f. Polyolefin: **1 inch (25 mm)** thick.

B. Chilled Water, up to 58 Degrees F (14 Degrees C) and below:

1. 3-inch and smaller: Insulation shall be **one of** the following with vapor barrier:

a. Cellular Glass: **2 inches (50 mm)** thick.
b. Mineral-Fiber, **Preformed Pipe, Type I 1 inch** thick.
c. Phenolic: **3 inches (75 mm)** thick.
d. Polyisocyanurate: **1 inch (25 mm)** thick.

2. 3-1/2 to 8-inch insulation shall be **one of** the following with vapor barrier:

a. Cellular Glass: **3 inches (75 mm)** thick.
b. Mineral-Fiber, **Preformed Pipe, Type I** 1**-1/2 inches (38 mm)** thick.
c. Phenolic: **3 inches (75 mm)** thick.
d. Polyisocyanurate: **1 inch (25 mm)** thick.

3. Larger than 8-inch (DN 200): Insulation shall be **one of** the following with vapor barrier:

a. Cellular Glass: **3 inches (75 mm)** thick.
b. Mineral-Fiber, **Preformed Pipe, Type I or Pipe and Tank Insulation**: **2 inches (50 mm)** thick.
c. Phenolic: **3 inches (75 mm)** thick.

C. Process Cooling Water, up to 65 Degrees F (18 Degrees C):

1. All sizes: Insulation shall be [**one of**] the following with vapor barrier:

a. Cellular Glass: **2 inches (50 mm)** thick.
b. Flexible Elastomeric: **1 inch (25 mm)** thick.
c. Mineral-Fiber **Preformed Pipe, Type I**: **1 inch (25 mm)** thick.
d. Phenolic: **3 inches (75 mm)** thick.
e. Polyisocyanurate: **1 inch (25 mm)** thick.
f. Polyolefin: **1 inch (25 mm)** thick.

D. Process Cooling Water, 66 to 110 Degrees F:

1. All sizes: Insulation not required. Vapor barrier required.

3.19 Outdoor, Aboveground Piping Insulation Schedule

A. Chilled Water and Brine:

1. 3-inch and smaller: Insulation shall be **one of** the following with vapor barrier:

a. Cellular Glass: **3 inches (75 mm)** thick.
b. Flexible Elastomeric: **3 inches (75 mm)** thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 **inches** thick.

d. Phenolic: **2 inches (50 mm)** thick.
e. Polyisocyanurate: **2 inches (50 mm)** thick.
f. Polyolefin: **3 inches (75 mm)** thick.
g. Polystyrene: **2 inches (50 mm)** thick.

2. 3-1/2-inch to 8-inch: Insulation shall be the following with vapor barrier:

a. Mineral-Fiber, Preformed Pipe Insulation, Type I **or** Pipe and Tank Insulation: 2-1/2 inches thick.

3. Above 8-inch: Insulation shall be the following with vapor barrier:

a. Mineral-Fiber, Preformed Pipe Insulation, Type I **or** Pipe and Tank Insulation: 3 inches thick.

3.20 Indoor, Field-Applied Jacket Schedule

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. None above 8 feet above finished floor.
2. **PVC**: **20 mils** thick.
3. Aluminum, **Stucco Embossed**: **0.016 inch** thick.

3.21 Outdoor, Field-Applied Jacket Schedule

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. Aluminum, **Stucco Embossed**: **0.016 inch** thick.

D. Piping, Exposed:

1. Aluminum, **Stucco Embossed**: **0.016 inch** thick.

3.22 Molten Salt and Ullage Gas Pipe Supports and Anchors

A. All Molten Salt Pipe supports and anchors shall be constructed in accordance with drawing details. Insulation shall be mounted up to the insulated pipe support and routed around the support.

B. Insulation shall be applied to the pipe as 2 – 2-inch thick layers. The layered seams (horizontal and vertical) shall be offset from one another a minimum of 12-inches.

C. All piping shall be supported in such a manner that neither the insulation nor the weather barrier is compromised by the hanger, pipe guide, pipe shoe or pipe anchor.

D. Where pipe guide, pipe shoe or pipe anchor supports are required, insulation shall be inserted to minimize pipe loss.

E. The pipe support or pipe anchor is sized not to be flush with the outer diameter of the pipe insulation. Approximately 3-inches of stainless steel pipe support after complete installation of insulation thickness as specified on the drawing details is to be exposed to ambient air for cooling prior to support stand connection.

F. Heat trace flower shall be installed as follows:

1. Coordinate installation of heat trace flower with insulator, heat trace installer, and pipe fitter. See drawing detail for Heat Trace Flower for additional requirements.

2. The heat trace (hot to hot and hot to cold junctions) shall be positioned below 8 and 4 o'clock positions and outside the insulation. Ensure heat trace flowers are intact prior to insulation.

3. A maximum of one heat trace cable through one ½-inch tubing is allowed.

4. Provide schedule 5, 304 stainless steel tubing size ½-inch diameter by 0.125-inch wall thickness for routing the heat trace cable from the molten salt pipe, vacuum relief pipe, valve bodies, valve bonnet, and flow meter, etc. to the exterior side of the insulation package.

5. Bend the straight tubing to provide a less than 90 degree elbow transition to route the cable inside the tubing to the exterior. The straight pipe bend is dependent on the cable bending radius. If the Contractor is unable to bend the elbow without kinking the pipe, then provide either 45° or 90° elbow with straight pipe.

6. Tack weld tubing bend elbow to carrier pipe to ensure tubing remains attached to carrier pipe.

7. Extended tubing through the insulation exterior jacket a minimum 1/2 - 3/4 inch. Extend cable hot-to-hot and hot-to-cold lead a minimum of 2-inches past the end of the tubing.
8. Provide escutcheon or some other means of sealing the tubing penetration through the insulation jacket. The area between the cable and tubing shall remain open to atmosphere and pointed down between 4-8 o'clock position to prevent water infiltration

END OF SECTION

Exceptional service in the national interest

Sandia National Laboratories

Section 23 21 13 – Hydronic Piping

March 2018

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 23 21 13 – Hydronic Piping

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to new Master spec style.
10/26/16	Russ Matheson; Jennifer Sawayda	Admin	1.10 - Quality Assurance; added reference to 230050 in ASME compliance; spelled out acronyms
3/6/18	Jennifer Sawayda	Admin	3 -year review completed. Minor administrative changes made.
11/16/18	Jennifer Sawayda	Admin	Made changes to eliminate grooved fittings content; removed content from Quality Assurance
3/22/19	Jennifer Sawayda	Subst	Took out glycol cooling water piping; added Pressure Seal Ends to Section 2.9; extensive changes to Section 3.1

Section 23 21 13 – Hydronic Piping

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Hot-water heating piping.
2. Chilled-water piping.
3. Condenser-water piping.
4. Makeup-water piping.
5. Condensate-drain piping.
6. Blowdown-drain piping.
7. Air-vent piping.
8. Safety-valve-inlet and -outlet piping.

B. Pipe and fittings to be used for modifications or additions must be the same material as the existing systems being modified, but must conform to the following, unless otherwise indicated on the applicable contract drawings.

C. Piping materials and installation procedures must conform to ASME B31.9, *Building Services Piping*, the International Mechanical Code, and this Section.

1.3 Definitions

A. PTFE: Polytetrafluoroethylene.

1.4 References

The current editions of the following standards are a part of this specification:

A. Sandia National Laboratories (SNL) Construction Standard Specifications and Drawings.

B. American Society of Mechanical Engineers (ASME)

Number	Title
ASME BPVC	Boiler and Pressure Vessel Code
ASME B1.1	Unified Screw Threads
ASME B1.2	Pipe Threads, General Purpose
ASME B16.3	Malleable Iron Thread Fittings Classes 150 and 300
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.9	Factory-made Wrought Steel Butt Welding Fittings
ASME B16.11	Forged Fittings, Socket-Welding and Threaded
ASME B16.18	Cast Copper Alloy Solder-Joint Pressure Fittings
ASME B16.22	Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
ASME B16.24	Bronze Pipe Flanges and Flanged Fittings, Class 150 and 300
ASME B16.33	Manually Operated Metallic Gas Valves for Use in Gas Piping Systems up to 125 psi (Sizes NPS ½ through NPS 2)
ASME B16.34	Valves - Flanged, Threaded, and Welding End
ASME B31.9	Building Services Piping
ASME B40.100	Pressure Gauges and Gauge Attachments Incorporating ASME B40.1 and ASME B40.7

C. American Society for Testing and Materials (ASTM)

Number	Title
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A153	Zinc Coating (Hot Dip) on Iron and Steel Hardware
ASTM A182	Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings and Valves and Parts for High-Temperature Service
ASTM A193	Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A194	Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
ASTM A234	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A307	Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A536	Standard Specification for Ductile Iron Castings
ASTM B43	Standard Specification for Seamless Red Brass Pipe, Standard Sizes
ASTM B61	Standard Specification for Steam or Valve Bronze Casting
ASTM B88	Standard Specification for Seamless Copper Water Tube
ASTM B280	Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

ASTM B687	Standard Specification for Brass-, Copper -, and Chromium-Plated Pipe Nipples
ASTM B819	Standard Specification for Seamless Copper Tube for Medical Gas Systems
ASTM B828	Standard Practice for Making Capillary Joint by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM D 2000	Standard Classification for Rubber Products …
ASTM F402	Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
ASTM F437	Standard Specification for Threaded CPVC Plastic Pipe Fittings, Schedule 80
ASTM F439	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F441	Standard Specification for CPVC Plastic Pipe, Schedules 40 and 80
ASTM F1476	Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications

D. American Water Works Association (AWWA)

- American National Standards Institute (ANSI)/AWWA C606, AWWA Standard for Grooved and Shouldered Joints

E. American Welding Society (AWS)

Number	Title
AWS A5.8	Specification for Brazing Filler Metal
AWS B2.1-8-005	Standard Welding Procedure Specification for Gas Metal Arc Welding of Austenitic Stainless Steel, 18 through 10 Gauge, in the As-welded Condition, with or without Backing Site License
AWS B2.2	Standard for Brazing Procedure and Performance Qualification

F. International Code Council (ICC)

- International Mechanical Code (IMC)
- International Plumbing Code (IPC)
- International Fuel Gas Code (IFGC)

G. American Gas Association (AGA)

H. Copper Development Association

1.5 Performance Requirements

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

1. Hot-Water Heating Piping: 150 pounds per square inch gauge (psig) (1035 kilopascals) at 200°F (93°C).

2. Chilled-Water Piping: 150 psig at 200°F
3. Condenser-Water Piping: 150 psig at 150°F
4. Makeup-Water Piping: 80 psig at 150°F
5. Condensate-Drain Piping: 150°F
6. Blowdown-Drain Piping: 200°F
7. Air-Vent Piping: 200°F
8. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

1.6 Action Submittals

A. Product Data: For each type of the following:

1. Plastic pipe and fittings with solvent cement.
2. Pressure-seal fittings.
3. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
4. Air control devices.
5. Hydronic specialties.

B. Leadership in Energy and Environmental Design (LEED) Submittals:

1. Product Data for Credit Indoor Environmental Quality (IEQ) 4.1: For solvent cements and adhesive primers, documentation including printed statement of volatile organic compound (VOC) content.
2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Detail, at 1/4 (1:50) scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1.7 Informational Submittals

A. Qualification Data: For Installer.

B. Welding certificates.

C. Field quality-control test reports.

D. All certifications for welders and brazers must be submitted to the Mechanical Sandia Construction Observer (SCO), for verification of quality assurance at least two weeks before starting any work. The procedures and certifications will be reviewed by the SNL-designated certified welding inspector.

E. Calibrated Balancing Valves: Provide submittal data that includes calibration curves.

1.8 Closeout Submittals

A. Operation and Maintenance (O&M) Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

B. ASME-Rated Pressure Vessels: Two copies of the manufacturer's data report for ASME-rated pressure vessels must be submitted in the O&M package.

C. As-Built Drawings: Upon completion of the work, the Contractor must revise all drawings to agree with the construction materials, capacities, locations, and routing as actually accomplished. The notation "As-Built" must be entered in the revision block, dated, and initialed.

1.9 Maintenance Material Submittals

A. Water-Treatment Chemicals: Coordinate chemicals to be provided with the SCO.

1.10 Quality Assurance

A. Installer Qualifications:

1. Installers of Copper or Bronze Pressure-Sealed Joints: Pipefitters must be trained by the pressure joint fitting manufacturer to join copper pipe with pressure-seal fittings.
2. Copper pressure-seal fittings must be installed using the proper tool, actuator, jaws, and rings as instructed by the press-fitting manufacturer.

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code – Steel."

C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. ASME Compliance:

1. Welded pipe shall comply with the guidelines as specified in 23 00 50 "Basic Mechanical Materials and Methods," part 1; section 1.5; paragraph C.

2. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. Performance qualification of welders/brazers must remain in effect indefinitely unless the welder/brazer does not weld or braze with the qualified procedure for a period exceeding 6 months, or there is a specific reason to question the ability of the welder/brazer.

F. Soldering: Conform to ASME B31.9, *Building Services Piping,* and Copper Development Association recommended practices.

PART 2 - Products

2.1 Acceptable Manufacturers

A. The following products and materials must be used unless shown otherwise on the drawings. Other products of equal or better quality and characteristics may be submitted in addition to those listed in this specification. All products and materials must be of new, unused condition unless such have been provided by SNL personnel.

B. General

Pipe and fittings to be used in modifications, repairs, or additions must be of the same material (steel, copper, or plastic) as the existing system being modified or repaired and must conform to the following unless otherwise indicated on the applicable contract drawings.

2.2 Copper Tube and Fittings

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B).

B. DWV tubing in first paragraph below is intended for nonpressure applications and is applicable for condensate drains.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Fittings: ASME B16.22.

E. Copper or Bronze Pressure-Seal Fittings:

1. Rigid ProPress™ NIBCO, Inc. or Stadler-Viega.
2. Housing: Copper or bronze
3. O-Rings and Pipe Stops: EPDM.
4. Tools: Manufacturer’s special tools.
5. Minimum 200-psig (1379-kPa) working-pressure rating at 250°F (121°C).

F. Wrought-Copper Unions: ASME B16.22.

G. Threaded brass fittings and nipples, ASTM B 43, ASTM B 687.

2.3 Flanges

A. Bronze: Class 150 bronze flange per ASME B16.24. Threaded or solder joint.

2.4 Steel Pipe and Fittings

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 “Piping Applications” article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 “Piping Applications” article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 as indicated in Part 3 “Piping Applications” article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150 as indicated in Part 3 “Piping Applications” article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 “Piping Applications” article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Forged-Steel Threaded and Socket-Weld Fittings: ASME B16.11, Class 2000 and 3000.

I. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

J. Forged-Steel Branch Fittings (such as Weld-O-Lets™ or Thread-O-Lets™): Manufacturers Standardization Society Standard Practice-97 (MSS-SP-97), with thickness to meet pipe pressure ratings.

2.5 Plastic Pipe and Fittings

A. Chlorinated polyvinyl chloride (CPVC) Plastic Pipe: ASTM F 441/F 441M, Schedules 80, plain ends as indicated in Part 3 "Piping Applications" Article.

1. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 439 for Schedule 80 pipe and Schedule 80 threaded fittings per ASTM F437.

- CPVC Fittings with a Female Adapter Component: All female-adapter fittings used in the transition from metal to thermoplastic pipe must be supplied with a reinforced collar of stainless steel around the threaded joint for added protection.

2.6 Joining Materials

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2 millimeter [mm]) maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

F. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.

a. CPVC solvent cement shall have a VOC content of 490 grams per liter (g/L) or less when calculated according to 40 Code of Federal Regulations (CFR) 59, Subpart D (Environmental Protection Agency [EPA] Method 24).
b. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

H. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.7 Transition Fittings

A. Plastic-to-Metal Transition Fittings:

1. CPVC one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cement-joint end.

B. Plastic-to-Metal Transition Unions:

1. MSS SP-107, CPVC union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and threaded union.

2.8 Dielectric Fittings

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Joining dissimilar materials (copper to steel). Use dielectric nipples, dielectric couplings, brass nipples, brass valves, or brass unions between copper and steel piping 2 inches and smaller. Use dielectric flange kits on larger piping. Dielectric unions must not be used to join two dissimilar metals (ferrous and nonferrous metallic piping.)
2. Description:

    a. Standard: American Society of Sanitary Engineering (ASSE) 1079.
    b. Pressure Rating: 250 psig (1725 kPa) minimum at 180°F.
    c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Description:

    a. Standard: ASSE 1079.
    b. Factory-fabricated, bolted, companion-flange assembly.
    c. Pressure Rating: 150 psig (1035 kPa) minimum at 180°F (82°C).
    d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Description:

    a. Nonconducting materials for field assembly of companion flanges.
    b. Pressure Rating: 150 psig (1035 kPa).
    c. Gasket: Neoprene or phenolic.
    d. Bolt Sleeves: Phenolic or polyethylene.
    e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Description:

a. Standard: International Association of Plumbing and Mechanical Officials Product Standard 66 (IAPMO PS 66)
b. Electroplated steel nipple, complying with ASTM F 1545.
c. Pressure Rating: 300 psig (2070 kPa) at 225°F (107°C).
d. End Connections: Male threaded.
e. Lining: Inert and noncorrosive, propylene.

2.9 Valves

A. Gate:

1. 2 inches and smaller: Bronze or brass body, 200 psi nonshock working pressure, solder or threaded ends, screwed bonnet, and full port. Bronze body – Nibco S-111 or Nibco T-111. Brass body – Nibco SI-8 or TI-8.
2. 2½ inches and larger: Iron body, 200 psi nonshock cold working-pressure rating, flanged ends, outside stem and yoke (OS&Y), bronze trim, rising stem, and solid wedge. Nibco F-617-0.

B. Ball:

1. 2 inches and smaller:

a. Two-Piece Body: Bronze or brass body, 600 psi nonshock working pressure, blow-out-proof captive stem, double Teflon seats, full-ported, stainless steel or chrome-plated brass ball, threaded or soldered ends. Bronze body: Nibco T-585-70 or S-585-70. Pressure-seal ends: Nibco PC-585-70. Brass body: Nibco T-FP-600 or S-FP-600.

1) System Drain Applications: May use a valve with integral hose connection, cap, and chain; full-port, blow-out-proof stem, double Teflon seats, and rated for 600 psi nonshock working pressure. Nibco 585-70-HC.
2) Three-Piece Body: Bronze body, 600 psi nonshock working pressure, blow-out-proof captive stem, double Teflon seats, full-port, stainless steel trim, and threaded or soldered ends. Nibco T or S-595-Y.

C. Globe:

1. 2 inches and smaller: Class 125, screwed ends, bronze body, inside screw, screw-in bonnet, renewable seat and disc. Nibco T-211.
2. 2½ inches and larger: Class 125, iron body conforming to ASTM A126 Class B, bronze trim, flanged ends, bolted bonnet, bronze disc, replaceable seats. Nibco F-718-B.

D. Butterfly:

1. Lug Type:

a. 2½ inches through 6 inches: 200 psi working pressure, ductile iron body, aluminum/bronze disc, EPDM liner, stainless steel shaft, resilient seat, O-ring seals, lug type for dead-end service, lever operator. Nibco LD2000 series.

b. 8 inches and larger: 150 psi or 200 psi working pressure, ductile iron body, aluminum/bronze disc, EPDM liner, stainless steel shaft, resilient seat, O-ring seals, lug type for dead-end service, gear operator. Nibco LD1000 or LD2000 series dependent on the application.

E. Check Valve:

1. 2 inches and smaller: Class 125, threaded ends, bronze body, Y pattern, renewable seat and disk, and screw cap. Nibco T-413
2. 2½ inches and larger:

a. Flanged Type: Class 125, iron body, silent check, flanged ends, globe style, spring-actuated, renewable seats and disc, bronze trim or 316 stainless steel trim. Nibco F-910.

F. Vertical Check: 2 inches and smaller: Class 125, threaded ends, bronze body, spring actuated, inline vertical lift type, TFE seat ring. Nibco T-480-Y.

G. Needle: 1 inch and smaller: Rated at 600 psi and 300°F, positive shut-off for gauges, brass. Weiss Instruments 25NVBR.

H. Thermoplastic (CPVC) Valves:

1. Ball: 2 inches and smaller: True-union body, rated for 225 psi at 70°F, CVPC body, blow-out-proof captive stem, Teflon seats, socket ends, full-port design, and EPDM or Viton seals. Approved manufacturers: Hayward, George Fisher, or Spears.
2. Butterfly: 1-1/2" and Greater: Rated for 150 psi at 73°F, CVPC body, 316 stainless steel shaft and hardware, 100% positive seal, and EPDM or Viton disc seals.

I. Bronze, Calibrated-Orifice, Balancing Valves, 2 Inches and Smaller:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Bell & Gossett (B&G), a Xylem brand

2. Body: Bronze, ball type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded.
7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. Cold Working Pressure (CWP) Rating: Minimum 200 psig (1380 kPa).
10. Maximum Operating Temperature: 250°F (121°C).
11. Bell and Gossett Series Model CB.
12. Provide calibration curves with submittals.
13. Size valves for operation in the midsection of curves at the coils specified flow rate.

J. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves, 2-1/2 Inches and Larger:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Bell & Gossett (B&G), a Xylem brand, Series Model CB.

2. Body: Cast-iron or steel body, ball or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged.
8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 175 psig (1200 kPa).
11. Maximum Operating Temperature: 250°F (121°C).

2.10 Air Control Devices

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   1. Bell & Gossett (B&G), a Xylem brand

B. Manual Air Vents:

   1. Body: Bronze.
   2. Internal Parts: Nonferrous.
   3. Operator: Screwdriver or thumbscrew.
   4. Inlet Connection: Nominal Pipe Size (NPS) 1/2 (Diameter Nominal [DN] 15).
   5. Discharge Connection: NPS 1/8 (DN 6).
   6. CWP Rating: 150 psig (1035 kPa).
   7. Maximum Operating Temperature: 225°F (107°C).

C. Automatic Air Vents:

   1. Body: Brass.
   2. Internal Parts: Nonferrous.
   3. Operator: Noncorrosive metal float.
   4. Inlet Connection: NPS 1/2 (DN 15).
   5. Discharge Connection: NPS 1/4 (DN 8).
   6. CWP Rating: 150 psig (1035 kPa).
   7. Maximum Operating Temperature: 240°F (116°C).
   8. B&G Model 87.

D. Air Purgers:

   1. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
   2. Maximum Working Pressure: 150 psig (1035 kPa).
   3. Maximum Operating Temperature: 250°F (121°C).

2.11 Bypass Feeder/Chemical Filter Feeder

A. A chemical bypass feeder must be installed on all heating and chilled-water loops and piped according to mechanical standard drawing MP5013STD.dgn. The bypass feeder must be a 5-gallon Neptune FTF-5HP filter feeder capable of an operating pressure up to 300 psig, operating temperature up to 200ºF, and flow up to 40 gallons per minute with a maximum initial pressure drop of 3 psi. The feeder must contain a stainless-steel filter bag screen, with polypropylene replacement bag filter. Feeder must have fill, inlet, outlet, and drain ports.

B. Ethylene and Propylene Glycol: Industrial grade with corrosion inhibitors and environmental-stabilizer additives for mixing with water in systems indicated to contain antifreeze or glycol solutions.

2.12 Glycol-Resistant Materials

A. All materials installed in a system containing a water/glycol solution must be resistant to (compatible with) glycol.

2.13 Hydronic Piping Specialties

A. Thermometers and Thermowells

1. Thermometers must be digital readout, solar-powered, union national pipe thread (NPT) connection, and with an ABS case. Each thermometer must be provided with a separable brass thermowell consisting of a properly sized bore. The well must be the length required for accurate reading of the measured media. Where thermometers occur in the insulated piping systems, or on insulated equipment, extension necks (lagging) must be provided so that the thermometer casing is outside of the insulation. Digital range must be -40°F to 300°F with a 3/8" liquid crystal display (LCD) and a 1% of reading accuracy. Weiss model number DVU 35 or Weksler model number AADHFC.

B. Pressure Gauges

1. Gauges for machine rooms, equipment rooms, and Central Utility Buildings (CUBs) must be industrial-type pressure gauges with safety-type rear blowout plug or panel, clear plastic lens, case consisting of one integral polypropylene part, ±0.5% accuracy, 4½" dial size. Weksler Series HA14. Gauges for point-of-use applications (such as process chilled-water drops, fan coil units, or user equipment) must be utility-type, heating, ventilating, and air conditioning (HVAC) gauges, bronze bourdon tube and brass socket, steel case, and plastic face 2½" dial size. Weksler Series 25TL. Range must be two times the system normal operating pressure. Gauges must be installed with snubbers and ¼" bronze needle valves. All gauges for steam systems must be provided with ¼" bronze needle valves, siphon tubes, and snubbers.

C. Y-Pattern Strainers:

1. 2 inches (DN 50) and smaller:

a. Body: ASTM B62, cast bronze with retainer cap tapped for closure plug.

b. End Connections: Threaded or solder ends
c. Strainer Screen: 20-mesh startup strainer, and perforated stainless-steel basket with 50% free area.
d. CWP Rating: 400 psig (2760 kPa) at 150°F.
e. Watts Series 777S or S777s; Kecley F or E-300.

2. 2-1/2 inches (DN 65) and larger (Flange Type):

a. Body: ASTM A 126, Class B, cast iron with bolted cap; cap tapped for closure plug.
b. Strainer Screen: 20-mesh startup strainer, and perforated stainless-steel basket with 50% free area.
c. CWP Rating: 200 psig (1380 kPa) at 150°F.
d. Kecley Style A Series.

D. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch (20-mm) misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250°F (121°C).

E. Flexible Connectors

1. 2 inches and smaller: Threaded or socket ends, Type 321 stainless steel or bronze corrugated inner tube and wire-braid outer shield, MetraFlex™ SST, BBT, or BBS, Mason MN, FFL.
2. 2-1/2 inches and larger: Elastomer connector, solid plate steel, Class 150 flanged ends, constructed of EPDM and KEVLAR®, temperature-rated at no less than 240°F. Control units must be installed per manufacturer's instructions. MetraFlex MightySphere or Mason SafeFlex.

F. Expansion fittings as indicated on Contract Documents.

G. Flexible Hose and Fitting

1. 1/4" – 3/4" hose and fitting for final lab equipment connection assemblies. Synthetic rubber tube, textile-braid reinforcement, polyester braided cover, low-pressure hose. Operating temperature range: -40°F to 212°F, water not to exceed 150°F, air not to exceed 165°F. Maximum operating pressure 150 psi. Aeroquip 2556 tubing and Socketless™ hose fittings, Parker 801 multipurpose Push-lok® hose and fittings, and Swagelok PB series rubber hose with push-on connections. Flexible hose connections are not permitted in concealed areas or for heating and cooling coil installations.

H. Hydronic Piping Packages

1. All individual or combination components must meet the individual component specifications stipulated in this standard with the exception that the isolation valves may be of standard port. Flexible hoses must be 24" or less in length. Hose construction must

be EPT or EPDM tube with stainless-steel-braid reinforcement. Each hose must have at least one swivel or union end. All components must have a working temperature range of 0° to 212°F and a working pressure rating of 300 psi. Hose must be fire-rated per UL-94. Hose installation must be kept as straight as possible, but in no case must the maximum bend radius stipulated by the manufacturer be exceeded. Multiple bends in a single hose are not allowed.

PART 3 - Execution

3.1 Piping Applications

A. Process chilled-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed, or pressure-seal joints.
2. STD steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
3. Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

B. Process chilled-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. STD steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

C. Chilled-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed, or pressure-seal joints.
2. STD steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

D. Chilled-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. STD steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

E. Heating-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed, or pressure-seal joints.

2. STD steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

F. Heating-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. STD steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

G. Condenser-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be one of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed or pressure-seal joints.
2. STD steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

H. Condenser-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be one of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. STD steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

I. Underground Condenser Water Piping: STD black steel, seamless Type S or welded Type E, Grade B, ASTM A53. Installed protective pipe coating systems must be of the same materials throughout.

1. Fittings and Joints: All joints in underground piping must be welded using STD forged-steel butt-weld fittings. Use of unions and flanges underground is prohibited. Fittings and joints must be protected with Polyken No. 1027 primer and Polyken No. 930-35 tape coating, 35 mil, 21 kilovolts (kV) dielectric strength, as manufactured by Tyco adhesives, Corrosion Protection Group. Minimum 1-inch overlap required.
2. Protective pipe covering must be factory- or field-applied according to manufacturer's written instructions. Products must be Polyken No. 1027 primer and Polyken No. 930-35 tape coating, 35 mil 21 kV dielectric strength, as manufactured by Tyco adhesives, Corrosion Protection Group. Minimum 1-inch overlap required.
3. Epoxy Coatings: 3M epoxy coatings may be used in place of the Polyken pipe coatings. 3M Scotchkote™ 6233, Fusion-Bonded Epoxy Coating, must be facility-specified and applied at 15-mil thickness for pipe and fittings. 3M Scotchkote 323, Liquid Epoxy Coating, must be facility-specified and applied at 25-mils thickness. Epoxy coatings must be applied according to manufacturer's written instructions. The coating, pipe, or joint must be inspected for continuity in accordance with NACE Standard RP0490-01, *Holiday Detection Fusion-Bonded Epoxy.*

J. Condensate-Drain Piping: Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

K. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

L. Air-Vent Piping:

1. Inlet: Same as service where installed.
2. Outlet: Type K (A), annealed-temper copper tubing with soldered or flared joints.

M. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.2 Valve Applications

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

B. Install throttling-duty valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors, and pipe drain to nearest floor drain or as indicated on drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

G. Valves must be installed at the locations shown on the drawings and where specified. All valves must be installed with their stems orientated horizontal or vertical upright and with sufficient clearance to allow for full-stem travel and the repair of two-piece or three-piece valves in place.

3.3 Piping Installations

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install piping at a uniform grade of 0.2% upward in direction of flow.

M. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

N. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the side or top of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

O. Installation of Valves: Valves must be installed at the locations shown on the drawings and where specified. All valves must be installed with their stems orientated horizontal or vertical and with sufficient clearance to allow for full-stem travel and the repair of two-piece or three-piece valves in place

P. Install unions in piping**,** NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

R. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

S. Install expansion loops, expansion joints, anchors, and pipe alignment guides as indicated on Contract Documents.

T. Identify piping as specified in Specification Section 23 00 50.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Specification Section 23 00 50.

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Specification Section 23 00 50.

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Specification Section 23 00 50.

3.4 Hangers and Supports

A. All piping must be rigidly supported from the building structure by means of adjustable ring-type, clevis, or band-type hangers. (Welding to the building structure is not permitted unless approved by the Structural Engineer.) Where pipes run side by side, support on rod and angle iron or Unistrut trapeze hangers. Hanger spacing must be as follows:

1. Horizontal:

Steel Piping	Maximum Spacing
⅜" and smaller	4'-0"
½" through 1"	6'-0"
1¼" and larger	10'-0"

Copper Piping	Maximum Spacing
⅜" and smaller	4'-0"
½" through 1¼"	6'-0"
1½" and larger	10'-0"

a. All Other Piping Materials: Pipes must be supported in accordance with the Piping Support Spacing table of the International Mechanical Code.

2. Vertical: Steel and copper piping must be supported at 10'-0" intervals, maximum spacing.

a. All Other Piping Materials: Pipes must be supported in accordance with the Piping Support Spacing table of the International Mechanical Code.

B. Round rods supporting the pipe hangers must be of the following dimensions unless otherwise specified on the project drawings by a professional structural engineer:

Pipe	Rod
⅜" to 2" pipe	⅜" rod
2½" to 3" pipe	½" rod
4" to 5" pipe	⅝" rod
6" pipe	¾" rod
8" through 12"	⅞" rod
14" through 16"	1" rod

C. Rods for trapeze hangers must be a minimum of 3/8" and must have the equivalent cross section, listed in Section 3.1.E.2, per pipe supported. The use of pipe hooks, chains, perforated iron strapping, or wire for pipe supports is not permitted.

D. Hanger rods must be galvanized or zinc-plated carbon steel per ASTM A307 Grade B, threaded per ASME B1.1 with a coarse-thread series, and with a Class 2A fit.

1. All hanger rod connections must use double-nut fastening. Hanger rods must not extend

more than one inch past the double nut or beam clamp.

E. Hanger rods must be installed vertically. No offset in hanger rod is permitted.

F. Place a hanger within 1'-0" of each horizontal elbow.

G. Use hangers that are vertically adjustable 1-1/2" minimum and a maximum of 2" after piping is erected.

H. Use copper-plated materials, PVC-coated materials, or nonconductive isolators on copper pipe and ferrous materials on ferrous pipes.

I. Soft copper tubing, where permitted, must be fastened to the building structure with Unistrut-type clamps and spaced not more than 6'-0" apart.

J. On 4" and larger piping, install hangers adjacent (within 1'-0" on each side) of strainers, valves, and all flanged items.

K. C-clamp-style hanger must only be installed with retaining clip.

L. Provide seismic restraints and vibration isolation as required by Contract Documents and Special Specifications.

M. All Other Piping Materials: Pipes must be supported in accordance with the Piping Support Spacing table of the International Mechanical Code. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

3.5 Pipe Joint Construction

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or Copper Development Association's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Tubing must be cut square, reamed, and burrs removed. Both the inside of fittings and the outside of tubing must be well-cleaned with sand cloth or wire brush before sweating. Care must be taken to prevent annealing of fittings and hard-drawn tubing when making connections.

1. Solder containing antimony **must not** be used to join metals containing zinc (for example, galvanized iron, galvanized steel, and brass).
2. Use sand cloth or a stainless-steel wire brush to clean surfaces to be joined.
3. Solder End Valve: Use a gate, globe, two-piece or three-piece ball valve for solder-end valves. When joining a solder-end valve, ensure valve is fully open. Apply heat to tube first. Transfer as much heat as possible through the tube to the valve. Avoid prolonged heating of the valve. Use a noncorrosive paste flux and solid-wire solder suitable for the service temperatures and pressures expected.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

New copper systems must be installed with socket-type fittings and with an argon or nitrogen purge applied. Flux must not be used except when joining specialty items and fittings that are not available in copper.

The following procedure must be followed:

1. Tube ends must be cut square using a sharp tubing cutter. The wheel must be free of grease, oil, and dirt. The cut end of the tubing must be deburred with a sharp, clean deburring tool, taking care to prevent chips from entering the tube or pipe.
2. The surfaces to be brazed must be cleaned mechanically. Joints must be recleaned if they become contaminated prior to brazing. Joints must be brazed within 1 hour of being cleaned.
3. Where dissimilar metal joints, such as copper to bronze or brass, are being brazed, flux must be applied sparingly to minimize contamination of the inside of the tube with flux. Where possible, short sections of copper tube must be brazed to the noncopper components, and the interior of the subassembly must be cleaned of the flux prior to installation in the piping system. Flux-coated brazing rods may be used in lieu of the application of flux to the surfaces to be joined for tubes 3/4" size and smaller.
4. While being brazed, joints must be continuously purged with oil-free dry nitrogen or argon to prevent the formation of copper oxide on the inside surface of the joint. The flow of the purge gas must be maintained until the joint is cool to the touch.
5. Exception: A final connection to an existing system must be permitted without the use of a purge gas.
6. During and after installation, openings in the piping system must be kept capped or plugged to avoid unnecessary loss of purge gas and to prevent contamination. Do not begin brazing until piping is fully purged of air. For continuous runs of piping, brazing must begin at the purge port area and continue through the system. The purge connection must not be changed. While brazing, a discharge opening must be provided on the opposite side of the joint from where the purge gas is introduced. During brazing, the purge gas flow rate must be maintained at a level that does not produce positive pressure in the piping system. While welding, the minimum purge rate must be 15 standard cubic feet per hour (scfh) for 1/4" tubing or 25 scfh for all tubing 3/8" and larger. Purge must continue after completion of braze until the joint is cool.
7. After brazing, the outside of all joints must be cleaned by washing with water and a stainless-steel brush to remove any residue and permit clear visual inspection of the joint. Where flux has been permitted, hot water must be used.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
3. Thermoplastic threaded pipe joints must be made leak-tight per product manufacturer's recommendations. When joining thermoplastic threaded pipe to metal threaded piping, attempts should be made to screw the plastic pipe into female metal pipe fittings to

reduce the likelihood of plastic fitting failure.

G. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" article.

Joints between sections of pipe and between pipe and fittings may be welded using either gas or electric welding equipment. Stainless steel welding must conform to AWS B2.1-8-005. All pipe surfaces must be thoroughly cleaned before welding. Each joint, except socket-weld joints, must be beveled before being welded. The Contractor must provide a nonflammable mat or blanket to protect the structure and adequate fire protection equipment at all locations where welding is done. All elbows must be long radius where space conditions allow. Wherever branch connections are made to piping systems on the main run, welding sockets or Weld-O-Lets may be used in lieu of reducing outlet tees for branch connections up to one-half the size of the main run. On connections larger than one-half the size of the main run, welding tees must be used. The use of fittings formed from welded pipe sections is not permitted. All welding must conform to the requirements of SNL Construction Standard Specification Section 23 00 50, Section 3.3. Any welding work requires the following:

1. A hot work permit from SNL Fire Protection.
2. A dedicated fire watch during the work process until thirty (30) minutes after completion.
3. A minimum 2-A-rated fire extinguisher located near the welding site.
4. Any other special requirements listed on the permit.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. All flanged joints must be face matched. Raised face flanges must not be mated to flat-faced cast-iron flanges on valves or equipment. The raised face must be machined flush. All flange bolt holes must straddle the horizontal and vertical centerlines unless otherwise noted. Install insulating kits on flanges connecting dissimilar metals, such as steel to copper, to prevent electrolytic action. Bolting must comply with ASME B31.3, *Process Piping*. Torque values and tightening sequence for bolts must be in accordance with flange manufacturer's instructions.

I. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

J. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

K. Swagelok Compression Fittings: Follow the manufacturer's installation instructions for assembling tubing and tube fittings. Use a sharp clean tube-cutter wheel to cut tubing. Remove burrs, chips, and scratches from the end of the tubing. Ensure that the tubing is fully bottomed in the fitting before final tightening. After assembly, check that the fitting is properly tightened by using a Gap Inspection Gauge.

3.6 Hydronic Specialties Installation

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2% upward slope toward tank.

D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.

E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

F. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches (1200 mm) above the floor. Install feeder in minimum NPS 3/4 (DN 20) bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 (DN 20) pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port ball valve.

G. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

   1. Install tank fittings that are shipped loose.
   2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

H. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system project requirements.

I. System Drains: Drains indicated on the drawings in connection with water distribution systems must be no smaller than 3/4" IPS. Install valve with bronze caps or plugs, unless otherwise noted. Additional drains must be installed at low points on the hot water and chilled water piping to ensure proper draining of the system, and all piping must pitch to the drains. System drains used on 14-inch and larger piping systems must use a minimum 1½-inch drain. Ball or gate valves with hose-end fitting and cap must be provided as drain valves at low points.

J. Discharge from pressure-relief valves must be piped full-size and extended to a nearby floor sink or to the outside of the building structure, unless otherwise shown on the drawings.

K. Insulation of all pipes, valves, fittings, and equipment must be in accordance with Section 23 07 19, "HVAC Piping Insulation," and 23 07 16, "HVAC Equipment Insulation" unless noted otherwise on the drawings.

L. Cross-Connection Prevention

   1. A reduced-pressure backflow-prevention assembly (RPBA) must be installed to prevent

cross-connection contamination between potable water systems and nonpotable, potentially polluted, or contaminated systems, such as drainage systems, soil lines, fire protection lines, or chemical lines.

2. All potable water fixture outlets with hose attachments, such as hose bibbs, janitor sinks, or lab sinks, must be protected by an approved (SCO or IAPMO) vacuum-breaker device.
3. Reduced-pressure backflow-prevention assemblies must be approved by the Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California (USC-FCCCHR).
4. Backflow-prevention assemblies used or installed under this contract must be tested by a Certified Backflow Control Assembly Tester who possesses a current (within 3 years from date of issuance) certificate that confirms the successful completion of an approved (SCO-specified or USC-FCCCHR, or Colorado Environmental Training Center, Golden, Colorado) training course.
5. The Contractor must perform an operational test on any new or relocated backflow-prevention assemblies used or installed under this contract. Passing backflow preventers must be labeled with a tag indicating the test performed, the tester's initials, and the date. Testing documentation must be submitted to the SCO.
6. Repairs to reduced-pressure backflow-prevention assemblies must be made with original manufacturer's parts.
7. Piping downstream of reduced-pressure backflow-prevention assemblies must be labeled "Nonpotable" or "NPW" in accordance with Section 23 00 50, “Basic Mechanical Materials and Methods.”
8. All RPBA devices must be installed at a maximum distance of 5 feet from finished floor with a 1-foot clearance maintained on all sides for ease of maintenance.
9. Adequate drainage must be provided for the RPBA and meet the following:

   a. Discharge must be piped full size (of the relief valve) and extend to a location shown on project drawings.
   b. Discharge piping must be sloped minimum 1/8" per foot.

3.7 Terminal Equipment Connections

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gauges and thermometers at coil inlet and outlet connections.

3.8 Flushing and Cleaning

A. Coordination for flushing and cleaning of the systems must be through the SCO to ensure that all systems, components, and controls are in place to execute Section 23 25 00 “Chemical Treatment for Hydronic Systems.”

3.9 Field Quality Control

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. All piping, equipment, and accessories installed under this contract must be inspected and pressure-tested by the Contractor in the presence of the SCO and approved before acceptance. The Contractor must furnish all labor, material, and equipment required for testing. If a hydrostatic test is to be performed, the Contractor must furnish the water from a source other than that of the system that is being repaired or modified. The use of data-logging instrumentation is recommended for testing. The Contractor must be responsible for all repairs and retesting as required. For test, the Contractor must provide a 4-inch or greater diameter pressure gauge with 1% full-scale accuracy. Pressure ranges and scale graduations for piping systems are specified in the following test pressure table.
2. Leave joints, including welds, uninsulated and exposed for examination during test.
3. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
4. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
5. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
6. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90% of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping." Refer to Table 1, *Test Pressures,* below.
5. After hydrostatic test pressure has been applied for at least 2 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

Table 1. Test Pressures

Test Pressure (psig or vacuum)					
System	Test Gauge Range	Test Gauge Graduation	Hydrostatic	Pneumatic	Vacuum
Heating Water and Chilled Water	200 psig	2 psig	150	NA	NA
Process Water Systems	1.5 times test pressure	2 psig	1.5 times design	NA	NA
Condenser Water	200 psig	2 psig	100	NA	NA

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 23 21 13

SPECIAL SPECIFICATION 232124S – HIGH TEMPERATURE MOLTEN SALT VERTICAL TURBINE PUMP

SANDIA NATIONAL LABORATORIES GEN 3 LIQUID-PATHWAY

Prepared by:

Prime Consultant
Mechanical, Electrical, Plumbing,
Telecommunications, Controls:

BRIDGERS & PAXTON
INNOVATIVE DEPENDABLE SOLUTIONS

Prepared for
Sandia National Laboratories
Albuquerque, NM

October 15, 2020
B&P Project No. 7828, Rev. 0
SNL Project No. 1981795

TABLE OF CONTENTS

1. OBJECT

This specification provides to the supplier with requirements for design, manufacturing, inspection and testing in works, and cleaning, painting, packing and protection for transport to site for the one hot chloride molten salt pump, and one cold chloride molten salt pump to be used at Sandia National Laboratories, Albuquerque, NM, NSTTF Solar Power Tower.

2. GENERAL

The Hot molten salt pump is a Variable Speed Drive (VSD) vertically mounted turbine pump supplying 720 ºC molten salt from the hot salt storage tank to the supercritical carbon dioxide (sCO_2) heat exchangers and back to the cold salt storage tank.

The sodium / salt heat exchanger system Cold Salt Pump is a VSD vertically mounted turbine pump supplying 500ºC molten salt from the cold salt storage tank to the Sodium / Salt Heat Exchanger.

All pumps are mounted on a steel beam framing system extending over the cold and hot salt storage tanks. The pump column and shaft will pass through a hole on top of the salt tank and extend down into the molten salt, taking suction directly from the heel. In the space between the deck and the top of the tank, the pump column will be surrounded by an insulated electric heat traced metal bellows. The pump discharge flange will be accessible above the horizontal plane of the access platform deck and will interface with the facility piping via a flanged connection. The pump motor will be mounted vertically above the pump discharge housing.

The variable frequency drive unit will be located nearby in an environmentally controlled room.

The chloride molten salt properties are described in attached Molten Salt Vertical Pump Data Sheets, see Appendix B.

Tank and pump height, and liquid levels are described in attached Pump/Tank diagram along with structural framing layout in Appendix A.

2.1. SERVICE REQUIREMENTS

Plant location and environmental conditions are described as follows:

- Site Location: Albuquerque, NM, Sandia National Laboratories, NSTTF
- Site Elevation: 5300 ft.
- Summer Outdoor Design Conditions: 96 °FDB, 60 °FWB
- Winter Outdoor Design Conditions: 16 °FDB

2.2. QUALITY ASSURANCE

Control the quality of items and services to meet the requirements of this Specification, referenced codes and standards, and other contract documents.

Contractor and its sub-Contractors, as applicable, shall have a quality Management System that complies with the applicable requirements of ISO

9001:2000 or equivalent International or National Standard (e.g., BS5750 Part 2, EN 29002 and ANSI/ASQC Q9002)

Owner reserves the right to evaluate Contractor's Quality Management System Documentation to decide if the systems meet the requirements of this project. Owner or they representatives also reserve the right to carry out appraisals and Quality Audits of Contractors' and their Sub-Vendors' Quality Management System during the period of the contract to verify compliance with and maintenance of the quality system and contract requirements

All material, parts, components, equipment, service and associated documentation are subject to examination by the owner or his representative, as specified in Annex 4.

2.3. CODES AND STANDARDS

The selection of materials and equipments and the design, construction, maintenance and repair of equipments and facilities covered by this Specification shall comply with latest editions, revisions or supplements of the following referenced codes, standards (to the extent defined in this specification) and local laws in effect on the date of contract.
Where the requirements of this specification differ from the requirements of the codes or standards referenced herein, the following order of priority shall apply

- Specification requirements and Data Sheet
- Codes and Standards herein after
- Supplier Standards

2.3.1. Specific Codes and Standards

The pump design, calculations, construction and testing shall be based on the following codes, standards, rules and guidelines as far as applicable

- ANSI/HI 2.3 – "Rotodynamic (Vertical) Pumps for Design and Application"
- ANSI/HI 2.4 – "Rotodynamic Pumps for Manuals Describing Installation, Operation and Maintenance"
- ANSI/HI 2.6 – "Vertical Tests"
- ANSI/HI 9.4 – "General guidelines for Sound Measurements"
- ANSI/HI 9.6.2 – "Centrifugal and Vertical Pumps for Allowable Nozzle Loads"
- ANSI/HI 9.6.4 – "Centrifugal and Vertical Pumps for Vibration Measurements and Allowable Values"
- ANSI/HI 9.6.5 – Centrifugal and Vertical Pumps for Condition Monitoring.
- API 610/ISO 13709: "Centrifugal pumps "
- API 682/ISO-21049: "Pumps-Shaft sealing systems"
- ASME B 1.20 – "Pipe threads, general purpose"
- ASME B16.5 – "Steel Pipe Flanges".
- ASME BPVC Section VIII, DIV. 1. – "Pressure vessels"
- ASME BPVC Section V. – "Non Destructive Examination".
- ASME BPVC Section IX – "Qualification Standard for Welding and Brazing"

- ASTM standards for materials and testing requirements
- MSS-SP-55 – "Quality standard for Steel Castings for valves, flanges and fittings and other piping"
- OSHA: Occupational Safety and Health Administration regulations.
- OSHA 29CFR1910 for Coupling and Coupling Guards.
- ASTM D3951 – 98(2004) Standard Practice for Commercial Packaging
- ASTM D6198 – 07 Standard Guide for Transport Packaging Design
- Code of Federal Regulations (CFR), Title 49 - Transportation"
- ISO 20361:2015 Liquid Pumps and Pump Units – Noise Test Code
- IEEE 112, IEEE Standard Test Procedures for Polyphase Induction Motors & Generators
- NEMA MG-1: Motors & Generators

In all instances of conflict between the applicable codes, standards, specifications, regulations, tests and procedures of organizations listed above, the Contractor shall follow the most stringent and conservative requirements. International codes equivalent to above codes listed may be acceptable subject to Purchaser's approval

3. SCOPE OF SUPPLY

The scope of supply shall also include the following equipment (but not limited to):

- 1 Cold Salt Pump
- 1 Hot Salt Pump

The major components and design features included in the scope will be as follows:

- Motor support frame for attaching a vertically mounted electric motor
- Sump head for collecting the pumped fluid from the bottom of the pump and providing a single discharge flange connection
- Thrust bearing for supporting the pump impellers and drive shafts and absorbing axial thrust
- Stuffing box or labrinth seal with single row of face packing for isolating the high pressure fluid from the environment should be used with nitrogen gas purge.
- N2 purge to pumps to remain on at all times once molten salt is loaded into storage tanks
- Series of connected discharge pipes to convey the pumped fluid up to the sump head
- One or more drive shafts to transmit power from the motor to the pump impellers
- One or more bush bearings and couplings to provide support and connections for the drive. One or more drive shafts to transmit power from the motor to the pump impellers shaft(s)
- One or more collectors or volutes for the pumped fluid
- One or more impellers to impart energy to the fluid
- Suction nozzle at the inlet to the impellers to provide low turbulence, low velocity inlet flow
- Premium Efficiency Electric Motor
- ABB Variable Speed Drive (VSD) for each pump

- Insulated coupling bellows to be installed between the pumps soleplates and the top of the tank flange connection.
- Piping, instrumentation and valves for Nitrogen injection 74 API plan for shaft purging.
- Vibration and temperature monitoring system (Bently Nevada or Rockwell Automation)
- PT-100 cable and vibration cable between primary element and junction box
- Special tools, consumable or any other disposable required for the start-up of the pumps.
- First load of any oil, lubricant or grease required, Supplier shall provide the specification data sheets.

The Supplier will be responsible for coordinating the design and operation of the pump, motor and VSD.

3.1. PERSONNEL TRAINING

The Supplier shall provide onsite training necessary to ensure safe operation of the equipment by Owner's operation and maintenance staff.

This training will be scheduled for (TBD) trainees and shall include:
- Three (3) days of classroom training (Theoretical part) at the end of erection/start of commissioning stage and
- Two (2) days of hand-on training (Practical part) during commissioning.

The detailed program of staff training will be defined (TBD) months before the beginning of the training.

The Supplier is responsible for the training expenses of their own personnel; training aids and training will be provided in English.

3.2. OTHER CONDITIONS

Equipment and services shall be supplied in accordance with the requirements of this Specification and the applicable requirements of all reference documents specified herein.

At Bidding stage Supplier shall supply one (1) copy in paper and one (1) copy in electronic format. During Project stage Supplier shall supply 3 copies in paper and one (1) copy in electronic format. The language for the documents shall be English.

TERMINAL POINTS
The following points will be the terminal ends of equipment supply:
- Pump discharge RTJ flanged with pressurized Inconel O-ring nickel coated.
- Nitrogen injection: inlet flange.
- Flanged Vents, Drains, quenching and Purging.
- Electrical and Instrumentation terminal box up to contactors.
- Terminal connections of Electrical Heat Tracing

- Grounding lugs for the bed plate and motor
- Inlet and outlet terminals of the variable speed drive.
- Terminal boxes for connection with DCS (alarms and signals).
- Instrumentation, auxiliary terminal box and control box for variable speed drive, temperature detectors.
- (2) Lifting lugs on pump mounting plate and (1) side lifting lugs near volutes for second crane to lay pump down horizontally..
- Soleplate including screw and nuts.

The following materials, equipment and services will be supplied by others:

- Grouting, foundations and associated civil works.
- External piping and associated valves, others than those specified herein, not forming an integral part of each pump.
- Power and control equipment, such us motor contactors, relays and all other items required for operation.
- Electrical and instrumentation wiring (control signals wiring with DCS).
- Auxiliary instruments, not forming an integral pump of each pump or equipment associated.
- Equipment field unloading, installation.
- Transport to site.

4. DELIVERY DATE

Bidders shall state in his proposal, the delivery data for the complete equipments and their accessories as well as a works schedule including the main manufacturing and testing activities.

The Supplier shall send 15 days after purchase order, the detailed design, engineering, manufacturing, test and delivery program.

The end data for this supply shall be no later than (HOLD).

5. DESIGN AND MANUFACTURING

5.1. DESIGN

The Sodium / Salt Heat Exchanger system has been designed with 1 Cold Salt Pump for operation with the following pump identification VS-2.

The Hot salt pumps has been designed with 1 pump for operation with the following pump identification VS-1A.

Each pump shall be operated at variable speed.

5.1.1. General

This specification covers the following vertical centrifugal pumps:

- Vertical turbine pumps, open suction with Single or multistage

diffuser design and extended shaft
- The pumps shall be identical in design. All replacement parts shall be interchangeable.
- Design for pumps and auxiliaries shall be according to a minimum service life of 30 years (excluding normal wear parts) and at least two years of continuous operation.
- Purchaser Data Sheet specify the pump's operation and rated points, as well as any other anticipate operating conditions.
- Arrangement of equipment, piping, and auxiliaries shall provide adequate clearance areas and safe access for operation and maintenance.
- Supplier shall establish in the proposal the pump setting and any distances required for a trouble free pump operation or maintenance
- Supplier shall assume unit responsibility for all pumps and auxiliary systems included in the scope of the order.
- Pump, motors, electrical components, and electrical installations shall be suitable for the area classification (class, group, division, or zone) specified by the purchaser.

5.1.2. Design Conditions

- The pump shall be designed for frequent startup and shutdown. It is anticipated that the pump shall be subjected to daily start-up and shutdown.
- Start-up of all pumps shall be with the corresponding discharge valve closed. When the pump stops, the discharge valve will shut slowly to ensure a shock free transient.
- Pumps shall be designed to drain completely when removed from the salt tanks. All lines carrying salt will be sloped to drain completely, without low points or pockets.
- Pump/ motor unit shall be capable of withstand reversing rotational speed, caused by the system head when the pump trip. No anti-reverse rotation device shall be used.
- Pumps are required that have stable head/capacity curves from run out to minimum flow
- The head at minimum flow shall be within 110% to 140% of the head at rated flow.
- The Best Operating Point (BEP) should be between Operating and Rated points
- Supplier shall state in the proposal the minimum stable continuous flow.
- Pumps shall be sized to allow of at least a 10% head increase considering the use of the variable speed driver to meet this requirement or by replacement of the impeller(s) with impeller(s) of

larger diameter.

- Motor sized to end of pump curve run out. Manufacturer's NPSHr pump curves shall be based on 3% head drop with cold water.
- All wetted surfaces shall be machined or hand finished to a smooth surface.
- The VSD shall be responsible for starting and stopping the pump, as well as driving the pump to the commanded speed. The VSD will be responsible for keeping the pump speeds outside of any unsafe operating ranges, including speeds where unsafe shaft responses may occur.
- Rated pump speed shall be based on a Suction Specific Speed (Nss) value of 8,500 (US units) and the NPSH available. Nss up to a maximum value of 10,000 (US units) may be used after Purchaser's written approval.
- All pressure retaining parts shall be sized in accordance with ASME VIII, Div. 1 or 2, and API 610.
- Rated pump speed differs at least 25% of the first wet critical speed with twice the normal wear and bushing clearances.
- The pump/motor unit natural frequency shall be predicted by Supplier, based on Finite Element Analysis. Natural frequencies shall be neither < 25% below rated speed nor < 30% above rated speed. The Purchaser will provide structure information and pipe discharge loads. "
- Rotor shall be dynamically balanced to ISO 1940-1 grade 2.5.
- Variable speed pumps shall operate over their specified speed range without exceeding the vibration limits of ANSI/HI 9.6.4
- Pump vertical thrust will double those required for water pumps due to the specific gravity of the pumped fluid. Pump rotor thrust loads will be carried out by thrust bearings located in the pump lantern ring. The thrust bearing will be capable of carrying thrust loads in both directions.
- The relative positions of the pumps and the tanks will change as the tanks expand and contract due to changes in the temperature of the tank inventory. The Supplier will supply a coupling bellows which shall be capable of absorbing the thermal expansion of the tank, considering the following temperatures:

	Cold Salt Tank	Hot Salt Tank
Ambient Minimum temperature, °C(ºF)	-10 (14)	-10 (14)
Maximum temperature, °C (ºF)	550 (1022)	740 (1364)

- To avoid any molten salts freezing around the shaft area beneath the soleplate the Supplier shall include the required insulation and heat tracing for the coupling bellows.

- Supplier shall state in the proposal the minimum distance between pump centreline and any tank element such us pump nozzle wall, tank wall, heaters, piping, etc.

5.1.3. Pump design and construction details

5.1.3.1. Pressure casing

- The design pressure of the discharge and head shall be based on the rated impeller shut off head, at maximum speed and maximum suction pressure, as well as at minimum operating temperature.
- Pump discharge column assembly shall have enough length to ensure adequate submergence at minimum salt tank level and they shall include the required lugs and reinforcements for lifting, operation and transport loads without any permanent deformation.
- Column flanges shall have register fits to facilitate alignment of the bowl, radial bearing(s), discharge head, and coupling. Register must be used to insure concentricity of rotating assembly. Column flanges will be the location for the radial bearing of the pump.
- Pressure casing shall be designed with a corrosion allowance that shall meet the minimum requirements laid down:
- Carbon steel materials and Castings 1.6 mm.
- Stainless steels materials: 0.7 mm.
- Nickel based steel materials: 0.7 mm.
- Discharge column and discharge pipe if exists shall consider the thermal expansion of the pumps. Discharge pipe shall include the required loops in order to minimize the thermal stresses.

5.1.3.2. Nozzle and pressure casings connections

- Pump discharge nozzle shall be flanged RTJ type, in accordance with ANSI B 16.5.
- Pressurized Inconel O-ring nickel coated for use with RTJ flange.
- Connections other than discharge nozzle shall be at least 1/2 NPS and RF type in accordance with ANSI B 16.5.
- Pipe nipples welded to the casing will include an isolation valve. Such connections shall be properly secured with supports and terminate in a flange. Valves shall not be welded to the pump casing.

- Allowable discharge nozzle loads shall be in accordance with API -610, Table 4, for the connecting pipe sizes
- Supplier shall submit allowable forces and moments for auxiliary connections, as well as the expected loads for the baseplate.

5.1.3.3. Impellers and Diffuser

- Impellers shall be semi-open mixed flow or radial flow types, fabricated from single casting with solid hubs.
- Due to the variable speed required the maximum impeller diameter should be used. Nevertheless, Supplier can consider the use of an intermediate diameter, for this case Supplier shall submit with his proposal, impeller diameter offered as well as minimum and maximum impeller diameters
- Each impeller shall be dynamically balanced to ISO 1940-1, grade 2.5.
- Impellers shall not be modified to correct hydraulic performance by under filling, overfilling or polishing without writing approval by the Purchaser.
- Impellers shall be keyed and individually secured to the shaft by a shoulder or split ring against the axial thrust in both directions.

5.1.3.4. Wear Rings

Renewable wear rings shall be furnished only on the casing side and they held in place by positively tight to the bowl/case. Integral wear rings shall be considered for the impeller side. Hardenable materials compatible with impeller material and exhibit low galling tendencies shall be selected. Supplier will consider that the only lubrication medium shall be the molten salts

5.1.3.5. Shafts and sleeves

- Shafts shall be turned, ground and polished steel. If pump length requires several shaft stages, they shall be assembled with keyed couplings to prevent disassembly during reverse rotation.
- Shaft shall include replaceable wearing sleeves with increased hardness protecting the shaft at the sliding areas with the sleeve bushings. The bushings shall have flutes that flush out solids, so they are not trapped between the bushing and sleeve causing pump failure. Wearing sleeves have to include positive fixing by means of bolting or other alternate method.
- Shaft material selection and lubrication have to consider lubrication with the molten salt. During start-up there will be short period of dry running as the column fills with salt. Low

flow start-up will be controlled by use of variable frequency drive.

- Shafts shall be machined and finished throughout their length so that the total runout isn't not more than 0.08 mm. Shafts runout shall be measured and with they supported on V blocks or rollers adjacent to its bearing.

5.1.3.6. Shaft sealing systems

- Mechanical seals are not allowed for these services.
- Shaft sealing shall include a throttle bushing positioned and held in place by a shaft nut and with an overflow port to the outside of the shaft column. Contact seals are not allowed.
- A system composed by a 74 API plan Nitrogen injection system (500°C) and a labyrinth seal shall be used to seal the upper section of the shaft and avoid the molten salt to reach the soleplate or the bearing housing. Supplier shall submit with the offer the Nitrogen requirements (Flow, Pressure and Maximum Temperature) shall be included

5.1.3.7. Bearing and bearing housing

- Pump shall be furnished with radial bearings and one thrust bearing.
- Thrust bearing shall be double ball angular contact type, designed for 50.000 operation hours at rated point. And they shall be able to withstand the maximum pump thrust load in both directions.
- Thrust bearing lubrication shall be grease lubricated, its housing shall be sealed to avoid the grease contamination into the molten salts.
- Provide water cooled jacket to protect bearing and lubrication system from overheating.
- Upper bearing housing shall be arranged so that bearings can be replaced without dismantling pump.
- Column fluted bushings shall be lubricated by the pumped Molten Salt.

5.1.4. Auxiliary Systems

5.1.4.1. Cooling system

- Upper bearing housing should be cooled by a fan attached to the pump shaft. Supplier can consider the use of an alternate design and in this case shall submit with the proposal a detailed explanation.

- Upper shaft shall be thermally isolated by a suitable method such as insulation or shield casing in order to control the shaft climbing

5.1.4.2. Coupling and guards

- Coupling and guard between driver and driven equipment shall be provided
- Coupling hubs shall be steel. flexible disk type couplings shall have disks of corrosion-resistant material and electrically isolated
- Spacer shall have a nominal length that permits removal of the coupling and rotor as applicable, without disturbing the driver or the suction and discharge piping.
- Flexible couplings shall be keyed to the shaft
- Coupling service factor shall be at least 1.5 for the maximum driver power.
- Removable coupling guards shall conform to the requirements of OSHA 29CFR1910 for Coupling and Coupling Guards regulations.

5.1.4.3. Baseplate

- The pumps will have a mounting soleplate to attach the pump base to a structural steel platform above the salt tanks. Vibration analysis will be performed to show that the pumps do not generate excessive vibration through the flow range within the minimum continuous and the run-out. Data output from the analysis shall be provided for design input into the pump structural support system.
- Pump mountings will be designed to minimize vibration and fatigue stresses over the entire Life of the plant.
- The supports for the motor will be separated from the supports for the pumps such as the motor can be removed from the pump lantern without dismantling the pump. Lifting lugs will be provided for the motor and the lantern ring (or the motor supports) and on the pump body to facilitate the installation and removal of the motor and the pump.
- Baseplate shall be provided with at least two lifting lugs. Lifting baseplate with all equipment mounted, shall not distort the baseplate or equipment. Four Jacking bolts must be in the pump base plate for aid in the removal of a pump that has been in service. Additionally, soleplate shall include grounding/leveling lugs and gasket material.

5.1.4.4. Heat Tracing

- Supplier design take into account that pumped salts will freeze at 752 °F (400 ºC) and salt vapors freeze at 896°F (480°C), so an electrical heat tracing system is required to avoid it, inside the upper section of the pump. The maximum exposure temperature on the hot salt pump is 1364 °F (740 °C). Heat tracing of the pump discharge and bellows will be provided on site and controlled to 932°F (500°C).
- Heating system shall consider at least the following operational requirements
- Allow pre-heat of the pumps for first run.
- Keep the pumps heat when stand-by
- Provide enough salt melting capacity to unblock and drain the pumps when removed for maintenance.

5.1.4.5 Supply instructions for the following procedures

1. <u>Heat up of dry pump install in storage tanks during preheating of tanks</u>

- Note; Do not rotate shaft during preheat or before molten salts are charged into tank. Bushings are dry
- Slowly heat pump and tank per OEM instruction.
- Check pump for free rotation by turning shaft by hand during heat up
- Check shaft rotation before charging storage tanks with molten salt.

2. <u>Removing pump from molten salt for maintenance</u>

- Piping system must be drained of all molten salts and motor and valves must be Lock out and tagged.
- Motor must be disconnected and removed first.
- Discharge spool piping must be disconnected and blind flange installed on discharge line piping. Removal of spool piping and all support piping must provide a clear vertical lifting area for the pump to be removed.
- Lift pumps slowly so molten salt and drain form both inside the column of discharge piping and drain off the outside of the pump column and volutes. Note: PPE must be worn by riggers removing the hot pump.

- Once pump is completely removed from tank and has stopped dripping molten salt, pump needs to be move to lay down area and a second crane attached to lay pump Horizontal. Note pump will still be hot and PPE must be worn.
- Once pump is horizontal it must be supported in four locations during cooling.
- Pump OEMs to provide spare parts list of commissioning spares to be at site and spare parts for two years maintenance.

3. Installing cold pump into hot molten salt

- Install new seal gasket on the bottom side of the pump mounting plate before lowering pump into tank
- WARNING: PPE must be worn when working near and round open pump opening of tank.
- When immersing the pump in the molten circulating medium that is already at temperature slowly immersed the pump at an immersion speed of max. 3" / min into the material being pumped.
- Note: The pump discharge flange may not fit tightly with mating flanges pipe. Be sure to install sealing O-ring of RTJ Flanges are used, pressurized Inconel O-ring with nickel coating. Also, all the supply pipes (e.g. for cooling medium, heating medium, barrier medium etc.) as well as any measurement and protection devices must be properly connected to the pump and if necessary, also made operational.
- Pump needs to set in hot salt for severasl hours and the be checked for free rotation of shaft beofr motor is installed. An impeller adjustment must be checked to insure axial location is correct.
- Motor must be tested for direction of roating before coupling to the pump shaft, then and only then, connect the motor and carry out a rotatory field test of the motor.

5.1.5. Drivers

5.1.5.1. Electrical Motors

- The motors have to be suitable to be fed through ABB VSD (insulated bearings, special winding, VSD-motor combined test and curves, etc), rated voltage of 460 Vac for hot salt pumps motors and cold salt pumps motors, and of 460 Vac for cold salt auxiliary pump motor, and frequency according to its design point.

- Test electric motors per NEMA MG-1, Motors & Generators and IEEE 112, IEEE Standard Test Procedures for Polyphase Induction Motors & Generators.
- Enclosures for mechanical protection shall meet NFPA70.
- Electric motor has to be designed to reach the run-out point (120% of design point) with a power reserve margin required to guarantee unlimited operation time with no overheating, adverse effects or premature wear or damages and considering the 1.15 Service Factor required.
- The motors are for vertical installation and their insulation class has to be F for a B temperature rise class application.
- For thermal protection, the motors offered shall have 2 Type K thermocouples per phase (6 in total) and 1 Type K thermocouple duplex per bearing (4 in total).
- The motors shall have heating elements to avoid condensation (suitable for 120Vac / 208Vac / 277Vac - 60Hz controlled by the VSD)
- The electric motor proposed has to consider the following design:
- Vertical flanged type.
- NEMA 4 dedicated junction box for power.
- NEMA 4 dedicated junction box for Space Heaters connection.
- NEMA 4 dedicated junction box for windings and bearing Type K thermocouple.
- Motors shall include their own lifting lugs.
- Motors shall have cooling by means of a direct shaft connected aluminum fan with protector.
- Supplier shall consider that motor cooling system proposed have to provide enough cooling capacity when motor is operating at reduced speed due the VSD.
- Customer will provide a single Power supply.

5.1.5.2. ABB Variable Speed Drives

- Motor Speed control shall be done via a VSD, and shall consider the following:
- VSD shall be according to ANSI and will comply the following codes and standards:
- IEEE 519- Standard practices and requirements for harmonic control in electrical power systems
- NEMA ICS 3.1-Safety standards for construction and guide for installation and operation of adjustable speed drive systems
- IEEE 444–Standard practices and requirements for thermistor converters and motor drives

- Pump shall be able to operate under stable conditions at full speed from 30% of the rated flow up to 120% of the design point, with an acceptable efficiency without cavitation, abnormal noise or vibration.
- Customer will provide the following feeders: main power (460 Vac 60Hz) and auxiliary power (120Vac / 208Vac / 277Vac - 60Hz) for hot salt pumps motors and cold salt pumps motors. Auxiliary power shall be enough for VSD auxiliaries and motor heating resistances.

VSD must be suitable for an inner short-circuit current of 35kA for 460 Vac VSD

- Supplier must indicate in the offer if the VSD will contain contactor and fuses or circuit breaker, to protect and operate the system.
- Supplier could suggest in the proposal another voltage to supply to the VSD.
- VSD shall include an NEMA 4 cabinet suitable to be installed indoor.
- Maximum clearances between transformers and VSD will be 20 meters, clearances between VSD and motors shall be about 100 meters.
- VSD shall have at least the following signals hardwired:
  - Inputs: speed set point (4-20mA from DCS), start signal (24V pulse from DCS), stop signal (24V pulse from DCS)
  - Output: speed signal (4-20mA), motor working (dry contact), motor stop (dry contact), VSD available for remote control (dry contact), VSD alarm (dry contact), VSD failure (dry contact).

5.1.6. Instrumentation

The instrumentation per each pump-motor shall include at least the following items:

1 Vibration and temperature monitoring system including all auxiliary components such as relays, terminals, interconnecting cables, power source, etc. for the following measurements:

- 3 x accelerometers (2 per pump and 1 for motor)
- 2 x Type K Thermocouple for pump bearing housing
- 4 x Type K Thermocouple for motor bearing housing
- 6 x Type K Thermocouple for motor winding (wiring directly from motor to monitoring system.
- 1 cabinet NEMA 4

- Configuration and operation software
- Vibration and Temperature Monitoring System enclose shall be NEMA 4, one (1) per pump. Total 9

In order to reduce common components and optimize control network, quote one unique enclose per each pump type (total 3)

- Cold Salt Pump
- Hot Salt Pump

Offer shall include preliminary drawings of monitoring system enclosure.

The supplier has to configure the vibration/temperature monitoring system with all the alarms and protection.

At Bidding Stage Supplier shall supply one (1) copy in electronic format of the monitoring system logic. During Project stage Supplier shall supply ONE (1) copy in electronic format

The vibration/temperature monitoring system and probes shall be readjusted and tuned by the supplier during the pumps commissioning and leave the system working.

Temperature detector in pump immersed bearing is not provided. Interface signals between vibration monitoring system and DCS shall be:

Digital relays:

- Vibration trip
- temperature trip
- temperature alarm
- vibration motor alarm
- vibration pump alarm
- Monitoring system status

Analog signals 4-20mA from the vibration and temperature modules will be hardwired to DCS.

The rest of information will be sent to DCS via communications, each Vibration monitoring system should have a communication interface link. The way to group the pump communication interface links to send to DCS will be done by others.

Interface signals between VSD and DCS:

Command orders from DCS to VSD will be pulse type (start/stop) and will be polarized by the DCS. Digital outputs from VSD to DCS will supply dry contacts to be polarized by DCS at 24 Vdc.
Analog signals from DCS to VSD (i.e. speed set point) will be passive signals from VSD (powered from DCS). Analog signals from VSD to the DCS, (i.e. speed signal), will be always energized by the VSD.

VSD Communication link with DCS should be preferably Modbus TCP, in order to homogenize all plant communication links with DCS.

The VSD will protect the motor, the fail reason will be sent to the DCS via ModBUS. The supplier shall provide alarms and trip set points and normal operation values.

5.2. MANUFACTURING, PACKING AND SHIPMENT

- Materials for pump parts shall conform to purchaser's data sheet. When the material is not specified, it shall be selected by the pump manufacturer.
- Materials shall be clearly identified in the proposal with their applicable standard, including the material grade. If no such designation is available, the supplier's material specification, giving physical properties, chemical composition, and test requirements, shall be included in the proposal.
- Materials, casting factors, and the quality of any welding shall be according to those required by
- ASME Section VIII, Division 1.

5.2.1. Castings

- Castings shall be sound and generally free from porosity, hot tears, shrink holes, blow holes, cracks, scale, blisters, and similar defects.
- Surfaces of castings shall be cleaned by sandblasting, shot blasting, chemical cleaning, or any other standard method
- Use of chaplets in pressure castings shall be minimized. Chaplets shall be clean, corrosion-free (plating permitted), and of a composition compatible with the casting. Chaplets shall not be used in impeller castings.
- Ferrous pressure boundary and impeller castings shall not be repaired by welding, peening, plugging, or coating, except as follows:
- Weldable steel castings may be repaired by welding with a qualified welding procedure based on the requirements of ASME BPVC Section VIII, Div. 1 and Section IX
- Iron castings may be repaired by plugging within the limits of the applicable ASTM standards.

5.2.2. Welding

- Welding and weld repairs of piping, pressure-containing parts, and wetted parts shall be performed and inspected by operators and procedures qualified in accordance with the referenced standards on Section 3.1
- Welding expected to reach high hardness have to be hardness tested. If hardness obtained is 200 Brinnell or bigger, the component shall be stress relieved by thermal treatment.
- All repairs and repair welds shall be reviewed by the manufacturer to ensure that they are properly heat treated and nondestructively examined for soundness and compliance with the applicable qualified procedures. Repair welds shall be non-destructively tested by the same method used to originally qualify the part.
- If approved by the purchaser, weld repairs may be made to cast iron casings using the supplier's proven weld procedures. Welding repairs shall be part of final documentation. The procedure and qualification reports shall be submitted with the proposal of repairing.
- Any that cannot be repaired according the standard codes will create a "Deviation report" which will describe the deviation proposed and the applicable solution. Customer will reserve the right to accept or refuse any deviation. No deviation can progress without the Customer approval

5.2.3. Nameplates and Rotation Arrows

- A stainless steel nameplate shall be securely attached at a readily visible location on the pump and on any other major piece of auxiliary equipment.
- Rotation arrows shall be cast or attached to each major item of rotating equipment at a readily visible location.
- As a minimum, pump nameplate content shall be as follows:
- Manufacturer,
- Size and type.
- Purchaser's pump item
- Manufacturer serial Number.
- Rated Flow m^3/h (gpm)
- Rated differential height m (ft)
- Rotation Speed. r.p.m.
- Casing design pressure barg (psig)
- Design Temperature ºC (ºF)
- Hydrostatic test pressure barg (ºF)

5.2.4. Cleaning and surface protection

- Cleaning, painting and surface protection for the external parts of every component above the soleplate shall be prepared and painted in a manner appropriate to the ambient conditions of services and for shipment in order to prevent all types of corrosion. Paint level according to ISO 12944, for more than 30 years and Annex 9.
- Carbon steel, bearing housings, and oil system components shall be coated with a suitable oil soluble preventative.
- Stainless steel will be free of harmful contaminants such as chlorides and low melting point metals. This includes, but is not limited to, paint and other coatings, tape, marking ink, and packing materials.
- The manufacturer shall prepare for each particular case a specific cleaning and surface protection procedure and shall summit it for purchaser's approval.
- Equipment shall be adequately supported for shipment. All loose parts shall be crated and/or boxed for shipment. Each box shall be appropriately marked for identification purposes

5.2.5. Insulation

Every part of the equipment/system to be insulated in accordance with data sheet requirements will be prepared in a suitable manner. The supply will include every accessory (clips, anchors, etc.) required for the correct execution of the insulation by others.

6. INSPECTION AND TESTING

6.1. GENERAL

- Supplier shall be responsible for conducting all the required tests and inspections and shall furnish to the purchaser with test results, material and inspection certificates, to demonstrate the compliance with this specification
- Supplier shall issue records of all tests, and examinations such as material certification, test results, repairs and heat treatment records, dimensional control and all related results to verify that the requirements of the specification have been met. Supplier shall keep records available at least 5 years.
- Supplier shall issue an Inspection Program Point including at least every inspection and test to be performed according to requirements herein included
- Purchaser/Owner participation in the inspection and testing shall be determined.
- As far as applicable Supplier shall notify to sub suppliers of the purchaser's inspection requirements

- Unless otherwise agreed, notification of an inspection or test shall be submitted to the purchaser in advance with at least 10 working days.
- If inspection and testing at workshop have been specified, purchaser and supplier shall coordinate manufacturing hold points and inspector's visits. Equipment required for the specified inspections and tests shall be provided by the manufacturer.
- Pressure retaining parts shall not be painted until final inspections and testing are complete.

6.2. SHOP TESTS

6.2.1. Raw Materials

- Supplier shall furnish certificate test material report (CMTR), that include chemical analysis and mechanical strength, toughness properties and heat treatment for the heats from which the material has been supplied for the following components:
- Pressure retaining castings and forgings.
- Impellers.
- Shafts
- All materials in contact with pumped fluid
- All relevant items shall be identified by permanent marking.

6.2.2. Non Destructive Testing (NDT)

NDE shall be performed in accordance with the methods and acceptance criteria standards laid down:

6.2.2.1. Methods

Methods for all NDT's conform to the relevant articles of *ASME BPVC*, Section V.

6.2.2.2. Acceptance Criteria:

- NDT's castings conform to ASME BPVC, Section VIII, div. 1, Appendix 7
- Radiography of welds conform to ASME BPVC, Section VIII, div. 1, UW-51 (for 100%) or UW-52 (for spot)
- Ultrasonic inspections of forgings conform to ASTM A-388
- Magnetic particle of welds and forgings conform to ASME BPVC, Section VIII, div. 1, Appendix 6.
- Liquid penetrant ASME BPVC, Section VIII, div. 1, Appendix 8

6.2.2.3. NDT Inspection Scope

- NDT's examination for pressure retaining parts shall be in accordance with ASME BPVC, Section VIII, div. 1, but at least radiographic examination of the circumferential butt welds (100%).

- Visual inspection of all casting surfaces in accordance with MSS-SP-055, prior to coating.
- Ultrasonic examination for shafts in the premachined surface condition

6.2.3. Dimensional control

- Supplier shall perform dimensional control for the relevant dimensions of parts and their assemblies.
- General dimensions of equipment shall be checked against approved drawings and item lists.
- Drive train alignment shall be checked before testing.

6.2.4. Testing

- Equipment required for the specified tests as well as auxiliary fluids shall be provided by the manufacturer.
- Performance and NPSH test shall be conducted in accordance with Hydraulic Inst. HI1.6.
- Performance tolerances shall be according to Grade A.
- All test data and records shall be collected. Supplier shall prepare a detailed report including certified test curves and test data compared to guarantee point

6.2.4.1. Hydrostatic test

- All pressure-retaining components including seal glands, seal chambers, and welded auxiliary process fluid piping shall be hydrostatically tested with liquid at a minimum pressure of 1,5 times the design pressure.
- Tests shall be maintained for a sufficient period not less than 30 minutes to permit complete examination of parts under pressure. Test shall be considered satisfactory when neither leaks nor seepage through the casing or casing joint is observed.
- Preliminary test before witnessed tests shall not be permitted
- Casing gaskets used during test shall be of the same design as those supplied with the equipment.
- Water for hydrostatic test shall have a maximum chlorides content of 50 ppm, if wetted stainless steel parts are tested. All residual liquid shall be removed from tested parts at the conclusion of the test.

6.2.4.2. Performance test

- A performance test shall be conducted for each pump with its contract driver. Test speed shall be within 3% of the motor nominal speed, any greater change in speed requires Purchaser's approval.
- Contract seals and bearings shall be used. Acceptable level of seal leakage during testing shall be zero visible leakage. Any leakage during the pump performance test requires their disassembly and repair.
- All joints and connections shall be checked for tightness, and any leaks shall be corrected.
- Vibration testing shall be in accordance with API 610 for a minimum of 5 of the 6 specified points listed. The discrete frequency velocity must be measured with a FFT spectrum using a Hanning window and a minimum frequency resolution of 400 lines. Maximum overall allowable is 6.5 mm/s RMS and maximum discrete is 4.4 mm/s RMS.
- Noise exposure limits (PEL) for an 8-hr TWA shall be limited to 80 dBA after insulation is applied at 3.3 ft. from machine. A 3 dBA tolerance shall be applied to the 80dBA baseline.
- All warning, protective, and control devices used during the test shall be checked for proper operation, and adjustments shall be made as require.
- All signal to and from monitoring system shall be tested to verify internal control program
- Performance test water temperature shall be at a temperature less than 50ºC.
- All running tests and mechanical checks shall be completed before the purchaser's inspection.
- Test data, including head, capacity, and power shall be taken at a minimum of eight points. These points shall be at least shutoff (no vibration data required), minimum continuous stable flow, midway between minimum and operation flow, normal operation flow, BEP point, rated flow, midway between rated and run out and run out flow.
- Test data shall be corrected for speed, density and viscosity.
- Disassembly of the pump after the performance test for any head adjustment, like machining impeller diameter, under filling or polishing, shall be cause for retest.

6.2.4.3. Isoefficiency test

- Pump OEM to advise if clearances used for salt bushings could affect the results of this test because of testing with ambient water. Or if, for the test that bushing clearances will simulate

running clearances of salt bushing when hot.
- The isoefficiency test shall be performed throughout all operation speed range, in steps of 100 rpm and at the same flow rates than Performance Test, except shutoff
- BEP flow for each speed should be clearly identified.

6.2.4.4. Submergence test

- A minimum submergence test shall be performed on one pump at rated and run-out flow.
- To performance this test, a shorter version of the pump will be accepted (by removing the intermediate sections of the pump).

6.2.4.5. Strip-test

- After performance and isoeficiency tests, one pump shall be dismantled to verify measures and tolerances of basic elements.
- The inspections shall be performed at least to the following components:
- Shaft (straightness, surface)
- Impellers (material wear, dynamic balance)
- Wear Rings (searing, setting)
- Sealings (deterioration, mounting)
- Bearings (deterioration, mounting).
- Measurements and tolerances control shall be performed to the following items:
- Impellers external diameters
- Wear rings
- Smooth bearings diameter measures and shaft zone measures, checking the internal set tolerances according with the assembly drawings.
- If any deviation has been encountered, the rest of the pumps shall be checked.

After all the installation work has been completed, and all the supply circuits are in operation, and, in the case of heatable pumps, the material to be pumped has reached the required viscosity (according to the ordering data), start-up can be commenced.

6.2.5. On site mechanical run test

- On site, the pump and driver assembly and their accessories systems shall be running at least during four (4) hours, at continuous operation flow rate, until stable oil temperature (minimum half hour). Test shall be performed in accordance with ASME PTC 8.2.
- During the test shall be verified aspects such as oil temperatures, vibration levels, electrical consumption, heating, protections, alarms,

instrumentation, etc; in addition to the equipment performance and its auxiliary components

7. GUARANTEES, TOLERANCES AND PENALTIES

7.1. GENERAL

The contractor shall warrant that the equipment furnished is entirely suitable for the service described herein and is in complete accordance with this Specification, except where modified by specific exceptions authorized in writing by the Owner. Contractor shall submit a certificate of conformance to the Owner.

7.2. GUARANTEES

The Supplier shall guarantee that the equipment furnished is suitable for the service described herein and is in complete in accordance with this Specification, except for deviations with written approved by the purchaser.

The Supplier shall guarantee in his proposal the following parameters:

Parameter	Requirement	Tolerance	PENALTIES (P) REJECT (R)
Delivery Date	Acc. to Spec. point 4	No positive tolerance	P
Rated point (Head and Flow)	Acc. to Data Sheet	Acc. to spec. 6.2.4	R
Rated Efficiency	Acc. to Data Sheet	Acc. to spec. 6.2.4	P
Rated Power	Acc. to Data Sheet	No positive tolerance	P
Minimum Stable Continuous Point (Head and Flow)	Acc. to Data Sheet	No positive tolerance	R
Head at Run Out Flow	Acc. to Data Sheet	± 5%	P
Reverse runaway speed	Acc. to Data Sheet	Acc. to spec. 5.1.2	P
First Critical Speed	Acc. to Data Sheet	$\pm$ 25%	R
Vibration	Acc. to Data Sheet	No positive tolerance	R
Noise level	Acc. to Data Sheet	3 dBA	R

7.3. TOOLS AND MAINTENANCE EQUIPMENT

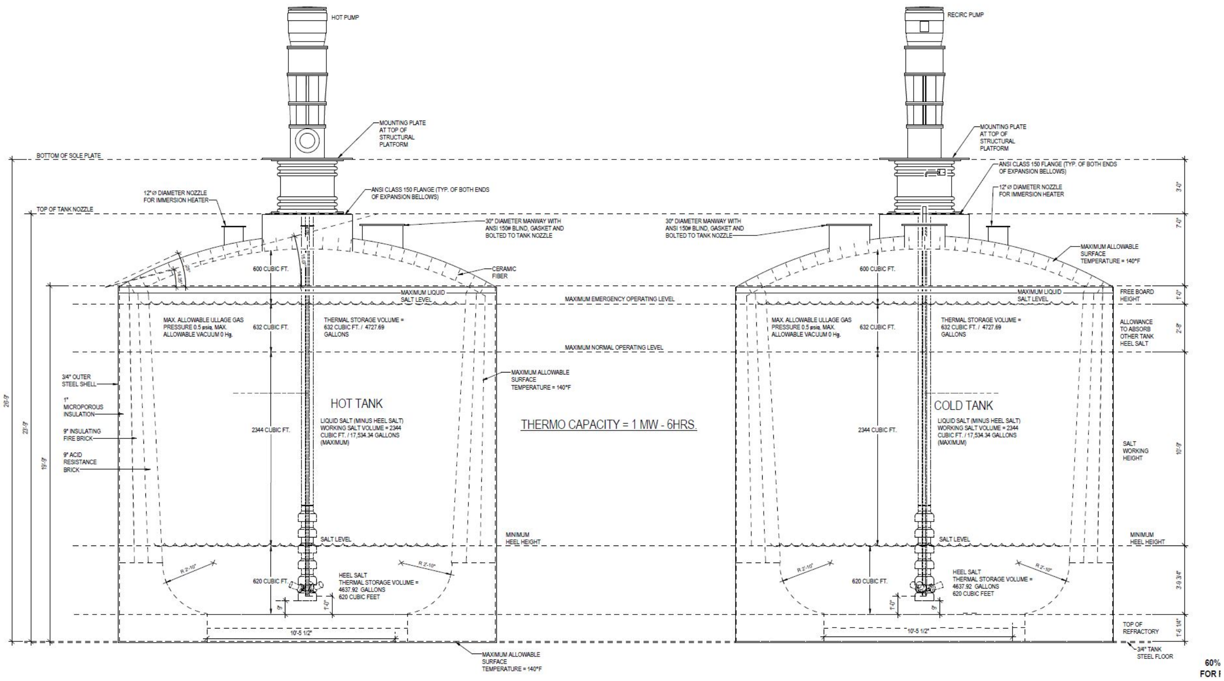
- Pumps shall be designed to be assembled, disassembled, and maintained, preferably with standard hand tools.
- If special tools shall be used, bidder’s proposal shall include a list of special tools and equipment, with unit prices, required for any part of the pump driver train.

7.4. RECOMMENDED SPARE PARTS

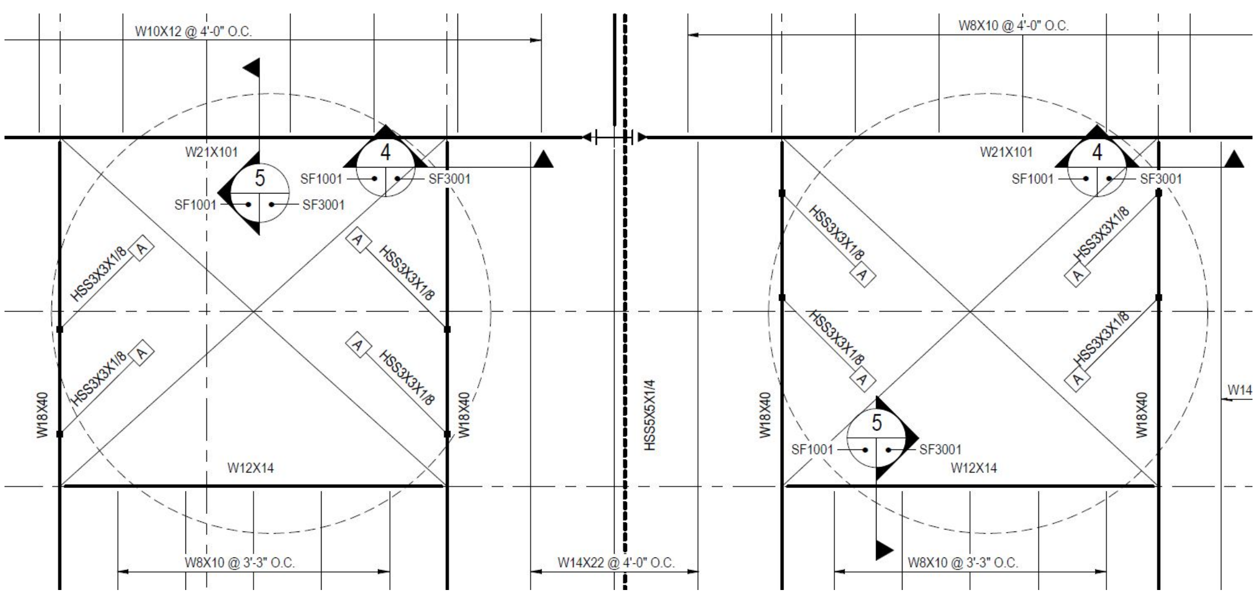
Bidder’s proposal shall include a list of the spare parts and components for the pump driver, with unit prices, taking into account the following conditions:

- Spare parts offered shall cover two (2) years of operation.
- Spare parts to be used during erection and commissioning shall not be considered as spare parts and they shall be quoted with the main equipment.
- 4 sets of RTJ flange O-rings: pressurized Inconel with nickel coating.

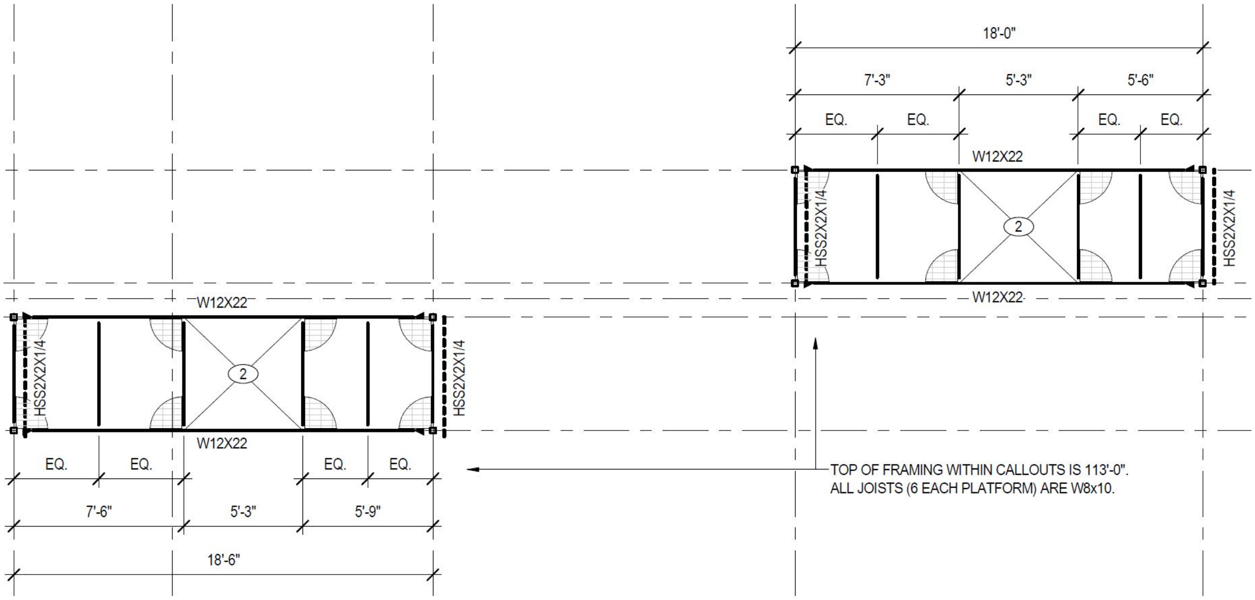
APPENDIX A – PUMP / TANK DIAGRAM



Bellow seal for pumps will be 36" from bottom of sole plate to tank flange connection. This will need to added to pump setting.



Structural Framing Plan for pump opening through main platform level.



Pump framing support level. Pump sets where keyed noted 2 is located on structure.

APPENDIX B – PUMP DATA SHEET

See attached Excel Spreadsheet for Hot and Cold Salt Pump performance criteria.
Pump TDH required is from the discharge flange above the sole plate.

HOT SALT PUMPS VS-1		
Chloride Salt	40 Mg / 20 NaCl / 40 KCl	Notes
Max. Operating Temp.	740°C	
S.G.	1.538	
Vapor Pressure	3.712 kPa	
Viscosity	2.309 cP	
Location	Outdoors	
Service	Intermittent	
Operating Flow	25 m^3/hr (110 gpm)	
Total Dynamic Head	22.9 m (75 ft)	
COLD SALT PUMP VS-2		
Chloride Salt	40 Mg / 20 NaCl / 40 KCl	
Max. Operating Temp.	520°C	
S.G.	1.677	
Vapor Pressure	0.169 kPa	
Viscosity	3.360 cP	
Location	Outdoors	
Service	Intermittent	
Operating Flow	25 m^3/hr (110 gpm)	
Total Dynamic Head	73.1 m (240 ft)	

SPECIAL SPECIFICATION

SECTION 232125S

MOLTEN SALT / ULLAGE GAS PIPING SYSTEMS

Page

SPECIAL SPECIFICATION

SECTION 15052S

MOLTEN SALT PIPING SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Materials and operations required for the installation of piping systems, including pipe, fittings, valves, equipment, joints, and tests for the following systems:

1. Hot Molten Salt Piping

2. Cold Molten Salt Piping

3. Ullage Gas Piping

B. Pipe and fittings to be used for modifications or additions must be the same material as the existing systems being modified, but must conform to the following, unless otherwise indicated on the applicable contract drawings.

C. Piping materials and installation procedures must conform to ASME B31.1, Power Piping for "*Nonboiler External Piping*", the International Mechanical Code, and this Section.

1.02 SUBMITTALS

A. General

1. All required submittals must be per SNL Construction Standard Specification Section 013300S, Submittal Procedures. Submittal data is required on all products whether or not it is a substitution to those that are listed in this specification. Product-submittal data must indicate the maximum allowable operating pressure and temperature of each component and any related manufacturing standard.

B. Submittal Data Required

1. Catalog data on pipe materials, fittings, and accessories.

2. Catalog data including procedures and requirements on orbital welder or other equipment to be used in pipe welding.

3. Shop Drawings of the entire Molten Salt Piping System.

4. Five weld specimens per Quality Assurance.

5. Pipe mill lot certifications.

6. Welding procedures. Include how the Contractor will demonstrate the pipe is clear of any welding slag based on the particular weld procedure and welding technique the Contractor chooses.

7. DI water source and DI water quality.

8. Cleaning, rinsing, drying, and packaging operations are required, provide a description of the manufacturer's proposed processes. Include procedure to perform final pipe clean.

9. Welding fill material.

10. List of all welding operators including ASME B31.1 certifications and final welding procedures. All welding certification will be for pipe materials used on this project only. All requirements and documentation listed under 1.03 Quality Assurance of this document shall be provided under Submittal requirements.

11. Pipe pressure test safety plan.

C. Project Closeout Records / Certifications

1. Test Water Quality Records.

2. Piping and weld material records and certification.

3. Record of welds performed by each welding operator.

4. Final list of all welding operators including ASME B31.1 certifications and final welding procedures.

5. Weld Inspection Records; on-site and off-site.

6. Radiography records.

7. Pipe Pressure Test Records / Logs.

1.03 QUALITY ASSURANCE

A. Welding

1. Qualify welding processes and welder performance in accordance with ASME B31.1, Power Piping. Certify that each welder has satisfactorily passed ASME B31.1 qualification tests for welding the following materials with schedule 80 (seamless) pipe with butt-welded joints, processes involved and, if pertinent, have undergone recertification.
   a. Haynes 230 ASTM B622 Alloy N06230, P-No.43
   b. Stainless Steel ASTM A213 TP304H, Alloy S30409, P-No.8

2. Welding procedures must address cleaning, joint clearance, overlaps, internal purge gas, purge gas flow rate, and filler metal.

3. Certification of procedures and operators applies for both shop and job site welding of pipe work.
   a. Acceptance is limited to qualification on piping using the same or equivalent procedures.
   b. Performance qualification test record, showing the name of the welder, procedures identification, date of successful qualification, results of procedure and performance qualification, and the date that the individual last used the procedure on pressure piping.

4. Operators must comply with SNL Construction Specification 010650, ES&H for Construction and Service Contracts, Section 1.05.E, Hot Work Permit.

5. Performance qualification of welders must remain in effect indefinitely unless the welder does not weld with the qualified procedure for a period exceeding 12 months, or there is a specific reason to question the ability of the welder.

6. Within four weeks of the Contractor receiving award of this contract, the Contractor shall submit five (5) specimens (samples) of 6-diameter pipe welds using all materials specified within this specification and procedures outlined either in this document or in accordance with ASME B31.1 in which the Contractor intends to use to construct the Molten Salt Test Loops for each welder on the project. This requirement applies to any additional welders added during the course of the project. SNL will submit the specimens to metallurgist for complete analysis to determine if the welds meet ASME B31.1. If consumable inserts or backing rings are used, their suitability shall be demonstrated by procedure qualification.

   This analysis will take a minimum of 6-weeks to complete once submitted. The Contractor will not be able to begin construction until welded specimens have been analyzed and approved. If the specimens fail, the Contractor will be required to re-submit 5 specimens for analysis and approval. The Contractor is responsible for all cost associated with weld specimen analysis and approval.

7. Submit all records identified under Quality Assurance as a Submittal per requirements of Specification 013300 for approval.

8. Contractor shall coordinate final pipe shop drawings with all final equipment approved shop drawings. This includes pump, furnace, salt-to-air cooler, valves and control components, etc.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the job site in good clean condition and properly protected against damage to finished interior or exterior surfaces.

1. All pipe lengths, spool pieces, fittings, and valves shall be stored with the ends capped or sealed in bags to prevent contamination of the interior of the pipe.

2. Store insulation, pipe, fittings, spool pieces, all control components and valves indoors in a dry, dust-free environment. Contractor is responsible for temporary indoor storage at site. Location to be determined after contract award.

3. Any material or equipment that becomes damaged or contaminated in handling shall not be used unless it is repaired or re-cleaned to the original requirements.

B. Storage Onsite

1. Store materials in an indoor location and in a manner to avoid damage. Stacking must be done in a way that prevents bending.

C. Keep handling onsite to a minimum. Exercise care to avoid damage to finishes of material.

D. Use a sling to hoist large valves. Do not use hand wheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 GENERAL

A. The following products and materials must be used unless shown otherwise on the drawings. Other products of equal or better quality and characteristics may be submitted in addition to those listed in this specification. All products and materials must be of new, unused condition unless such have been provided by SNL.

B. For the purposes of this specification, "mill lot", "mill heat", and "heat lot" refer to lot designations from the steel foundry process.

C. All components shall be suitable for automatic orbital welding or stick weld unless otherwise specified.

1. All materials used in the Hot Molten Salt Piping System including weld fill shall be rated for a service duty of 1364°F (740°C).

2. All materials used in the Cold Molten Salt Piping System including weld fill shall be rated for a service duty of 968°F (520°C).

3. All materials used in the Ullage Gas Piping System including weld fill shall be rated for a service duty of 968°F (520°C).

D. All components shall be permanently marked with the heat number for manufacturer's ID number using vibratory etch or electro-etch processes. Any heat numbers which appear to have been tampered with shall be immediately removed from the premises and replaced with valid and approved pipe material.

2.02 MATERIALS FOR MOLTEN SALT PIPING SYSTEMS

A. Hot Molten Salt Piping

1. Performance Criteria

a. All piping shall be capable of continuous operations as follows:

1) Fluid: Hot Molten Salt containing 40MgCL / 20 NaCl / 40 KCl (Molar).

2) Continuous Operating Pressure: 100 psig.

3) Maximum Operating Temperature: 1364°F (740°C).

2. Piping

a. Hot Molten Salt (Sizes 2-inches): Schedule 80S, Haynes 230, ASTM B622 N06230, P-No.43, (seamless), with butt-welded joints. (NO EXCEPTIONS).

1) Material: 57Ni – 22Cr – 14W – 2Mo – La.

2) Solution Annealed 2125-2175°F and rapidly cooled.

3) Pipe Wall Thickness per ASME B36.19M-2018

b. Pressure – Temperature ratings shall be in accordance with ASME B31.1 Appendix A or ASME BPVC.II.D.

1) Maximum Allowable Stress at 1800°F is 0.45 ksi.

c. Non-destructive Test: 100% hydrostatic pressure tested at 550 psi.

d. Metallurgical Test: Grain size per ASTM E-112 and Intergranular Corrosion per ASTM A-262 "E" plus Tests ACC.

3. Fittings

a. All Hot Molten Salt pipe fittings shall meet the same performance requirements for pipe material. All fittings shall be Haynes 230, schedule 80 suitable for butt-weld. Pumps, valves and heat exchangers require either flange connection or Grayloc® connections.

b. Seamless Butt-Welded Fittings: ASTM B366 and ASME B16.9, equal in thickness to meet pipe pressure ratings. Ends machined for butt welds.

c. Pressure – Temperature ratings shall be in accordance with ASME B31.1, Table 126.1 Specifications and Standards and ASME BPVC.II.D Table 1B.

d. ANSI/ASME B16.34 RTJ flange joints at pumps, valves or heat exchanger are acceptable.

e. Threaded joints are not acceptable.

f. Long radius 90° Elbows shall be used in all cases unless other radius elbows are authorized by SDR. All vertically installed elbows will have an 85 degree slope cut.

g. Mitered bends are not acceptable.

h. Only eccentric reducers are permitted, concentric reducers are not acceptable.

4. Pipe Supports, Hangers, Guides, and Anchor

a. See drawings and pipe support schedules for Molten Salt pipe supports, guides, and anchor requirements.

5. Gaskets

a. Pressurized Inconel 625 O-Ring with Nickel 200 coating.

6. Bolts and Nuts

a. Bolts and Nuts must conform to ASTM A193-B8M Type 1.

b. Carbon content of material shall be 0.04% or higher.

c. Heat treatment: heated above 1900°F and rapidly cooled.

B. Cold Molten Salt Piping

1. Performance Criteria

a. All piping shall be capable of continuous operations as follows:

1) Fluid: Cold Molten Salt containing 40MgCL / 20 NaCl / 40 KCl (Molar).

2) Continuous Operating Pressure: 225 psig.

3) Maximum Operating Temperature: 968°F (520°C).

2. Piping

a. Cold Molten Salt (Sizes 2-inches): Schedule 80S, Stainless-Steel 304H, ASTM A213 S30409, P-No.8, Solution Annealed (seamless), with butt-welded joints. (NO EXCEPTIONS).

1) Material: 18Cr – 8Ni.

2) Solution Annealed 2100-2150°F and rapidly cooled.

3) Pipe Wall Thickness per ASME B36.19M-2018

b. Pressure – Temperature ratings shall be in accordance with ASME B31.1 Appendix A or ASME BPVC.II.D.

1) Stainless-Steel 304H Maximum Allowable Stress at 1000°F is 14.0 ksi.

c. Non-destructive Test: 100% hydrostatic pressure tested at 550 psi.

d. Metallurgical Test: Grain size per ASTM E-112 and Intergranular Corrosion per ASTM A-262 "E" plus Tests ACC.

3. Fittings

a. All Cold Molten Salt pipe fittings shall meet the same performance requirements for pipe material. All fittings shall be Stainless-Steel 304H, schedule 80 suitable for butt-weld. Pumps, valves and heat exchangers require either flange connection or Grayloc® connections.

b. Seamless Butt-Welded Fittings: ASTM A366 and ASME B16.9, equal in thickness to meet pipe pressure ratings. Ends machined for butt welds.

c. Pressure – Temperature ratings shall be in accordance with ASME B31.1, Table 126.1 Specifications and Standards and ASME B31.1, Appendix A.

d. ANSI/ASME B16.34 RTJ flange joints at pumps, valves or heat exchanger are acceptable.

e. Threaded joints are not acceptable.

f. Long radius 90° Elbows shall be used in all cases unless other radius elbows are authorized by SDR. All vertically installed elbows will have an 85 degree slope cut.

g. Mitered bends are not acceptable.

h. Only eccentric reducers are permitted, concentric reducers are not acceptable.

4. Pipe Supports, Hangers, Guides, and Anchor

a. See drawings and pipe support schedules for Molten Salt pipe supports, guides, and anchor requirements.

5. Gaskets

a. Pressurized Inconel 625 O-Ring with Nickel 200 coating.

6. Bolts and Nuts

a. Bolts and Nuts must conform to ASTM A193-B8M Type 1.

b. Carbon content of material shall be 0.04% or higher.

c. Heat treatment: heated above 1900°F and rapidly cooled.

C. Ullage Gas Equalizer and Vent Piping

1. Performance Criteria

a. All piping shall be capable of continuous operations as follows:

1) Fluid: Cold Molten Salt containing 40MgCL / 20 NaCl / 40 KCl (Molar).

2) Continuous Operating Pressure: 225 psig.

3) Maximum Operating Temperature: 968°F (520°C).

2. Piping

a. Cold Molten Salt (Sizes 2-inches): Schedule 80S, Stainless-Steel 304H, ASTM A213 S30409, P-No.8, Solution Annealed (seamless), with butt-welded joints. (NO EXCEPTIONS).

1) Material: 18Cr – 8Ni.

2) Solution Annealed 2100-2150°F and rapidly cooled.

3) Pipe Wall Thickness per ASME B36.19M-2018

b. Pressure – Temperature ratings shall be in accordance with ASME B31.1 Appendix A or ASME BPVC.II.D.

1) Stainless-Steel 304H Maximum Allowable Stress at 1000°F is 14.0 ksi.

c. Non-destructive Test: 100% hydrostatic pressure tested at 550 psi.

d. Metallurgical Test: Grain size per ASTM E-112 and Intergranular Corrosion per ASTM A-262 "E" plus Tests ACC.

3. Fittings

a. All Cold Molten Salt pipe fittings shall meet the same performance requirements for pipe material. All fittings shall be Stainless-Steel 304H, schedule 80 suitable for butt-weld. Pumps, valves and heat exchangers require either flange connection or Grayloc® connections.

b. Seamless Butt-Welded Fittings: ASTM A366 and ASME B16.9, equal in thickness to meet pipe pressure ratings. Ends machined for butt welds.

c. Pressure – Temperature ratings shall be in accordance with ASME B31.1, Table 126.1 Specifications and Standards and ASME B31.1, Appendix A.

d. ANSI/ASME B16.34 RTJ flange joints at pumps, valves or heat exchanger are acceptable.

e. Threaded joints are not acceptable.

f. Long radius 90° Elbows shall be used in all cases unless other radius elbows are authorized by SDR. All vertically installed elbows will have an 85 degree slope cut.

g. Mitered bends are not acceptable.

h. Only eccentric reducers are permitted, concentric reducers are not acceptable.

4. Pipe Supports, Hangers, Guides, and Anchor

a. See drawings and pipe support schedules for Molten Salt pipe supports, guides, and anchor requirements.

5. Gaskets

a. Pressurized Inconel 625 O-Ring with Nickel 200 coating.

6. Bolts and Nuts

a. Bolts and Nuts must conform to ASTM A193-B8M Type 1.

b. Carbon content of material shall be 0.04% or higher.

7. Heat treatment: heated above 1900°F and rapidly cooled.

PART 3 - EXECUTION

3.01 PIPE CLEANING

A. Field Cleaning For Molten Salt and Ullage Gas Piping

1. General: All molten salt pipe, ullage gas pipe and fittings not delivered pre-cleaned or that have failed the visual inspection by the SDR shall be cleaned as follows.

a. Cleaning Materials:

1) Gas for pipe drying shall be filtered oil-free air or nitrogen.

2) Phosphate-free Detergent: Triton X100, Micro, or Amway LOC.

3) DI Water: The Contractor shall provide DI water for cleaning, rinsing, and final pressure test.

b. Cleaning Piping Spools:

1) Examine each pipe spool or fitting as applicable for roundness, damaged ends, warping, cracks, or signs of mishandling.

2) Degrease component by soaking in an aqueous-type degreasing agent or a phosphate-free detergent solution (0.01 percent detergent in DI water).

3) Rinse with DI water until inlet and outlet resistivity of the rinse water is equal.

4) Wipe external pipe or fitting surfaces with DI to remove ink markings and surface smudges.

5) Dry pipe or fitting interior with filtered oil-free air.

6) Visually inspect interior for contamination, discoloration, or other rejectable surface anomalies. If unable to correct the visual problems by recleaning, reject and label the rejected item.

7) Bag spool ends or fitting prior to shipping.

8) Attach a label to the spool or fitting exterior certifying it has been cleaned.

c. Cleaning piping (If They Have Failed Inspection):

1) Submerge in a continuously circulating detergent/DI water solution at 0.01 percent (1 teaspoon phosphate-free detergent per 13 gallons) for a minimum of 5 minutes. Fully disassemble valves during cleaning. Use nylon brushes covered with a cleanroom wipe to remove contaminants as needed.

2) Rinse with DI water until inlet and outlet resistivity of the rinse water is equal.

3) Blow parts dry with filtered oil-free air. Wipe surfaces with a swab saturated with DI water. Inspect for contamination or damage. Re-clean if necessary. Any materials that cannot be cleaned or are damaged shall be labeled "rejected" with the date.

4) Blow cleaned parts dry with filtered oil-free air, assemble, place in clean polyethylene bags, and heat seal. Attach label to bag certifying that component has been cleaned.

3.02 PIPING INSTALLATION

A. General

1. Molten salt and ullage gas equalizer/vent piping must slope towards either the hot or cold tank a minimum of 5 degrees. Pipe must be cut accurately to measurements established at the construction site and must be worked into place without springing or forcing, properly clearing all openings and equipment. Cutting or weakening of structural members to facilitate piping installation is not permitted. Pipes must have burrs removed by reaming and must be so installed as to permit free expansion and contraction without damage to joints or hangers. Piping must be run parallel and must slope back to storage tank a minimum of 5 degrees (NO EXCEPTIONS). There can be absolutely no flat places in the piping system installation; otherwise, molten salt fluid will freeze during loss of electrical power. Pipe, valves, and fittings must be located with a sufficient distance from other work to permit the installation of the ultra thick insulation system. Adequate clearance must be provided between the insulation systems so that easy removal of insulation to perform maintenance on heat trace cabling can be conducted periodically.

B. Preheat

1. All piping and fittings must be preheated to a minimum temperature of 50°F (10°C) prior to welding avert or relieve the detrimental effects of high temperature and severe temperature gradients inherent in welding. Pre-heat zone shall extend at least 3-inches beyond each edge of the weld.

2. Temperature verification prior to welding is required through use of indicating crayons or INFRARED temperature sensor.

C. Hangers and Anchors

1. See drawings and pipe support schedules for Molten Salt and ullage gas equalizer/vent piping supports, hangers, and anchor installation requirements.

D. Equipment Connections

1. All piping connections to pump, valves, heat exchangers and other equipment must be installed without strain at the pipe connection of the equipment. The strain load cannot exceed the requirements of API. There are no flange connections to equipment allowed. Pipe connections to equipment must be welded.

2. Welded Joints: Joints between sections of pipe and between pipe and fittings may be welded using electric welding equipment. Stainless steel welding must conform to ASME B31.1, Power Piping. All pipe surfaces must be thoroughly cleaned before welding. Each joint must be beveled before being welded. The Contractor must provide a nonflammable mat or blanket to protect the structure and adequate fire protection equipment at all locations where welding is done. All elbows must be long radius where space conditions allow. Welding tees must be used where shown on drawings. The use of fittings formed from welded pipe sections is not permitted. All welding must conform to the requirements of ASME B31.1 and SNL Construction Standard Specification Section 15050, Basic Mechanical Materials and Methods. Any welding work requires the following:

   a. A hot work permit from SNL Fire Protection.

   b. A dedicated fire watch during the work process until thirty (30) minutes after completion.

   c. A minimum 2-A-rated fire extinguisher located near the welding site.

   d. Any other special requirements listed on the permit.

3. Vacuum Relief Drains: Drains indicated on the drawings in connection with the molten salt piping system must be no smaller than 1-inch IPS. The drain pipes shall slope a minimum of 1/8-inch per foot to a stainless steel drum.

E. Insulation of all pipes, valves, fittings, and equipment must be in accordance with Section 230719S, Piping Insulation, unless noted otherwise on the drawings.

F. Heat trace flower shall be installed as follows:

1. Coordinate installation of heat trace flower with insulator, heat trace installer, and pipe fitter. See drawing detail for Heat Trace Flower for additional requirements.

2. The heat trace (hot to hot and hot to cold junctions) shall be positioned below 8 and 4 o'clock positions and outside the insulation. Ensure heat trace flowers are intact prior to insulation.

3. A maximum of one heat trace cable through one 1-/2-inch tubing is allowed.

4. Provide schedule 5, 304 stainless steel tubing size ½-inch diameter by 0.125-inch wall thickness for routing the heat trace cable from the molten salt pipe, vacuum relief pipe, valve bodies, valve bonnet, and flow meter, etc. to the exterior side of the insulation package.

5. Bend the straight tubing to provide a less than 90 degree elbow transition to route the cable inside the tubing to the exterior. The straight pipe bend is dependent on the cable bending radius. If the Contractor is unable to bend the elbow without kinking the pipe, then provide either 45° or 90° elbow with straight pipe.

6. Tack weld tubing bend elbow to carrier pipe to ensure tubing remains attached to carrier pipe.

7. Extended tubing through the insulation exterior jacket a minimum ½ - 3/4 inch. Extend cable hot-to-hot and hot-to-cold lead a minimum of 2-inches past the end of the tubing.

8. Provide escutcheon or some other means of sealing the tubing penetration through the insulation jacket. The area between the cable and tubing shall remain open to atmosphere and pointed down between 4-8 o'clock position to prevent water infiltration.

G. Identification and Labels

1. All piping systems must be labeled and identified in accordance with Section 230050, Basic Mechanical Materials and Methods. Contractor shall provide special pipe labeling identifying Molten Salt Supply Pipe, Molten Salt Return Pipe, and Ullage Gas Equalizer/Vent Pipe in accordance with SNL Standard Specification 230050.

H. Instrumentation

1. Temperature and pressure instrumentation must be of industrial quality and should be easily read from a normal vantage point from within the area. If instrumentation is placed in piping 10' above the finished floor, a large 5-inch dial must be used for ease of reading. Local instrumentation installed on point-of-use equipment must be of a commercial utility quality, and that can be easily read from a vantage point near the equipment. Outdoor instrumentation must be protected with weather shields.

I. Filler Materials

1. The deposited weld metal shall have essentially the same alloy content as the metal being joined and be of essentially the same tensile strength. Filler material

shall conform to the requirements of ASME Boiler and Pressure Vessel Code, Section IX. Acceptable filler materials are:

a. Hot Molten Salt (Haynes 230):
   1) AWS A5.12 EWCe-2
b. Cold Molten Salt (Stainless-Steel 304H)
   1) AWS A5.9 ER316H
   2) AWS A5.9 ER16-8-2
c. Ullage Gas Equalizer/Vent (Stainless-Steel 304H)
   1) AWS A5.9 ER316H
   2) AWS A5.9 ER16-8-2

2. Store welding rods in a warm dry area in accordance with the manufacturer's recommendations.

J. Backing Rings

1. Backing rings are NOT ACCEPTABLE unless the Contractor can demonstrate that the use of backing ring meets ASME B31.1 and will not intrude up inside the pipe and trap molten salt flow during passive drain back to the storage tank. The inside of the pipe must be as smooth as possible in order not to trap salt which would eventually freeze and cause buildup.

2. Consumable (dissolvable) backing rings used by orbital welders are acceptable as long as the inside of pipe is as smooth as possible and welding slag is not a residual left inside the pipe. If welding slag is a residual, the Contractor shall be responsible for cleaning the of all welding slag and demonstrate to the SDR that the piping system is completely clean of all slag.

3. Whichever welding procedure is selected by the Contractor, the Contractor is responsible for providing a final system which is free of all welding slag. The Contractor is responsible for demonstrating the system is free of welding slag prior to the system being filled with molten salt. The system will not have strainers or any other such device used to remove foreign material from the circulating fluid.

K. Joint Preparation And Alignment

1. Weld bevels shall be suitable for the welding process used and the contour shall permit complete fusion throughout the joint. Bevels shall conform to those used in the procedure qualification; however, when not specified, they shall be in accordance with the requirements of ASME B31.1, Power Piping.

2. Each qualified welder or welding operator shall be assigned an identification symbol. Each weld shall be marked with the identification symbol of the welder or welding operator. A log book shall be maintained at the site which maintains records of welds, welder name and ID numbers, welding machine serial numbers for each weld, weather conditions for each weld, pipe temperature for each weld, and other weld parameters such as purge flow rates, etc.

3. Each weld book will be inspected by the SDR or SNL welding inspector representative. The SNL welding inspector will audit a minimum of 20% of the production welds and will initial the log book for only those production welds inspected.

4. Weld bevels shall be made by machining, grinding, or thermal cutting, and the surfaces shall be reasonably smooth and true.

5. Piping stub-ins shall conform to the branch connection tables at the end of this Section. No 45 degree stub-ins, only 90 degree stub-ins are acceptable as noted on 90 Degree Branch Reinforcement Charts. Where stub-ins are used, the Contractor shall inspect piping after stub-in welding completion and shall mechanically remove any weld splatter on the pipe interior.

6. Where the ends of piping components are to be joined by welding and the internal surface misalignment exceeds 1/16 inch, that component, with the wall extending internally, shall be internally trimmed (see Figure 127.3 of ASME B31.1) so that the adjoining internal surfaces are flush. However, the resulting thickness of the welded joint shall not be less than the minimum design thickness plus any corrosion allowance.

7. Materials that require preheating for welding shall be preheated at the same temperature for thermal cutting or gouging.

8. All surfaces to be welded shall be clean and free from paint, oil, dirt, scale, and other materials detrimental to welding. Prior to welding, wire brush joints to be welded with stainless steel wire brushes or stainless steel wool.

9. Fit-up shall be made by tack welding or using lugs. Weld procedures shall identify in detail the tack weld length and spacing for approval.

10. Tack welds shall be made by a qualified welder under a qualified welding procedure. Tack welds that are part of the root pass shall be made with the same electrodes as are to be used for the first pass. Tack welds that have cracked shall be removed by grinding. Tack welds shall be of the same quality as required in the completed weld and shall be visually examined for defects before applying any completed passes. The ends (starts and stops) of the tacks shall blend in smoothly with the base metal so subsequent passes can be applied without interruption. Provide two tacks (the weld start and 180 degrees away) on 1-inch

pipe, and three tacks on 2-inch and larger pipe (the weld start and at 120 degree intervals).

11. Peening is prohibited on the root pass and final pass of a weld.

12. No welding shall be done if there is impingement on the weld area of rain, snow, sleet, or excessive wind, or if the weld area is frosted or wet.

13. The welding sequence and procedure and any heat treatment for welding end valve shall be such as to preserve the seat tightness of the valve.

14. The clear distance between centerlines of adjacent girth butt welds shall not be less than four times the pipe wall thickness, or 1 inch, whichever is greater.

15. End connections of shop fabricated spool pieces shall be provided as follows. Any exception to the following will be indicated on the piping drawing and approved by the Contractor prior to fabrication.

    a. Where field welding is required to join the ends of two pieces of fabricated pipe, or a piece of pipe and a welding fitting, the shop fabricator shall furnish both adjacent ends beveled for field welding and fabricated to the Drawing dimensions plus 3 inches.

    b. Where field welds occur at stub-ins to a field fabricated straight-run, the shop fabricator shall furnish the spool end contoured and ready for welding. Should a reinforcement fitting (i.e., weldolet) be required, it shall be included in the shop spool.

    c. End preparation for groove welds specified in ASME B16.25, or any other which meets the WPS, is acceptable.

    d. It is permissible to size pipe ends of the same nominal size to improve alignment if wall thickness requirements are maintained.

    e. Butt-weld fittings manufactured in accordance with ASME B16.9 may be trimmed to produce an angular joint offset in their connections to pipe or to other butt-weld fittings provided the total angular offset produced between the two jointed parts does not exceed 3 degrees.

L. Welding Process

1. All welds shall be made by the direct current, reverse polarity, inert gas tungsten arc welding (GTAW) or automatic orbital welder. Shop welding and fabrication shall be made in accordance with the submitted welding procedure qualifications, as reviewed and approved by the SDR. Tungstens shall be ceriated. Use of thoriated tungsten is prohibited.

2. Welds shall be done using approved automatic bench weld equipment or automatic orbital welder. Hand welds shall be used only at specific locations approved by the SDR.

3. No welding shall be performed if there is impingement of rain, snow, sleet, or high wind in the work area.

4. For all systems, oxygen shall be purged from pipe interior with argon prior to welding. A flowing argon purge shall be provided to prevent excessive, heavy oxidation of interior of pipe system. Heat tinting is normal and acceptable.

5. All welds shall be performed under dynamic (flowing) argon purge. The interior surface preparation shall include buffing all welds and surface anomalies. The interior surface shall be cleaned free of black carbonization, slag, weld splatter, and rust stains and restored to a near clean-for-oxygen-service condition.

M. Weld Contour And Finish

1. Welding requirements shall be as follows:
   a. All longitudinal welds shall have 100 percent penetration to the root of the joint.
   b. Penetration requirements of girth butt welds shall be within the acceptable limits specific in paragraph 127.4.2 of ASME B31.1.
   c. Any defects found shall be removed, repaired by welding, and the area reexamined.

3.03 PIPE WELD EXAMINATION

A. All pipe welds and pipe to equipment welds shall be examined by the SNL SDR in accordance with ASME B31.1, Power Piping, 136.4.

3.04 RADIOGRAPHY

A. Welds to Be Examined

1. The locations of welds and points at which they are to be examined by spot radiography in accordance with ASME B31.1, Power Piping, shall be selected or approved by the SNL SDR.

2. SNL is responsible for providing an agency to perform all radiography.

3. As a minimum, 5 welds for each welder shall be shot; however, not less than 20 welds for the entire project shall be shot. Also, final closure welds to the Pump and Cooler shall be 100% radiographed.

B. Progressive Sampling for Examination

1. When examination reveals a defect, two additional welds by the same welder shall be given the same type of examination at the Contractors expense.

2. If the welds examined under 1. above are acceptable, the defective weld shall be repaired or replaced and re-examined per B31.1. If any of the two additional welds fail, then two more additional welds for each weld that failed shall be radiograph.

3. All welds found to be defective shall be repaired or replaced, and re-examined at the Contractors expense.

3.05 TESTING PIPING SYSTEMS - GENERAL

A. Prior to installation of the insulation system and after completion of the weld examinations and radiography listed above, the entire molten salt piping system shall be tested to insure tightness. The Contractor shall perform a hydrostatic leak test as stated in this document in accordance with ASME B31.1.

3.06 HYDROSTATIC TEST

A. A special precaution will be required when testing stainless steel systems. Use of high chloride content city or industrial water can lead to stress corrosion cracking at the welds. The Contractor shall provide DI water greater than or equal to 0.5 megohm-cm for hydrostatic testing. If DI water is not available in this range, RO water shall be used. Further, water shall not be allowed to remain in the piping system after the test is completed. The Contractor shall be responsible for evacuating all water from the piping system including all components and equipment. The Contractor shall be responsible for proper disposal of water in accordance with all regulatory requirements and SNL requirements. Stainless steel systems shall have some oxygen present to promote renewal of the protective oxide layer.

1. The Contractor shall provide test certifications that the water to be used meets all requirements listed in this document to the SDR prior to filling of the piping system.

B. SPECIAL PROVISIONS FOR TESTING

1. All safety measures required by codes or ordinances or reasonably applicable to the situation shall be provided by the Contractor in conjunction with the testing of the piping systems. Contractor shall include in their Safety Plan provisions for pressure test of Molten Salt piping at high pressures. The plan shall identify exclusion areas around the piping system/area during such tests. The Contractor shall not proceed with any testing without SNL approval of the Pipe Test Safety Plan.

2. Pipe Subassemblies. Piping subassemblies may be tested either separately or as assembled piping.

3. Testing of pipe subassemblies constructed off site may be performed provided all procedures including witnessing are met per the requirements of this specification and ASME B31.1.

4. Closure Welds. The final weld connecting piping systems or components which have been successfully tested, need not be leak tested provided the weld is examined in-process and passes with 100% radiographic examination per ASME B31.1.

5. If the SDR considers hydrostatic leak testing of a particular weld to be impracticable, then the weld shall be 100% radiographed.

6. The weld connections to the pumps, valves, heat exchangers and salt storage tanks shall be considered as Closure Welds. Pipe connections to the pump and salt air cooler shall not be subjected to hydrostatic leak test. These equipment connections shall require the weld to be 100% radiographed.

7. Any equipment not rated for the maximum test pressure shall be completely isolated from hydrostatic leak testing. If the Contractor fails to protect any equipment, such equipment shall be replaced immediately by the Contractor. No equipment shall remain connected to the piping system which has been subjected to pressures outside that particular components maximum pressure rating.

C. Repairs or Additions After Leak Testing

1. If repairs or additions are made following the leak test, the affected piping shall be retested, except that for minor repairs or additions.

D. Hydrostatic Leak Test

1. Molten Salt piping must be a hydrostatic leak test at the test pressures specified and must show no drop in pressure in a 2-hour period.

E. Test Pressures

1. All points within the piping system shall be tested by a hydrostatic test with DI water or RO water. The test pressures are based on using water at a temperature less than 200°F per ASME B31.1, 137.4.5.

2. Test pressures shall be measured at the base of the system.

Table 1. Test Pressures

System	Hydrostatic Test Pressure
Hot Molten Salt Piping	250 psig
Cold Molten Salt Piping	350 psig
Ullage Gas Equalizer/ Vent Piping	100 psig

F. Pipe Pressure Test Records

1. The Contractor shall electronically record all pressure tests over the entire test duration period and submit these records to SNL at project close out. These test records shall be signed off by the Contractor and SNL Inspector as a minimum.

G. Test Water Removal

1. After completion and acceptance of all testing, the Contractor shall drain out all water from the system. The Contractor shall provide a temporary small mesh screen to filter water through in order to demonstrate the system is clean. If welding slag or other debris is found, and the SDR determines it is significant enough, the Contractor shall re-fill the piping system with DI water and circulate the water with sufficient velocity to demonstrate to the SDR that the piping system is clean of all debris.

2. All temporary pipe fittings used to fill and drain the piping system of water including the fittings used to pressure test shall be removed in their entirety. There shall be no pipe voids left behind which can trap molten salt fluid.

3.07 WELDING INSPECTION RECORDS / LOGS

A. Contractor is responsible for maintaining up to date welding inspection records / logs at the job site of all welds. The following information shall be contained in the records / logs as a minimum.

1. Welders Certification per ASME B31.1 for approved welding procedures.

2. Approved welding procedures per ASME B31.1.

3. Welder responsible for performing welds.

4. Drawings indicating each weld and welder responsible for performing such weld. Drawings indicating specific welds shall be signed and dated by welders.

5. Weld fill material records.

6. Pipe material certification records.
7. Records / Certifications for orbital welder machine.
8. Weld Examination / Evaluation inspection logs per ASME B31.1 for welds.
9. Records / drawings identifying welds radiographed.
10. Pipe pressure test records.

B. Records / Log Inspection

1. Contractor shall maintain all records up to date on a daily basis. SNL reserves the right to inspect these records at any given time.

C. Project Closeout

1. All records shall be submitted to SNL upon final acceptance of the project per requirements of 1.02 Submittals and Section 01330S Submittal Procedures.

- END OF SECTION -

Exceptional service in the national interest

Sandia National Laboratories

Section 23 25 00 – Chemical Treatment for Hydronic Systems

October 2018

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 23 25 00 – Chemical Treatment for Hydronic Systems

Table of Contents

Page

Change Log

Date	Changes Requested By	Editor	Type	Change Description
4/18/16	Freeman Leaming	Freeman Leaming	General	Updated for 2004 formatting.
8/21/18	Tim Peterson	Jasent Quintana	Subst	3-year review performed; updated Sections: 1.3, 1.5, 2.1, 2.3, 2.4, 3.1, 3.3, 3.4, Attachment 1

Section 23 25 00 – Chemical Treatment for Hydronic Systems

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specifications.

B. Where contradictions occur between this Section and Division 01, the more stringent of the two shall apply. The Sandia National Laboratories (SNL) Water Treatment Engineer or Sandia Delegated Representative (SDR) shall determine which is most stringent.

C. Related Sections: Refer to the following sections for related work.

1. Section 01 33 00, "Submittal Procedures"

1.2 Summary

A. Section Includes: Hydronic piping system flush and clean procedures and chemical water treatment systems including applicable equipment, piping, tubing, interconnection components, electrical controls, water treatment materials, chemical test equipment, and cleaning chemicals for cleaning and maintaining treatment of the following mechanical systems.

1. Closed Loop: Hot water boilers and heating water systems.
2. Closed Loop: Chillers and chilled water systems.
3. Cooling towers and condenser water systems.

1.3 Definitions

A. SNL/NM: Sandia National Laboratories New Mexico Site

B. SDR: Sandia Delegated Representative

C. SCO: Sandia Construction Officer

1.4 Action Submittals

A. Submit according to Section 01 33 00 "Submittal Procedures," indicating specific chemical treatment products and equipment.

1. Submit operation and maintenance data on all control equipment, chemical feed pumps, timers, water meters, and other applicable equipment including a spare parts list and local suppliers as appropriate.

1.5 Quality Assurance

A. Installing contractor shall follow the procedures herein, unless alternative procedures are pre-approved by SDR and SNL Water Treatment Engineer.

B. Galvanized Cooling Tower(s) Only: Installing contractor will need to notify the SCO that the cooling tower(s) will require passivation. SCO will coordinate the passivation process with SNL's Water Treatment Engineer at least 6 weeks before system is scheduled to be fully commissioned in order to coordinate resources/equipment set-up with Water Treatment Service Provider. Depending on the cooling tower manufacturer, passivation durations between 4–8 weeks will be required before system can be treated with standard condenser system water treatment chemicals.

C. SNL personnel will provide sufficient chemicals and testing reagents for the initial cleaning, start-up, and passivation of all systems.

1. The SNL Water Treatment Engineer and/or Mechanical Systems Engineer will provide direction for proper control equipment and controls sequencing.
2. SNL personnel will provide testing services and/or equipment for measurement of water quality parameters during cleaning, flushing, and/or passivation process.
3. SNL personnel will provide Safety Data Sheets (SDS) for all Sandia-furnished chemicals.

D. SNL personnel will take over the care of the chemical treatment of the systems as soon as piping systems commissioning is complete or construction completion is achieved, whichever comes first.

E. Refer to standard drawing MP5013STD.dgn for direction on closed-loop water treatment systems equipment and piping installation for bypass filter feeder unit

F. Provide to SDR the name of the competent person who will be injecting the cleaning and water treatment chemicals.

G. If a system must be drained for any reason, it shall be treated immediately upon being refilled to avoid creating any "flash rust" internal to the piping system. Immediately contact the SCO (inspector) for water treatment chemicals should this happen.

PART 2 - Products

2.1 Chemicals – Condenser Water Systems

A. Contact SCO (inspector) at least two weeks prior to hydrotesting systems to insure chemicals are onsite for pre-treatment and post-treatment.

B. For chemical treatment calculations, have the system contracting Design Engineer document the following in the project submittal:

1. Piping: material, diameter, and lengths for each hydronic system to be installed

2. Piping installation method (i.e. welded flange, Cu sweating, Pro-Press, etc.) for all piping sections to be installed

C. For initial cleaning of the system, SNL personnel will provide a liquid alkaline cleaner (CL-483).

D. SNL personnel will provide a scale and corrosion inhibitor (CW-8800-RTC) to aid in the general cleanliness of the recirculating water.

E. SNL personnel will provide an oxidizing biocide (SB-6300) in liquid form to minimize bacterial activity in the condenser system.

F. For select systems, SNL personnel will provide a biodispersant (CW-7740) that improves biocide effectiveness as well as lift and suspend silt and organic matter in the condenser system.

G. If necessary, SNL personnel will provide a non-oxidizing biocide (AQ7423) in liquid form to minimize algal growth. The SNL Water Treatment Engineer will advise on this issue.

H. <u>Galvanized Cooling Tower(s) Only</u>: SNL personnel will provide an alkalinity-reducing pre-treatment chemical (CW-8251) to prevent “white rust” formation on the surface of galvanized cooling towers.

2.2 Chemicals – Closed Water Systems

A. Contact SCO (inspector) at least two weeks prior to hydrotesting systems to insure chemicals are onsite for pre-treatment and post-treatment.

B. For chemical treatment calculations, have the system contracting Design Engineer document the following in the project submittal:

1. Piping: material, diameter, and lengths for each hydronic system to be installed

2. Piping installation method (i.e. welded flange, Cu sweating, Pro-Press, etc.) for all piping sections to be installed

C. For initial cleaning of the system, SNL personnel will provide a liquid alkaline cleaner (CL-483). Contractor will provide chemical pump to recirculate the cleaner and water.

D. SNL personnel will provide a scale and corrosion inhibitor (CS-4015) for final closed-loop treatment.

2.3 Equipment Requirements

A. All water meters, sample piping, conduit and wire, pot feeders, and valves are contractor furnished and installed. Feed tanks, pumps, chemical treatment panels, and other equipment specific to the chemical treatment program are SNL furnished and installed by contractor.

B. The chemical feed tanks and panel shall be located such that there is easy access for maintenance personnel. Minimum floor space is 5 ft by 9 ft for the tanks. Panel shall not be installed directly above the tanks. Typical panel size is 4 ft tall by 8 ft wide. Panel may be installed on a wall or floor mounted system; however, proper bracing is necessary.

C. Provide ¾″ sample line from a weld-o-let on each of the cooling tower pipes. The weld-o-let shall be located on the side or top of the pipe and not the bottom as debris from the system can collect and clog water treatment equipment resulting in treatment malfunction. This line will be routed to the chemical treatment panel area and terminated with a ball valve at 8 ft above the finished floor. Provide insulation and/or heat tape if routed outside or on a perimeter wall. Avoid trapping water in outdoor piping and slope piping to provide self drainage when systems are non-operational. Final connections to chemical treatment panel will be done by others.

1. Provide ¾″ copper sample line from cooling tower return pipe.
2. Provide ¾″ PVC (sch80) sample line from cooling tower supply pipe
3. Indoor Sumps – SB-6300 chemical feed line: provide a dedicated 1″ PVC (sch80) line from water treatment panel to each cooling tower sump. This line will encapsulate a 3/8″ section of poly tubing for biocide chemical injection.

2.4 Equipment Required – Closed Water Systems

A. Provide a separate chemical bypass feeder for each closed water system. See standard drawing MP3013STD.dgn for details. The feeder shall be a Neptune FTF-5DB 5-gal filter feeder capable of an operating pressure of 300 pounds per square inch gauge (psig), up to 200°F, and flow up to 40 gpm, and a maximum initial pressure drop of 3 psi. The feeder shall contain a stainless steel fiber bag screen, with a 5 micron polypropylene replacement bag filter. Filter feeder unit shall be installed and supported at floor or wall at a maximum height of 5′ above finished floor. Size as specified in the construction drawings.

PART 3 - Execution

3.1 Supervision

A. Installation, start-up, and testing of chemical water treatment systems must be witnessed by the SDR, SCO, and/or SNL water treatment personnel. Contractor shall provide sign-off sheets for all stages as necessary

3.2 Cleaning and Start-Up Procedures – General

A. Check equipment for proper installation and operation prior to commencing cleaning. Check chemical injection ports to ensure safe and effective introduction of cleaning chemicals and water treatment chemicals.

B. Air handler and terminal unit coils, chillers, and boilers shall be isolated prior to cleaning and flushing of main distribution piping.

C. Water shall be drained to the sanitary sewer only – draining to the ground or storm sewer is not acceptable.

D. The cleaning and start-up procedures shall commence immediately after the system(s) hydrotesting, and shall be reflected in the Commissioning Plan and commissioning schedule. The maximum amount of time that a loop can be untreated is 48 hours. If cleaning and flushing of the system(s) cannot be accomplished immediately after the hydrotest, the water used for hydrotesting shall be charged with the pre-treatment/passivating chemical at a volume determined by the SNL Water Treatment Systems Engineer and/or Water Treatment Service Provider.

E. Cleaning and flushing shall occur prior to the start-up of boilers and chillers.

3.3 Cleaning, Pretreatment, and Start-Up Procedures – Condenser Water System

A. General Information

1. The automatic conductivity controller shall be calibrated by SNL personnel, and the proper operation of the blow-down valve shall be verified prior to the start-up of the condenser system.

2. Galvanized Cooling Tower(s) Only: Do not subject new galvanized towers to alkaline cleaners (recirculating water pH>8.5) or acidic situations (recirculating water pH<6.8) to ensure no corrosion will occur on galvanized surfaces. Galvanized towers will require a special start-up procedure to ensure proper protection of the protective zinc coating. Contact the SCO and/or SNL Water Treatment Systems Engineer before proceeding.

B. Piping and Tower Cleaning and Flushing Procedure

1. Ensure cooling tower deck, basin, and sides are cleaned and free of dirt and debris; sweep and/or vacuum surfaces as needed

2. Verify that any heating, ventilating, and air conditioning (HVAC) coils, heat exchangers, chillers, and boilers are isolated.

3. Fill the entire system with water and recirculate for one hour. Ensure that all valves are open and no dead legs are present. If possible, bypass the condenser to ensure that no large particles are introduced into the tubes.

4. Drain the entire system at the lowest available point(s). Remove all debris from the tower basin, all screens, and strainers.

5. Repeat rinse until all debris has been removed from the piping system.

6. Wash out the tower's internal basin and splash fill.

7. Refill the entire system with water and recirculate for one hour. Ensure that all valves are open and no dead legs are present. If possible, bypass the condenser to ensure that no large particles are introduced into the condenser tubes.

8. Test the system to ensure cleanliness and stability. Required water quality is as follows:

a. Total Dissolved Solids: <500 uS/cm
b. pH: <7.8
c. Soluble Iron: <0.5 ppm as Fe (optional)
d. Color: No visible color or suspended soils

SNL personnel will provide testing services and/or testing equipment. SNL Water Treatment Systems Engineer or SNL delegate must accept and sign off on water quality before proceeding. If needed, continue to drain and refill the system until water quality parameters are met.

9. Open all valves once water quality is acceptable in the above steps.

C. Final Treatment Procedure

1. <u>Galvanized Cooling Tower(s) Only:</u> Contractor to contact the SCO to initiate passivation process. Do not add inhibitor or biocide until passivation is complete.

2. Add sufficient inhibitor and biocide treatment immediately following flushing and cleaning per directions and begin circulation.

3. Maintain system circulation for at least one week after the completion of start-up procedures to promote inhibitor effectiveness.

4. If a system must be drained for any reason, it shall be treated immediately upon being refilled. Contact SCO for water treatment chemicals immediately should this happen.

3.4 Cleaning and Start-Up Procedures – Closed Loop Water Systems (Chilled, Heating Systems)

A. Pipe Cleaning and Flushing Procedure

1. Drain system after hydro-testing.

2. Close off any 1″ or smaller lines (such as coils); isolate heat exchangers, chillers, and boilers.

3. Refill the rest of the system with potable water removing all air that may be entrained in the lines. Ensure that all valves (except those supplying smaller legs) are open and that no dead legs are present.

4. Circulate water for one hour.

5. Add the cleaning solution (CL-483, liquid alkaline cleaner) to the filter feeder unit (with polypropylene filter installed) per SNL Water Treatment Systems Engineer's directions.

6. Using contractor-supplied chemical pump, recirculate for at least 8 hours, preferably overnight and as close to full flow as possible; run number of pumps

expected during peak load operation. If possible, heat system to 120°F during circulation. Provide flow rate to SCO.

7. Bleed and feed the entire system immediately after the circulation pumps have been stopped. Add water at the normal make-up feed water location; bleed from the farthest point in the system (e.g., makeup water in the basement and bleed in the penthouse). Continue the bleed and feed process until the flowing parameters are met:

    a. Total Dissolved Solids: <500 uS/cm
    b. pH: <7.8
    c. Soluble Iron: <0.5 ppm as Fe (optional)
    d. Color: No visible color or suspended soils

    SNL will provide testing services and/or testing equipment. SNL Water Treatment Systems Engineer or SNL delegate must accept and sign off on water quality before proceeding.

8. Remove, inspect, and clean all strainers located in the distribution piping.

9. Open all valves once water quality is acceptable in the above steps.

B. Final Treatment Procedure

1. Add sufficient inhibitor treatment immediately following flushing and cleaning of the closed loop system(s) per SNL Water Treatment Engineer's directions.

2. System circulation should be maintained for at least two weeks after completion of start-up procedures to promote inhibitor effectiveness.

3. If a system must be drained for any reason, it shall be treated immediately upon being refilled. Contact the SCO for water treatment chemicals immediately if this should happen.

3.5 Documentation

A. Document flushing procedure on the attached checklist and return to the SDR.

END OF SECTION 23 25 00

Attachment 1

Turn in records of duration of flushing and cleaning procedure and of treatment chemicals added, as well as any recommendations for improvements to procedures.

System Cleaning & Flushing Checklist

Bldg ____

System (ChW, HW) ____

Initial Flush of System		Date	Responsible Party	Initials
	Isolate condenser, boiler, or chiller if possible		Contractor	
	Isolate all small loops (coils)		Contractor	
	Open all valves and/or circuit setters		Contractor	
	Circulate system for 1 hour minimum		Contractor	
	Drain water to sanitary sewer		Contractor	
	Clean all strainers, filters, and sumps		Contractor	
	Refill system with clean water		Contractor	
Cleaning of System				
	Keep equipment isolated as in initial flush		Contractor	
	Add CL483 to system (SNL SCO to verify)		Contractor	
	Install polypropylene filter in pot feeder		Contractor	
	Circulate system for 8 hours minimum		Contractor	
	Drain water to sanitary sewer		Contractor	
	Clean all strainers, filters, and sumps		Contractor	
	Refill system with clean water		Contractor	
	Test water to ensure no cleaner (CL483) remains:		SNL	
	pH (less than 7.8)			
	Conductivity (less than 400 uS/cm)			
	Color (clear)			
	Solids (none visible)			
	Iron (less than 2 ppm) optional			
	Repeat drain/refill/test if water quality is unacceptable		Contractor	
Final Treatment of System				
	Add or begin chemical feed to system immediately after cleaning (SNL SCO to verify)		SNL	
	Add CS4015 to ChW or HW system		SNL	
	Initiate control of condenser treatment system via chemical treatment panel		SNL	

If system is drained for any reason, contact SNL Water Treatment Engineer for chemical addition immediately.

Exceptional service in the national interest

Sandia National Laboratories

Section 23 31 13 – Metal Ducts

February 2020

Release Date: 02/19/2020
Next Review Date: 02/19/2023

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 23 31 13 – Metal Ducts

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to new Master Spec style.
6/15/18	Tim Peterson	Admin	Removed addendum sentence under 2.1; updated the title and number of a spec; basic editing
1/15/2020	Tim Peterson	Subst	3-year review performed; sentence added to 2.1E, 2.3B; parts added to Section 3.4; removed parts of 3.9B

Section 23 31 13 – Metal Ducts

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. This specification, in conjunction with the contract documents and design drawings, provides the minimum requirements for materials and operations used in the fabrication and installation of ductwork. Systems covered by this document include heating, ventilating, air conditioning (HVAC) and exhaust for pressure classes from minus 10" to plus 10" water gauge (w.g.). Operations include the specification of ductwork materials, gauges, pressure classifications, construction, duct liners, filters, dampers, connectors, supports, testing, and certifications. This specification does not include ductwork requirements for materials handling systems. The materials, products, accessories, and methods listed in this specification shall be followed unless noted otherwise on the drawings.

B. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round and flat-oval ducts and fittings.
4. Double-wall round and flat-oval ducts and fittings.
5. Sheet metal materials.
6. Duct liner.
7. Sealants and gaskets.
8. Hangers and supports.
9. Seismic-restraint devices.

1.3 References

The current editions of the following standards are to be considered a part of this specification:

A. Sandia National Laboratories (SNL) Standard Specifications

Number	Title
Section 23 05 93	Testing, Adjusting, and Balancing for HVAC
Section 23 31 16	Nonmetal Ducts
Section 23 31 19	HVAC Casings
Section 23 33 00	Air Duct Accessories

B. The latest edition of the following codes and standards shall be used. Where differences between standards and this specification exist, this specification shall take precedence. Where standards allow for the use of alternate materials and methods, the contractor shall submit for approval a request to use alternate materials and methods before beginning work.

C. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

"HVAC Duct Construction Standards – Metal and Flexible"
"HVAC Duct Systems Design"
"Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems"
"Accepted Industry Practice for Industrial Duct Design"
"HVAC Systems – Testing, Adjusting and Balancing"
"Round Industrial Duct Construction Standards"
"Rectangular Industrial Duct Construction Standards"
"HVAC Air Duct Leakage Test Manual"
"IAQ Guidelines for Occupied Buildings Under Construction"

D. National Fire Protection Association (NFPA)

Number	Title
80	Standard for Fire Doors and Other Opening Protectives
90A	Standard for Installation of Air-Conditioning and Ventilation Systems
90B	Standard for Installation of Warm Air Heating and Air-Conditioning Systems
255	Building Materials, Test of Burning Characteristics Standard Method of Test of Surface Burning Characteristics of Building Materials (same as ASTM E84)

E. American Welding Society (AWS)

Number	Title
D9.1	Sheet Metal Welding Code

F. American Society of Heating, Refrigeration and Air-Conditioning Engineers

Number	Title
62.1	Ventilation for Acceptable Indoor Air Quality
90.1	Energy Standard for Buildings Except Low-Rise Residential Buildings

G. American Society for Testing and Materials (ASTM)

Number	Title
A36	Standard Specification for Carbon Structural Steel
A240	Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels
A480	Standard Specification for General Requirements for Flat Rolled Stainless Heat-Resisting Steel Plate, Sheet and Strip
A492	Standard Specification for Stainless Steel Rope Wire

Number	Title
A653	Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated by the Hot Dip Process
A1008	Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
B209	Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
C916	Standard Specification for Adhesives for Duct Thermal Insulation
C920	Standard Specification for Elastomeric Joint Sealants
C1071	Standard Specification for Fibrous Glass Duct Lining Insulation
C534	Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Pipe Loading
D3363	Standard Test Method for Film Hardness by Pencil Test
E84	Standard Test Method for Surface Burning Characteristics of Building Materials
E477	Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Material and Prefabricated Silencers
E488	Standard Test Methods for Strength of Anchors in Concrete Elements
E814	Standard Test Method for Fire Tests of Through-Penetration Fire Stops

H. American Welding Society (AWS)

Number	Title
B2.2	Brazing Procedures and Performance Qualifications
D9.1	Sheet Metal Welding Code

I. Underwriter's Laboratories (UL)

Number	Title
181	Factory Made Air Ducts and Air Connectors
555	Standard for Safety Fire Dampers
555S	Leakage Rated Dampers for Use in Smoke Control Systems
723	Test for Surface Burning Characteristics of Burning Materials (ASTM E84)
94VO	Flammability of Plastic Materials

J. American Society of Civil Engineers (ASCE/SEI 7)

- Minimum Design Loans for Buildings and Other Structures

K. California Department of Health Services

- Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers

L. International Code Council

- International Mechanical Code

M. North American Insulation Manufacturers Association (NAIMA)

- Fibrous Glass Duct Liner Standard

N. National Air Duct Cleaners Association (NADCA)

- The Standard for the Assessment, Cleaning and Restoration of HVAC Systems (ACR)

O. Code of Federal Regulations (CFR)

- Title 40, Part 59, Subpart D – National Volatile Organic Compound Emission Standards for Consumer and Commercial Products

1.4 Performance Requirements

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible." Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.5 Action Submittals

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Safety Data Sheets on sealants and adhesives.
4. Seismic-restraint devices.

B. Leadership in Energy and Environmental Design® (LEED) Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 – "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 – "HVAC System Construction and Insulation."
3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 – "Duct Leakage Tests."
4. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 – "Ventilation System Start-up."
5. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of volatile organic compound (VOC) content.
6. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the

California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

D. Delegated-Design Submittal when required on the Descriptive Submittal List or requested by the Sandia Delegated Representative (SDR):

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.

E. Design Calculations: Calculations for selecting hangers and supports.

F. Alternative Materials and Methods: Proposed deviations of materials and methods from these specifications require approved submittal information prior to any construction. Submittals should clearly note the submittals are for a change to the specifications and identify the applicable paragraph from this specification. Submittals shall include physical descriptions and results of testing and analysis to support the equal performance of the substituted items. Testing and analysis shall follow the guidelines for *Functional Criteria* from the SMACNA standards.

1.6 Informational Submittals

A. Coordination Drawings: When required on the Descriptive Submittal List, the contractor shall submit ¼" or ⅛" scale plan drawings, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.

6. Items penetrating finished ceiling, including the following:

   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.7 Quality Assurance

A. Employ qualified sheet metal workers in accordance with SMACNA *Duct Construction Standards*.

B. Asbestos Free: Insulating and sealing materials must be certified to be free of asbestos.

C. Brazing: Certify brazing procedures, braziers, and operators in accordance with AWS B2.2, *Brazing Procedures and Performance Qualifications*.

D. Welding Qualifications: Qualify procedures and personnel according to AWS D9.1M/D9.1, “Sheet Metal Welding Code,” for duct joint and seam welding.

E. Attachments such as conduit and pipe to ductwork are not permitted.

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 – “Systems and Equipment” and Section 7 – “Construction and System Start-up.”

G. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 – “HVAC System Construction and Insulation.”

1.8 Warranty

A. Ductwork system components furnished under this contract shall be guaranteed against defective design, materials, and workmanship for the full warranty period, which is standard with the manufacturer or supplier, but in no case less than one year from the date of system acceptance.

PART 2 - Products

2.1 Single-Wall Rectangular Ducts and Fittings

A. General Fabrication Requirements: Comply with SMACNA’s “HVAC Duct Construction Standards – Metal and Flexible” or SMACNA Rectangular Industrial Duct Construction Standards, except:

   1. Construct ducts using Pittsburgh Lock or Double Corner seams.

2. Cross-Breaking:
   a. Sheet metal ducts and fittings over 19" wide shall be beaded, cross-broken, or otherwise stiffened, to eliminate oil canning or vibration.
   b. Vertical and horizontal sheet metal barriers, duct offsets, and elbows 19" wide or larger shall be cross-broken.
   c. Cross-breaking shall be applied to the sheet metal between the standing seams or reinforcing angles. The center of cross-break shall be of the required height to assure surfaces being rigid.

B. Duct fabrication shall be based on indicated static-pressure class unless otherwise indicated.

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

E. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

1. Radius Elbows: Radius elbows with a rectangular cross section shall have a centerline radius of not less than the width of the duct or shall be furnished with single thickness splitter vanes. A single splitter vane shall be used for elbows with a ratio of inside radius to duct width of 0.5 to 0.2. Two splitter vanes shall be used for ratios less than 0.20.
2. Square Elbows: Square elbows shall be equipped with single thickness turning vanes, with a radius of 4.5", and a separation of 3.25", pre-assembled on runners constructed per SMACNA Accepted Industry Practice for Industrial Duct Design. Vanes shall be securely attached to the runners and properly aligned so the vanes remain tangent to the airstream. Vanes shall be welded to the runners in systems with pressures greater than 6" w.g. or velocities greater than 3000 fpm. The maximum unsupported length of vanes shall be 36".

2.2 Double-Wall Rectangular Ducts and Fittings

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

1. McGill AirFlow LLC.
2. Sheet Metal Connectors, Inc.

B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" based on indicated static-pressure class, unless otherwise indicated.

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x degrees F (0.039 W/m x K) at 75 degrees F (24 degrees C) mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

G. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.

1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x degrees F (0.034 W/m x K) at 75 degrees F (24 degrees C) mean temperature.

H. Inner Duct: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent.

I. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 2-1, "Rectangular Duct/Traverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

J. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

2.3 Single-Wall Round and Flat-Oval Ducts and Fittings

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

    a. Lindab Inc.
    b. McGill AirFlow LLC.
    c. SEMCO Incorporated.
    d. Sheet Metal Connectors, Inc.
    e. Spiral Manufacturing Co., Inc.

B. Round Ductwork: Spiral lockseam or longitudinal welded seam.

1. Minimum galvanized steel or stainless-steel gauges, hanger spacing, and reinforcement shall be per SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" for pressures from negative 4" w.g. up to positive 10" w.g. For pressures less than negative 4" w.g., or greater than positive 10" w.g., minimum galvanized steel or stainless-steel gauges, hanger spacing, and reinforcement shall be per SMACNA "Round Industrial Duct Construction Standards."
2. Fittings: Fittings shall have a wall thickness not less than that required for longitudinal-seam straight duct.
3. Elbows:

    a. Elbows for round ducts shall have a minimum centerline radius of 1-½ times the diameter of the duct and shall be constructed without splitters.
    b. Smooth or stamped elbows shall be used whenever possible.
    c. When gored elbows are used, they shall be constructed as follows: Elbows up to 36° shall have two gores, 37° through 72° shall have three gores, and 73° through 90° shall have five gores. The gores shall be tack welded and coated with sealer.
    d. Four gore adjustable elbows are permitted for systems rated at 1" w.g. or less. The gores shall be tack welded and coated with sealer.

C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension). Ductwork and fitting spiral lockseam or welded with gauges, reinforcement, and supports conforming to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible": Positive pressure applications only, up to 10" w.g. For negative pressure applications, submit special design and reinforcement requirements.

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 inches (1524 mm) in Diameter: Flanged.

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

F. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

2.4 Double-Wall Round and Flat-Oval Ducts and Fittings

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

1. Lindab Inc.
2. McGill AirFlow LLC.
3. SEMCO Incorporated.
4. Sheet Metal Connectors, Inc.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class, unless otherwise indicated.

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

   a. Transverse Joints in Ducts Larger Than 60 inches (1524 mm) in Diameter: Flanged.

2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

   a. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
   b. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing

requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

D. Inner Duct: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent.

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x degrees F (0.039 W/m x K) at 75 degrees F (24 degrees C) mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

F. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.

1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x degrees F (0.034 W/m x K) at 75 degrees F (24 degrees C) mean temperature.

2.5 Sheet Metal Materials

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, blistering, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90 (Z275) zinc coating (0.90 oz/sq. ft. both sides).
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60 (Z180) zinc coating (0.60 oz/sq. ft. both sides).
2. Minimum Thickness for Factory-Applied PVC Coating: 4-mil PVC coating on exposed surfaces (exterior of duct for underground applications and interior of ducts and fittings for fume handling) and 2-mil coating on opposing sides of ductwork. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by a nationally recognized testing laboratory (NRTL) for compliance with UL 181, Class 1.

D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" article. Surface finish in concealed locations shall be No. 2B. Stainless steel ductwork shall be of the spiral lockseam type with factory fabricated fittings.

F. Stainless Steel (Teflon®) Coated Ductwork: Base metal shall be AISI 300 series stainless steel, constructed to a duct gauge and reinforcing system in accordance with SMACNA's "Round Industrial Duct Construction Standards" with a Class 1, -6" w.g. schedule. Longitudinal seams shall be fusion welded. Transverse seams shall be butt welded; no dissimilar filler materials allowed. The coating shall be a Teflon fluoropolymer barrier thermoplastic resin with an average thickness not to exceed 12 mils. Acceptable manufacturer is PermaShield Pipe® or equivalent.

G. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

H. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the Environmental Protection Agency (EPA) for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: black

I. Supports: Angle iron, channels, saddles, band straps, rods, and related supporting materials shall be galvanized or red oxide coated.

J. Fasteners: Use galvanized rivets, screws, and bolts throughout, except use stainless steel fasteners on stainless steel ductwork.

K. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or Ethylene Propylene Diene Terpolymer (EPDM) gasket materials.

L. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.6 Duct Liner

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

   a. CertainTeed Corporation; Insulation Group.
   b. Johns Manville.
   c. Knauf Insulation.
   d. Owens Corning.

2. Surface burning characteristics: Liners shall have a maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84.

3. Maximum Thermal Conductivity:

    1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x degrees F (0.039 W/m x K) at 75 degrees F (24 degrees C) mean temperature.
    2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x degrees F (0.033 W/m x K) at 75 degrees F (24 degrees C) mean temperature.

4. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
5. Non-oxidizing, vinyl acrylic, Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

    a. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
    c. Operational temperature ranges from -20 degrees to +160 degrees F; curing time 24 hours. Manufactured by United McGill, type Uni-Tack.

B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

    a. Aeroflex USA Inc.
    b. Armacell LLC.
    c. Rubatex International, LLC

2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

    a. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Mechanical Fasteners: Galvanized steel, suitable for adhesive, mechanical or welding attachment (self-stick, adhesive fasteners are not permitted). Provide fasteners that will not damage the liner when applied as recommended by the manufacturer, that do not cause leakage within the duct, and that will sustain a 50-pound tensile dead load perpendicular to duct wall.

D. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s) or greater.
7. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm (12.7 m/s) or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

   a. Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.7 Sealant and Gaskets

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Fire Stopping: Seal ductwork penetrations to halt the spread of fire, water, and smoke through firewalls and floors and as indicated on contract drawings with fire-resistant sealant. Maximum allowable flame spread, as tested by ASTM E814, is 25 with a smoke-developed rating no higher than 50.

C. Self-adhering vinyl coated fabric duct tape is not permitted, except to temporarily seal the duct openings for contamination prevention.

D. Outdoor Ducts (without exterior insulation):

1. Polymeric rubber, resins, and reinforcing materials dispersed in solvent: 24-hour cure time, ultraviolet (UV) resistant, operational temperature range of -20 degrees F to +150 degrees F, manufactured by United McGill, type Uni-Weather or approved equal.

E. Indoor Ducts and Outdoor Ducts with Exterior Insulation:

1. Ductwork: Water based, vinyl acrylic polymeric sealant, nonflammable, fire retardant, operational temperature range of -25 degrees F to +200 degrees F, 48-hour cure time. Manufactured by Ductmate®, type Pro-Seal® or approved equal.
2. Pressurized Ductwork: Ductwork that is to be sealed while under pressure shall be sealed with water-based mastics with fiberglass reinforcing and with short curing times. Manufactured by Versa Grip, type 102 (Hard Cast) or approved equal.

F. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

G. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

H. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch w.g. (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch w.g. (2500-Pa) static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.8 Hangers and Supports

A. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

B. Strap and Rod Sizes and spacing: Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

1. Straps and angles shall be manufactured from galvanized steel; rods shall be manufactured from uncoated or galvanized steel.
2. Perforated iron band for duct support is prohibited.
3. Wire for duct support is prohibited.
4. Round duct hangers shall use strap bands that conform to the duct in a manner that does not cause deformation to the duct. Trapeze hangers are not acceptable for round ducts.
5. Round duct shall be supported with duct saddles to cradle the duct and prevent deformation to the duct.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.9 Seismic-Restraint Devices

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Ductmate Industries, Inc.
3. Hilti Corp.
4. Kinetics Noise Control.
5. Loos & Co.; Cableware Division.
6. Mason Industries.
7. TOLCO; a brand of NIBCO INC.
8. Unistrut Corporation; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - Execution

3.1 Duct Installation

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," SMACNA's "Round Industrial Duct Construction Standards," or SMACNA's "Rectangular Industrial Duct Construction Standards" (as per Part 2, *Products*) and this specification.

C. Install round and flat-oval ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Ductwork installation shall not proceed until representatives from the other contracting trades have been consulted to ensure there are no layout or installation conflicts, unless otherwise directed by the SDR.

N. Structural conditions of the building may indicate that modifications to the ductwork are necessary. Dimensions on drawings indicate free inside area. Actual duct dimensions may need to be altered for insulation allowance when required. Ducts shall be transitioned or divided as may be required; whenever this is necessary, the equivalent area shall be maintained. Such corrections shall be approved and directed by the SDR before modifications are started.

O. Exit passageways, stairs, ramps, and other exits shall not be used as a part of the air return, supply, or exhaust.

P. Installation and workmanship shall be such that the system is free from buckling, warping, breathing (oil canning), and vibration. Installation must conform to the requirements set forth in NFPA 90A and 90B.

3.2 Installation of Flexible Ducts

A. Provide flexible duct in fully extended condition, free from kinks, and free from compression.

B. Use only the minimum length required to make the connection.

C. Do not exceed 5'-0" in length, fully extended.

D. Where horizontal support is required, hanger or saddle material shall be wide enough so it does not reduce the internal diameter of the duct and shall be a minimum 1" wide banding material hangers at not more than 2'-6" centers. Maximum allowable sag ½" per foot of support spacing. Flexible duct shall extend straight for several inches from a connection before bending.

E. Make joints and connections with ½" wide positive locking steel, nylon, or plenum-rated draw bands. Connections shall be per SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

F. Use insulated flex where insulated duct is required.

3.3 Installation of Metal Ductwork

A. Install with a minimum of 4" separation from earth to the duct or insulation finish.

B. Securely fasten at each change in direction.

C. Install branch connections and couplings tight to the duct wall surface to minimize projection into the duct. Secure with sheet metal screws at intervals of 12" with a minimum of three screws in each connection.

3.4 Installation of Underground Ducts

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

1. Blue Duct
2. Black Max

B. For installation of underground ducts, refer to design. Design shall be reviewed and approved by Sandia National Laboratories (SNL) engineer.

C. Use High Density Polyethylene (HDPE) for underground ducts and install in accordance with the manufacturer's requirements.

D. Duct and fittings shall conform to the International Code Council (ICC) International Mechanical Code for underground plastic duct systems.

E. Duct and fittings must meet the external loading properties of ASTM D2412.

3.5 Installation of Exposed Ductwork

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that do not comply with these requirements.

3.6 Duct Sealing

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" article according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-inch w.g. (500 Pa) and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-inch w.g. (500 Pa): Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.

9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-inch w.g. (500 Pa) and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-inch w.g. (500 Pa): Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.7 Duct Liners

A. Install duct liners at locations as shown on the drawings and in accordance with North American Insulation Manufacturers Association (NAIMA) Fibrous Glass Duct Liner Standard. Apply with a single layer of indicated thickness.

B. Do not install liners within 24" of evaporative cooling equipment, across fire dampers, or within 3' downstream of duct humidifiers.

C. Apply adhesive coating to all exposed edges of liner that do not receive nosing treatment.

D. Metal nosing shall be installed over exposed liner edges that face upstream of the airflow.

3.8 Duct Penetrations

A. Ducts through masonry openings and along edges of all plenums at floors and walls shall be provided with a continuous 2" x 2" x ⅛" galvanized angle iron, which shall be bolted to the construction and made airtight to the same by applying silicone caulking compound. Sheet metal at these locations shall be bolted to the angle irons.

B. Ducts through drywall or plaster walls and ceilings shall be finished with a 22-gauge galvanized steel flange neatly installed.

3.9 Hanger and Support Installation

A. Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, or structural-steel fasteners appropriate for construction materials to which hangers are being attached. Where practical, install concrete inserts before placing concrete.

C. Exterior Ducts: Unless detailed otherwise on the drawings, exterior ducts supported on roofs shall be supported with structural steel angle or channel sized per SMACNA standards for trapeze hangers and supported with pipe or angle columns.

1. Hangers shall be spaced a minimum of 5' on center.
2. The minimum size of the trapeze hanger shall be supported with 1-½" x 1-½" x 3/16" angle or C3 X 4.1 lb. channel sized.
3. Minimum column supports shall be 2" diameter standard weight pipe and coordinated with roofing penetration requirements.
4. Round duct shall be supported with duct saddles to cradle the duct and prevent deformation to the duct.

D. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

E. Hangers Exposed to View: Threaded rod and angle or channel supports.

F. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at maximum intervals of 16 feet (5 m).

G. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.10 Seismic-Restraint-Device Installation

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet (12 m) on center (o.c.), and longitudinal supports a maximum of 80 feet (24 m) o.c.
2. Brace a change of direction longer than 12 feet (3.7 m).

B. Select seismic-restraint devices with capacities adequate to carry present static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and setting anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the SDR if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors.

3.11 Connections

A. Make connections to equipment with flexible connectors complying with Section 23 33 00 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.12 Field Quality Control

A. Perform tests and inspections.

1. The contractor shall be responsible for providing a joint and cooperative effort to coordinate the test and balance.
2. Inspection: The contractor shall ensure filters, dampers, louvers, gauges, electrical components, and other accessories referenced in this document are installed correctly and system is operating in compliance with requirements prior to startup and request for final inspection. After all deficiencies are corrected, then Test and Balance can be performed.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. The leakage test shall meet the leakage classification (C_L) of 6 or less using the following equation. $C_L = F/P^{0.65}$.
3. Test the following systems:
   a. Ducts with a Pressure Class Higher Than 3-inch w.g. (750 Pa): Test representative duct sections**,** selected by the SDR from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
   b. Laboratory Exhaust Ducts: Test representative duct sections, selected by the SDR from sections installed, totaling no less than 100 percent of total installed duct area for each designated pressure class.
   c. Ductwork specified for leak testing on the contract documents shall be tested for leaks.
   d. Ductwork systems that contain less than 500 sq. ft. of sheet metal shall not be leak tested, unless indicated on the contract documents.
   e. Testing is not required for other ductwork rated 0 to 3″ w.g.
4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give **seven** days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

2. Test sections of metal duct system, chosen randomly by the SDR, for cleanliness according to “Vacuum Test” in National Air Duct Cleaners Association (NADCA) ACR, “Assessment, Cleaning and Restoration of HVAC Systems.”

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.13 Duct Cleaning

A. Ductwork shall be cleaned as it is being installed, to remove oil, film, and dust, allowing sealants, such as silicone caulk, to cure before duct is cleaned and sealed.

B. Clean new duct system(s) before testing, adjusting, and balancing.

C. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 23 33 00 “Air Duct Accessories” for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

D. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use high-efficiency particulate air (HEPA) filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

E. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

F. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents, as approved by SNL, if fungus is present. Apply antimicrobial agents according to manufacturer’s written instructions after removal of surface deposits and debris.

3.14 Start Up

A. Air Balance: Comply with requirements in Section 23 05 93, “Testing, Adjusting, and Balancing for HVAC.”

END OF SECTION 23 31 13

Section 23 33 00 – Air Duct Accessories

June 2020

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 23 33 00 – Air Duct Accessories

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Reformatted to new Master Spec style.
5/27/20	Gabe Martinez	Subst	Added specification references; placed other references into table and provided updated references; added ASHRAE and AMCA; changes and updates to Sections 2.3–2.9; removed duct silencer section; changes to manufacturers in 2.10–2.13; added duct

			sizing table to 2.14; changes, deletions, and additions to 2.15–3.1

Section 23 33 00 – Air Duct Accessories

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Ceiling radiation dampers.
7. Smoke dampers.
8. Combination fire and smoke dampers.
9. Corridor dampers.
10. Flange connectors.
11. Duct silencers.
12. Turning vanes.
13. Remote damper operators.
14. Duct-mounted access doors.
15. Flexible connectors.
16. Flexible ducts.
17. Duct security bars.
18. Duct accessory hardware.

B. Related Requirements:

1. Section 28 31 11, "Digital, Addressable Fire-Alarm System" for duct-mounted fire and smoke detectors.
2. Section 23 05 53, "Identification for HVAC Piping and Equipment"

1.3 References

A. The latest edition of the following codes and standards shall be used. Where differences between standards and this specification exist, this specification shall take precedence. Where standards allow for the use of alternate materials and methods, the contractor shall submit for approval a request to use alternate materials and methods before beginning work.

B. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

Number	Title
006-2006	HVAC Duct Construction Standards–Metal and Flexible
	HVAC Systems Duct Design
	Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
	Accepted Industry Practice for Industrial Duct Design
005-2003	HVAC Systems–Testing, Adjusting and Balancing
1520	Round Industrial Duct Construction Standards
002-2011	Rectangular Industrial Duct Construction Standards
016-2012	HVAC Air Duct Leakage Test Manual

C. National Fire Protection Association (NFPA)

Number	Title
80	Standard for Fire Doors and Windows
90A	Standard for Installation of Air-Conditioning and Ventilation Systems
90B	Standard for Installation of Warm Air Heating and Air-Conditioning Systems
96	Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
255	Building Materials, Test of Burning Characteristics Standard Method of Test of Surface Burning Characteristics of Building Materials (Same as ASTM E84)

D. American Society for Testing and Materials (ASTM)

Number	Title
A209	Standard Specification for Seamless Carbon-Molybdenum Alloy-Steel Boiler and Superheated Tubes
A240	Standard Specification for Heat–Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels
A480	Standard Specification for General Requirements for Flat Rolled Stainless Heat-Resisting Steel Plate, Sheet and Strip
A653	Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated by the Hot Dip Process
B221	Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
C916	Standard Specification for Adhesives for Duct Thermal Insulation
C1071	Standard Specification for Fibrous Glass Duct Lining Insulation
E84	Standard Test Method for Surface Burning Characteristics of Building Materials
E477	Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Material and Prefabricated Silencers

Number	Title
E814	Standard Test Method for Fire Tests of Through Penetration Fire Stops

E. American Welding Society (AWS)

Number	Title
B2.2	Brazing Procedures and Performance Qualificatioins
D9.1	Sheet Metal Welding Code

F. Underwriter's Laboratories (UL)

Number	Title
181	Factory Made Air Ducts and Air Connectors
555	Standard for Safety Fire Dampers
555S	Leakage Rated Dampers for Use in Smoke Control Systems
723	Test for Surface Burning Characteristics of Burning Materials (ASTM E84)
94VO	Flammability of Plastic Materials

G. North American Insulation Manufacturers Association (NAIMA)

Number	Title
AH116	Fibrous Glass Duct Construction Standard
AH124	Fibrous Glass Duct Liner Standard
90A	Standard for Installation of Air-Conditioning and Ventilation Systems
90B	Standard for Installation of Warm Air Heating and Air-Conditioning Systems
96	Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
255	Building Materials, Test of Burning Characteristics Standard Method of Test of Surface Burning Characteristics of Building Materials (Same as ASTM E84)

H. Air Movement and Control Association International (AMCA)

Number	Title
500-D	Laboratory Methods of Testing Dampers for Rating
90A	Standard for Installation of Air-Conditioning and Ventilation Systems
90B	Standard for Installation of Warm Air Heating and Air-Conditioning Systems
96	Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
255	Building Materials, Test of Burning Characteristics Standard Method of Test of Surface Burning Characteristics of Building Materials (Same as ASTM E84)

I. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)

Number	Title
62.1	Ventilation for Acceptable Indoor Air Quality
90.1	Energy Standard for Buildings Except Low-Rise Residential Buildings

1.4 Action Submittals

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Leadership in Energy and Environmental Design (LEED) Submittals:

1. Product Data for Prerequisite Indoor Environmental Quality (IEQ) 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 – "Systems and Equipment."
2. Product Data for Prerequisite Energy and Atmosphere (EA) 2: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/Illuminating Engineering Society of North America (IESNA) 90.1, Section 6 – "Heating, Ventilating, and Air Conditioning."

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances, as well as method of field assembly into duct systems and other construction. Include the following:

   a. Special fittings.
   b. Manual volume damper installations.
   c. Control-damper installations.
   d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
   e. Duct security bars.
   f. Wiring Diagrams: For power, signal, and control wiring.

1.5 Informational Submittals

A. Coordination Drawings: When required on the Descriptive Submittal List, the contractor shall submit ¼" or ⅛" scale plan drawings, showing the reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

1.6 Closeout Submittals

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

PART 2 - Products

2.1 Assembly Description

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with the Sheet Metal and Air Conditioning Contractor’s National Association’s (SMACNA's) "HVAC Duct Construction Standards – Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 Materials

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60 (Z180).
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a **No. 2** finish for concealed ducts and 2B finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221 (ASTM B 221M), Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 Dampers

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Pottorff.
4. Ruskin Company.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 1000 fpm (5.1 m/s).

D. Maximum System Pressure: 1-inch wg (0.25 kPa).

E. Frame: Hat-shaped, 0.06-inch (16 ga.; 1.5-mm) thick, galvanized sheet steel thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, end pivoted, maximum 6-inch (150-mm) width, 0.025-inch (0.6-mm) thick, roll-formed aluminum with sealed edges. Blades shall be positively locked to the shafts.

1. Blade Action: Parallel.
2. Blade Seals: Neoprene, mechanically locked.
3. Blade Axles:

   a. Material: Stainless steel.
   b. Diameter: 0.20 inch (5 mm).

G. Tie Bars and Brackets: Galvanized steel.

H. Return Spring: Adjustable tension.

I. Bearings: Steel ball or synthetic pivot bushings.

1. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

J. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Chain pulls.
4. Screen Mounting: Front mounted in sleeve.

   a. Sleeve Thickness: 20 gauge (1.0 mm) minimum.
   b. Sleeve Length: 6 inches (152 mm) minimum.
   c. Screen Mounting: Rear mounted.
   d. Material: Galvanized or Stainless Steel.
   e. Type: Bird.

5. 90-degree stops.

K. Dampers shall have an external locking manual quadrant. On duct systems with external insulation, the quadrant shall be installed with a 2″ standoff bracket to clear the insulation. The quadrant shall have a wing nut for locking the damper in place and a scale for indicating the position of the damper. (A handle attached directly to the damper shaft is not acceptable.)

L. The end of the shaft shall be permanently marked to indicate blade position.

M. Dampers shall be of the same material as the duct material.

N. Round dampers up to 24" shall be single blade butterfly type. Frames shall include rolled stiffener beads to allow easy sealing of spiral ductwork joints.

2.4 Barometric Relief Dampers

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Pottorff.
4. Ruskin Company.

B. Suitable for horizontal or vertical mounting.

C. Maximum Air Velocity: 1000 fpm (5.1 m/s).

D. Maximum System Pressure: 2-inch wg (0.5 kPa).

E. Frame: Hat-shaped, 0.06-inch (16 ga.; 1.5-mm) thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.

F. Blades:

1. Multiple, 0.025-inch (0.6-mm) thick, roll-formed aluminum.
2. Maximum Width: 6 inches (150 mm).
3. Action: Parallel.
4. Balance: Gravity.
5. End pivoted.

G. Blade Seals: Neoprene.

H. Blade Axles: Stainless steel.

I. Tie Bars and Brackets:

1. Material: Galvanized steel.
2. Rattle free with 90-degree stop.

J. Return Spring: Adjustable tension.

K. Bearings: Stainless steel, oil-impregnated bronze, or molded synthetic.

L. Accessories:

1. Flange on intake.
2. Adjustment device to permit setting for varying differential static pressures.

2.5 Manual Volume Dampers

A. Standard, Steel, Manual Volume Dampers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:

a. McGill AirFlow LLC.
b. Nailor Industries Inc.
c. Pottorff.
d. Ruskin Company.

or

2. Contractor fabricated per SMACNA "Duct Construction Standards Metal and Flexible" section for Volume Dampers with the following exceptions:

    a. Dampers shall be prefabricated in a frame to attach to the duct. The frame for rectangular dampers shall be minimum 16-gauge galvanized steel, structural hat channel with reinforced corners.
    b. Round dampers up to 24" shall be single blade butterfly type. Frames shall include rolled stiffener beads to allow easy sealing of spiral ductwork joints.

3. Standard leakage rating, with linkage outside airstream.
4. Suitable for horizontal or vertical applications.
5. Frames:

    a. Frame: Hat-shaped, 0.06-inch (16 ga.; 1.5-mm) thick, galvanized sheet steel.
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.

6. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized-steel or stainless-steel to match duct system material, 0.064 inch (1.62 mm) thick.

7. Blade Axles: Galvanized steel or stainless-steel to match duct system material.
8. Bearings: Sleeve type. Pressed into frame. Stainless steel, oil-impregnated bronze, or molded synthetic.
9. Tie Bars and Brackets: Galvanized steel.

B. Low-Leakage, Steel, Manual Volume Dampers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:

    a. McGill AirFlow LLC.
    b. Nailor Industries Inc.
    c. Pottorff.
    d. Ruskin Company.

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

4. Suitable for horizontal or vertical applications.
5. Frames:

    a. Hat shaped.
    b. 0.10-inch- (12 ga.; 2.7-mm-) thick, galvanized sheet steel.
    c. Mitered and welded corners.
    d. Flanges for attaching to walls and flangeless frames for installing in ducts.

6. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized, roll-formed steel, or stainless steel 0.- inch (1.62 mm) thick.

7. Blade Axles: Stainless steel or galvanized-steel to match duct system material.
8. Bearings:

    a. Stainless steel, oil-impregnated bronze, or molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals: Neoprene.
10. Jamb Seals: Cambered stainless steel.
11. Tie Bars and Brackets: Galvanized steel.
12. Accessories:

    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

C. Manual Balancing Dampers (Lab Exhaust Systems):

Dampers shall be factory fabricated—either butterfly or blast gate type—and rated for up to 3000 fpm velocity and 4" wg. For pressures greater than negative 4" wg, dampers shall be constructed per SMACNA Round Industrial Duct Construction Standards.

1. Bearings shall be sleeve type stainless steel, oil-impregnated bronze, or molded synthetic, pressed into the frame.
2. All butterfly dampers shall have an external locking manual quadrant. On duct systems with external insulation, the quadrant shall be installed with a 2″ standoff bracket to clear the insulation. The quadrant shall have a wing nut for locking the damper in place and a scale for indicating the position of the damper. (A handle attached directly to the damper shaft is not acceptable.)
3. Blast gate dampers shall have a bolt to lock the blade in position.
4. Continuous through shafts of ½" diameter and welded or bolted to the blades.

D. Jackshaft:

1. Size: 0.5-inch (13-mm) diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

E. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.6 Control Dampers

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:

1. McGill AirFlow LLC.
2. Nailor Industries Inc.
3. Pottorff.
4. Ruskin Company.

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:

1. Hat shaped.
2. 0.05-inch- (18 ga.; 1.3-mm-) thick stainless steel.
3. Mitered and welded corners.

D. Blades:

1. Multiple blade with maximum blade width of 6 inches (152 mm).
2. Opposed-blade design unless indicated otherwise on the drawings.
3. Aluminum.
4. 0.064 inch (14 ga.; 1.62 mm) thick single skin.
5. Blade Edging: Edge seals shall be replaceable and of vinyl, silicone rubber, neoprene, or other synthetic elastomer.

E. Blade Axles: 1/2-inch- (13-mm-) diameter; nonferrous metal; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 degrees F (minus 40 to plus 93 degrees C).

F. Bearings:

1. Stainless steel, oil-impregnated bronze, or molded synthetic.
2. Thrust bearings at each end of every blade.

G. Each damper section shall have an individual motor, derated so there is 10 percent over-capacity available over published rating for dust and corrosion buildup, and shall be additionally sized to operate against the total static pressure of the system

2.7 Fire Dampers

A. Basis-of-Design Product: Subject to compliance with requirements. Provided product shall be from Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 by a nationally recognized testing laboratory (NRTL). Do not use curtain-type dampers.

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 2375-fpm (12-m/s) velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Round type with blades outside airstream; fabricated with roll-formed, 0.034-inch- (0.85-mm) thick galvanized steel.

F. Mounting Sleeve: Factory or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.05 (1.3 mm) thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.024-inch (0.61-mm) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch (0.85-mm) thick, galvanized steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

1. Heat-Responsive Device: Shall have an electric resettable link.

2.8 Combination Fire and Smoke Dampers

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Pottorff.
6. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL. Each damper shall bear a UL stamp, be marked with the UL hour classification, flow direction, and maximum pressure and velocity and be "for use in dynamic systems."

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 2375-fpm (12-m/s) velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel, with welded corners and mounting flange.

F. Heat-Responsive Device: Shall have an electric resettable link.

G. Smoke Detector: Integral, factory wired for single-point connection.

H. Blades: Single piece airfoil damper blades for rectangular dampers.

I. Leakage: Class I.

J. Rated pressure and velocity to exceed design airflow conditions.

K. Mounting Sleeve: Factory-installed, 0.039-inch (1.0-mm) thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

L. Damper Motors: Two-position action.

M. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

N. Motor Types:
   1. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
   2. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
   3. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 degrees F (minus 40 degrees C).
   4. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).

O. Electrical Connection: 115 V, single phase, 60 Hz.

P. Accessories:

   1. Auxiliary switches for signaling fan control or position indication.
   2. Momentary test switch test and reset switches, damper remote mounted.

2.9 Flange Connectors

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:

1. Ductmate Industries, Inc.
2. Nexus PDQ; Division of Shilco Holdings Inc.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gauge and Shape: Match connecting ductwork.

2.10 Turning Vanes

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Elgen Manufacturing.
4. METALAIRE, Inc.
5. SEMCO Incorporated.
6. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: Single wall only.

F. Single thickness turning vanes shall have a radius of 4.5", and a separation of 3.25", pre-assembled on runners constructed per SMACNA, "Accepted Industry Practice for Industrial Duct Design." Vanes shall be securely attached to the runners. Vanes shall be welded to the runners in systems with pressures greater than 6" wg or velocities greater than 3000 fpm. The maximum unsupported length of vanes shall be 36".

2.11 Duct-Mounted Access Doors

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:

1. Flexmaster U.S.A., Inc.
2. Greenheck Fan Corporation.
3. McGill AirFlow LLC.
4. Nailor Industries Inc.
5. Pottorff.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Doors with observation windows shall be constructed with tempered or tempered wire glass.
   d. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
   e. Fabricate doors airtight and leak tested to perform with minimal air leakage.
   f. Pressure: Doors shall have a minimum pressure rating of 6 in. wg (1493 Pa).

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

   a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches (460 mm)] Square: Two hinges or continuous and two sash locks.
   c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges or continuous and two compression latches.
   d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges or continuous and two compression latches with outside and inside handles.

4. Access doors shall be provided adjacent to each fire damper, smoke damper, smoke detector, and control device and for any additional locations shown on the drawings. The opening size shall be large enough to permit maintenance and resetting of the device in a safe manner.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Pressure: Doors shall have a minimum pressure rating of 6 in. wg (1493 Pa).
4. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.

5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.12 Duct Access Panel Assemblies

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:

1. Ductmate Industries, Inc.
2. Flame Gard, Inc.
3. 3M.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch (1.3-mm) carbon or 0.0428-inch (1.1-mm) stainless steel.

D. Fasteners: Carbon or Stainless steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 degrees F (1093 degrees C).

F. Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.

2.13 Flexible Connectors

A. Provide flexible connections, constructed of approved fireproof, waterproof, non-asbestos, glass fabric, at the inlet and outlet connection of each fan unit, securely fastened to the unit and to the ductwork by a galvanized iron band provided with tightening screws. There shall be no metal-to-metal contact at flexible connections. There shall be no stretching of the flexible material at flexible connections.

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Elgen Manufacturing.
4. Ventfabrics, Inc.
5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

C. Materials: Flame-retardant or noncombustible fabrics.

D. Coatings and Adhesives: Comply with UL 181, Class 1.

E. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches (146 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 30 oz./sq. yd. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3. Service Temperature: Minus 40 to plus 200 degrees F (Minus 40 to plus 93 degrees C).

G. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to ultraviolet (UV) rays and ozone.

1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
3. Service Temperature: Minus 50 to plus 250 degrees F (Minus 45 to plus 121 degrees C).
4. Provide metal sun shield over exposed flex connectors. Sun shields shall be mounted to only side of the flexible connection.

H. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 degrees F (Minus 55 to plus 260 degrees C).

I. Laboratory/Chemical Exhaust System, Flexible Connectors: Teflon coated glass fabric.

1. Minimum Weight: 16 oz./sq. yd. (474 g/sq. m).
2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 degrees F (Minus 55 to plus 260 degrees C).

J. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

2.14 Flexible Ducts

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:

1. Flexmaster U.S.A., Inc.
2. Thermaflex
3. Novaflex
4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Noninsulated, Flexible Duct – Lab Exhaust Systems: Factory-fabricated assembly of neoprene-coated polyester with galvanized steel helix reinforcement. Pressure Rating: 10-inch wg (12KPa) positive or 10-inch wg (4 KPa) negative.

1. Maximum Air Velocity: 5500 fpm (25 m/s).
2. Temperature Range: Minus 20 to plus 250 degrees F (Minus 28 to plus 120 degrees C).
3. Flexible duct shall be a UL94V0 approved material. Novaflex Model U-LOK 200 or equal.

C. Insulated, Flexible Duct (Low Pressure): UL 181, Class 1, laminated inner liner of aluminum foil, fiberglass, and polyester supported by a galvanized steel helix coil formed to the inner liner, a fiberglass insulation blanket, and a polyethylene outer jacket.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 5.0-inch wg (1250 Pa) negative through 16″ diameter.
2. Maximum Air Velocity: 5500 fpm (20 m/s).
3. Temperature Range: Minus 20 to plus 250 degrees F (Minus 29 to plus 99 degrees C).
4. Insulation R-value: Maximum thermal conductance of 0.16 British thermal units (BTU)/Hour (Hr.) ft.^{2} degrees F (R-6.0).
5. Flexible duct shall have a flame-resistant rating of 25 or less and a smoke developed rating of 50 or less.
6. Flexmaster Type 5 or equal.

D. Insulated, Flexible Duct (High Pressure): UL 181, Class 1, laminated inner liner of aluminum foil, fiberglass, and polyester supported by a galvanized steel helix coil formed to the inner liner, a fiberglass insulation blanket, and a polyethylene outer jacket.

1. Pressure Rating: 20-inch wg (5000 Pa) positive and 5.0-inch wg (1250 Pa) negative through 16″ diameter.
2. Maximum Air Velocity: 5500 fpm (20 m/s).
3. Temperature Range: Minus 20 to plus 250 degrees F (Minus 29 to plus 99 degrees C).
4. Insulation R-value: Maximum thermal conductance of 0.16 British thermal unit BTU/Hr. ft.^{2} degrees F (R-6.0).
5. Flexible duct shall have a flame-resistant rating of 25 or less and a smoke developed rating of 50 or less.
6. Flexmaster Type 3 or equal.

E. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.

F. Flex Duct Sizing Table:

G.

Duct Size	Design Airflow (cfm)
5″	50
6″	75
7″	110
8″	160
9″	225
10″	300
12″	480
14″	700
16″	1000
18″	1300
20″	1700

2.15 Duct Security Bars

A. Basis-of-Design Product: Subject to compliance with requirements, provide as indicated on drawings or comparable product.

B. Description: Field- or factory-fabricated and field-installed duct security bars.

C. Configuration: Refer to the Sandia National Laboratories standard drawing.

D. Provide minimum 12x12 lockable access door in the duct on the secure side of the boundary. For additional information, refer to the “Duct-Mounted Access Doors” section of this spec.

2.16 Duct Testing & Instrumentation Ports

A. Instrument Test Holes: Stainless steel or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

1. Factory-fabricated duct and fittings with predetermined location of test holes for monitors should be utilized.

2.17 Louvers

A. Construction: Louvers shall have the maximum free area (minimum 50% of nominal size) and minimum pressure drop for each type as listed on the drawing louver schedule and shall be manufactured from 6063-T6 aluminum, or 18 gauge galvanized steel and finished with Kynar®. Slats shall be inclined at least 45 degrees from the horizontal, overlap a minimum of 1" Slats over 48", and shall have intermediate supports. An integral rain channel shall be formed with the slats. Louvers shall include a ½–¾" mesh galvanized steel or aluminum bird screen. Louvers shall be compatible with the adjacent substrate. Louver performance shall be certified in accordance with the AMCA 511 Certified Ratings Program, shall have a weather rating of at least AMCA 500-L Water Penetration, and shall be licensed to bear the AMCA seal. Selection shall be from Greenheck ESD, ESJ, EVH, EHH series.

PART 3 - Execution

3.1 Installation

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft or control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install fire and combination fire/smoke dampers according to UL listing.

G. Install duct security bars as detailed on the drawings.

H. Connect ducts to duct silencers rigidly.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. At outdoor-air intakes and mixed-air plenums.

3. At drain pans and seals.
4. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall links.
5. At security bar locations (on the secure side of the penetration)
6. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. Access Doors: Provide in locations indicated on drawings and as required to properly and easily service, maintain, and inspect duct coils, fire dampers, and other equipment.

L. Label access doors to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. Connect terminal units to supply ducts directly or with maximum 12-inch (300-mm) lengths of flexible duct. Do not use flexible ducts to change directions.

O. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.

P. Connect flexible ducts to metal ducts with ½" wide positive locking steel, nylon, or plenum rated straps. Connections shall be per SMACNA “Duct Construction Standards.”

Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

3.2 Field Quality Control

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Verify dampers are properly sealed when fully closed.

END OF SECTION 23 33 00

SPECIAL
SPECIFICATION 250523S
AUTOMATED FLOW CONTROL
MOLTEN SALT VALVES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes requirements for providing high temperature molten salt globe valves with automated positioners.

1.2 DEFINITIONS / RESPONSIBILITIES

A. This section contains the following definitions and responsibilities:

1. SNL – Sandia National Laboratories

2. Supplier – Valve Manufacturer

1.3 SCOPE OF WORK

A. The Valve Manufacturer(s) (here after referred as Supplier) for this project will provide ball valves and globe valves and associated actuators. The Supplier shall be responsible for manufacturing the valves per this specification; testing and certification of valves, shipping of valves to Sandia National Laboratories in Albuquerque, New Mexico. The chloride salt fluid mixture the valves will be exposed to has a molar mass of 40 MgCl / 20 NaCl / 40KCl.

B. The Supplier may provide a “No Bid” for any particular valve above if the Supplier is unable to meet the specifications for a particular valve seal or valve style.

1.4 VALVE PERFORMANCE CRITERIA

A. The selection of the Supplier shall not be based only on price, but based on the following “Best Value Criteria”:

1. Valve Manufacturer’s past experience in manufacturing valves for the molten salt industry temperature of 720°C. Provide a list of previous experience which includes specific solar site, fluid, and operating temperature range. The list of previous experience shall include names, phone numbers, e-mail addresses, and all relevant contact information.

2. Valve Manufacturer’s selection of bellows seal, or packing materials and packing rings suitable for molten salt application. In addition, Provide a list of the Valve Manufacturer’s past experience and tests performed to validate in using such materials at similar temperature range with molten salt.

3. Codes and Standards valves are manufactured and tested to.

4. Valve flow control performance.

5. Operational time between preventative maintenance requirements.

6. Suppliers approach to guaranteeing the valve will operate at the given high temperatures with molten salt.

7. Materials used to build the valves.

8. Valve delivery dates to site.

9. Price

1.5 QUALITY ASSURANCE

A. The following items shall be included as a minimum:

1. ASME B31.1 for power piping valves.

2. Seat Leak Test: ANSI/FCI 70-2 (SPP-433).

3. Factory Valve Inspections/Quality Assurance Report.

1.6 WARRANTY

A. None.

1.7 SUBMITTALS

A. Submittal Procedure:

1. Provide with the Bid three (3) sets of: Assembly and dimensional drawings, weights, seal information, Cv charts for globe valve performance, valve flow control performance curves, furnished specialities and accessories, letter confirming that the valves are for molten salt high temperature duty and is suitable for installation outdoors in Albuquerque. Provide list of code and standards valves are manufactured and tested to.

   a. Provide a list of Valve Manufacturer's past experience in manufacturing valves for the molten salt industry (580°C and above). Provide a list of previous experience which includes specific solar site, fluid, and selection of bellows seal, packing materials, packing rings and operating temperature range.

   b. Schedule for delivery.

2. Seven (7) sets within 30 days after award: Full shop drawings for valves including assembly drawings, materials of construction, and seal information.

3. Provide (7) sets of Operations and Maintenance (O&M) Manuals with valve delivery.

4. Provide (3) sets of Installation Requirements with valve delivery.

5. Provide (7) sets of Factory Certificates/Leak Test Report/Factory Inspection Report with valve shipment.

1.8 SCHEDULE

A. The Supplier is expected to meet the following schedule for delivery of valves and actuators:

1. Bid Date: TBD.

2. Bid Award: TBD.

3. Delivery of Full Shop Drawings: TBD. (Due 30 days after Award).

4. Final Shop Drawing Approval by SNL: TBD (10 days after Delivery of Shop Drawings)

5. Valve Delivery Date to SNL Albuquerque, NM Site: TBD (12 weeks after approval of Final Shop Drawings).

B. The Supplier shall provide monthly update to SNL on milestone progress, schedule gain or slips with regards to delivery date as identified in this specification.

PART 2 - PRODUCTS

2.1 VALVE MANUFACTURERS

1. Flowserve – Valve Manufacturer
   Slater Controls
   333 E. Main, Ste. 150
   Farmington, NM 87401
   Phone: 505-320-8411

   Contact: Antonio Garcia

2.2 MINIMUM VALVE DUTY REQUIREMENTS

A. Provide globe valves capable of performing satisfactorily in the following service conditions:

1. Maximum Continuous Operating Pressure:

   a. Cold Salt System: 225 psig.

   b. Hot Salt System: 225 psig.

2. Maximum Operating Temperature:

   a. Cold Salt System: 1022°F (550°C).

   b. Hot Salt System: 1364°F (740°C).

3. Minimum Operating Temperature:

   a. Cold Salt System: 896°F (480°C).

   b. Hot Salt System: 1256°F (680°C).

4. Fluid Mixture (Molten Chloride Salt): 40MgCl / 20NaCl / 40KCl (molar).

5. Fluid Flowrate: See Valve Schedule 2.5.

6. Maximum Temperature Cycling per 24 hour period: 3 (three).

7. Continuous Operating Period without shutdown: 3000 hours

8. Cold Salt Pipe Sizes: 2-inch, Stainless-Steel 304H schedule 80.

9. Hot Salt Pipe Sizes: 2-inch, Haynes H230 schedule 80.

10. Specific Gravity:

   a. Cold Salt At 932°F: SG= 1.677.

   b. Hot Salt AT 1328°F: SG= 1.538.

2.3 COLD SALT FLOW CONTROL VALVE GENERAL MANUFACTURING REQUIREMENTS

A. Globe flow control valves shall be manufactured with the following features as a minimum as applicable to the specific valve style.

1. Manufacturer / Model / Body Type / Trim: Flowserve / Mark Two / Globe / Standard

2. Size / Pressure Class / Body Form: 2.00 inch / Class 600

3. Trim Number / Cv: 1.62 Cv 49.0 / linear

4. Flow Direction: Flow Over

5. Body Material / Bonnet Material: Stainless-Steel 304H / Stainless-Steel 304H

6. End Connection: Integral flange / Valtek Standard

7. Flange Finish: 125 – 250 Ra

8. Extended Bonnet Material: Stainless-Steel 304H

9. Plug Material / Treatment: Stainless-Steel 304H / Full Cont. Alloy 6

10. Stem Material / Treatment: Stainless-Steel 304H / Alloy LGA

11. Seat Ring Material / Facing: Stainless-Steel 304H / Full Bore Alloy 6

12. Seat Retainer: Stainless-Steel 304H

13. Guides Upper / Lower: Stainless-Steel 316 & GL PTFE Alloy 6

14. Bellows Type / Material: Bellows / Inconel 625 with Nickel 200 outerply

15. Body Bolting / Bonnet Flange Material: B8 – 8A (304 Stainless) / 316 Stainless

16. Gaskets: Pressurized Inconel 625 Metal O-Ring with Nickel 200 coating

17. Gland Flange Material: Stainless-Steel 304H

18. Gland Flange Bolting: High Temperature Bolting with Loaded Washers

B. Actuator

1. VL Cylinder / Aluminum

2. Size: 50 / Air

3. Stroke / Spring: 1.5 / Dual

4. Fail / Air To Open

5. Tubing Size / Material: ¼” / 304 Stainless-Steel

6. Fitting Manufacturer: Bi-Lok / 316 Stainless-Steel

7. Actuator O-Ring: Buna-N

8. Spud: 2.00/0.75-16 UNF

C. Positioner

1. Model StarPac 3

D. Code

1. Weld Requirements: ASME BPVC Section IX

E. Accessories

1. Provide six factory mounted Type K thermocouples, two mounted to valve body, two mounted to valve bellows and two mounted to extended bonnet. Locate one thermocouple near bottom of valve bonnet approximately 2-inches above valve body, and one thermocouple at valve bonnet where valve packing is located within valve bonnet.

   a. The thermocouples will be connected to the valve using welded Swagelok fitting same size as sheath furrow and nut. The length of each of the three thermocouple conductors shall be sufficient to reach the actuator enclosure.

F. Hand operation

1. A side mounted handwheel (13:1 ratio) shall be provided for emergency operation, engaged when the motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. The handwheel or selection lever shall not move on restoration of motor drive. Provision shall be made for the hand/auto selection lever to be locked in both hand and auto positions. It should be possible to select hand operation while the actuator is running or start the actuator motor while the hand/auto selection lever is locked in hand without damage to the drive train.

2. Clockwise operation of the handwheel shall give closing movement of the valve unless otherwise stated in the data sheet. For linear valve types the actuator handwheel drive must be mechanically independent of the motor drive and should be such as to permit valve operation in a reasonable time with a manual force not exceeding 400N through

G. Remote Valve Position/Actuator Status Indication

1. Four contacts shall be provided which can be selected to indicate any position of the valve, Provision shall be made for the selection of a normally closed or open contact form. Contacts shall maintain and update position indication during handwheel operation when all external power to the actuator is isolated.

2.4 HOT SALT FLOW CONTROL VALVE GENERAL MANUFACTURING REQUIREMENTS

A. Globe flow control valves shall be manufactured with the following features as a minimum as applicable to the specific valve style.

1. Manufacturer / Model / Body Type / Trim: Flowserve / Mark Two / Globe / Standard

2. Size / Pressure Class / Body Form: 2.00 inch / Class 600

3. Trim Number / Cv: 1.62 Cv 49.0 / linear

4. Flow Direction: Flow Over

5. Body Material / Bonnet Material: Haynes H230 / Haynes H230

6. End Connection: Integral flange / Valtek Standard

7. Flange Finish: 125 – 250 Ra

8. Extended Bonnet Material: Haynes H230

9. Plug Material / Treatment: Haynes H230 / Full Cont. Alloy 6

10. Stem Material / Treatment: Haynes H230 / Alloy LGA

11. Seat Ring Material / Facing: Haynes H230 / Full Bore Alloy 6

12. Seat Retainer: Haynes H230

13. Guides Upper / Lower: Haynes H230 & GL PTFE Alloy 6

14. Bellows Type / Material: Bellows / Inconel 625 with Nickel 200 outerply

15. Body Bolting / Bonnet Flange Material: B8 – 8A (304 Stainless) / 316 Stainless

16. Gaskets: Pressurized Inconel 625 Metal O-Ring with Nickel 200 coating

17. Gland Flange Material: Haynes H230

18. Gland Flange Bolting: High Temperature Bolting with Loaded Washers

B. Actuator

1. VL Cylinder / Aluminum

2. Size: 50 / Air

3. Stroke / Spring: 1.5 / Dual

4. Fail / Air To Open

5. Tubing Size / Material: ¼” / 304 Stainless-Steel

6. Fitting Manufacturer: Bi-Lok / 316 Stainless-Steel

7. Actuator O-Ring: Buna-N

8. Spud: 2.00/0.75-16 UNF

C. Positioner

1. Model StarPac 3

D. Code

1. Weld Requirements: ASME BPVC Section IX

E. Accessories

1. Provide six factory mounted Type K thermocouples, two mounted to valve body, two mounted to valve bellows and two mounted to extended bonnet. Locate one thermocouple near bottom of valve bonnet approximately 2-inches above valve body, and one thermocouple at valve bonnet where valve packing is located within valve bonnet.

   a. The thermocouples will be connected to the valve using welded Swagelok fitting same size as sheath furrow and nut. The length of each of the three thermocouple conductors shall be sufficient to reach the actuator enclosure.

F. Hand operation

1. A side mounted handwheel (13:1 ratio) shall be provided for emergency operation, engaged when the motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. The handwheel or selection lever shall not move on restoration of motor drive. Provision shall be made for the hand/auto selection lever to be locked in both hand and auto positions. It should be possible to select hand operation while the actuator is running or start the actuator motor while the hand/auto selection lever is locked in hand without damage to the drive train.

2. Clockwise operation of the handwheel shall give closing movement of the valve unless otherwise stated in the data sheet. For linear valve types the actuator handwheel drive must be mechanically independent of the motor drive and should be such as to permit valve operation in a reasonable time with a manual force not exceeding 400N through

G. Remote Valve Position/Actuator Status Indication

1. Four contacts shall be provided which can be selected to indicate any position of the valve, Provision shall be made for the selection of a normally closed or open contact form. Contacts shall maintain and update position indication during handwheel operation when all external power to the actuator is isolated.

2.5 VALVE SCHEDULE

A. Furnish type and quantity of valves listed below in accordance with the performance requirements listed within this specification.

Valve Schedule:

Valve ID	Valve Style	Valve Size	Pipe Size	Flow Control	Pos. Shut Off	Min. Flow Contr	Max. Flow Contr	Oper Pres.		Max. Temp.
FCVC-1	Globe	2”	2”	Proportional (Pneumatic)	Yes	15 gpm	110 gpm	190 psig		1022°F
FCVC-2	Globe	2”	2”	Proportional (Pneumatic)	Yes	15 gpm	110 gpm	190 psig		1022°F
FCVH-1	Globe	2”	2”	Proportional (Pneumatic)	Yes	15 gpm	110 gpm	80 psig		1364°F
FCVH-2	Globe	2”	2”	Proportional (Pneumatic)	Yes	15 gpm	110 gpm	80 psig		1364°F
FCVH-3	Globe	2”	2”	Proportional (Pneumatic)	Yes	15 gpm	110 gpm	80 psig		1364°F
FCVH-4	Globe	2”	2”	Proportional (Pneumatic)	Yes	15 gpm	110 gpm	80 psig		1364°F
FCVH-5	Globe	2”	2”	Proportional (Pneumatic)	Yes	15 gpm	110 gpm	80 psig		1364°F

PART 3 - EXECUTION

3.1 START-UP SERVICE BY MANUFACTURER

A. The Supplier shall engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing and operational testing of the system.

B. Supplier representative shall be present at the job site during the installation of the valve motorized actuators and shall provide instruction to the SNL's Subcontractor on how to install the motorized actuators. Supplier Representative shall be at job site a minimum of 10 days.

C. Startup and Operational Test

1. The Supplier's factory-authorized service representative shall assist the testing and balancing sub-contractor and owner's representatives in the start-up and operational testing of the system.

2. Test and adjust controls. Notify SNL of damaged and malfunctioning controls and equipment. After SNL's Subcontractor has replaced malfunction controls, retest and adjust controls until system is accepted by SNL.

3.2 TRAINING

A. The Actuator Supplier's authorized service representative shall instruct SNL's designated representative in these procedures during the start-up and test period. The duration of the instruction period shall be 2 days, during normal working hours. Provide 14-day notice to the SNL Technical Representative prior to instruction.

B. The Valve Supplier's authorized service representative shall instruct SNL's designated representative in valve packing replacement procedures. The duration of the instruction period shall be 1 day, during normal working hours. Provide 14-day notice to the SNL Technical Representative prior to instruction.

END OF SECTION

SPECIAL SPECIFICATION

SECTION 257001S

PROCESS EQUIPMENT CONTROL SYSTEM

Page

CONSTRUCTION SPECIAL SPECIFICATION

SECTION 257001S

PROCESS EQUIPMENT CONTROL SYSTEM

PART 1 - GENERAL

1.01 QUALIFICATIONS

A. Process Equipment Control System (PECS) suppliers must be engaged in the business of installation and service of industrial or scientific control systems on a regular basis and must have at least five (5) years experience. The PECS supplier shall only utilize full-time factory trained and qualified service staff to install, program, support and maintain the PECS. Determination of satisfactory compliance will be at the sole discretion of the A/E and/or SNL.

B. All Installers on the project shall be required to have successfully completed the Control System Manufacturer's Installation Certification classes on the control systems be installed. The Contractor shall present for review the certification of completed training, including the hours of instruction and course outlines upon request. The Contractor shall present for review the professional resumes of all programmers that will actually be performing the work on the project for approval by the A/E and/or SNL.

1.02 SCOPE

A. It is the intent of this Section to provide, install, connect, and calibrate the entire PECS as indicated on the Contract Drawings and as necessary to provide fully automatic control for all systems as shown in the control drawings, stated in the sequences of operation, indicated in the electrical diagrams, or as otherwise indicated in the Contract Documents. Some equipment controls may be specified to be provided in the Contract Documents outside this Section. As work of this Section, the Contractor shall coordinate with these other suppliers and trades to provide a completely integrated control system.

B. It is the responsibility of the bidder to read and conform to all sections of the Specifications, review all Contract Drawings of all Divisions, and coordinate with all equipment suppliers of material specified under other sections of the Specifications including any Sandia-furnished material (SFM).

C. The engineering, installation supervision, programming, graphics development, calibration, startup, and checkout necessary for a complete and fully operational control system as specified hereafter shall be provided under this Section.

D. Provide startup documentation verifying proper operation of all points and all integrated systems.

E. Provide a brief user's manual with screen shots for operators.

F. Provide training and instruction of the installed control system.

G. Provide assistance to commissioning agent in testing and acceptance of the control system.

1.03 SUBMITTALS

A. Within thirty (30) days of contract award, submit eight (8) sets of shop drawings and submittal data in accordance with Section 013300S and the General Contract Requirements. These submittals shall be reviewed by the mechanical and electrical sub-contractors for coordination review and evaluation prior to being submitted for review. Letters from these sub-contractors verifying that they have reviewed the submittals, and any comments regarding the submittals, must be attached as part of the submittal.

B. Submittals shall consist of shop drawings, catalog data sheets, and point verification forms as defined in the following paragraphs.

1. Shop drawings shall be provided which show all control devices, electrical wiring diagrams, control system schematics, sequences of operation, and a materials list. All systems and the associated control components, as well as all connections between components, shall be clearly indicated. The submittal shall clearly indicate the required coordination with equipment supplied by others, including any Sandia-furnished equipment. Simply showing a connection with no identification or termination will be considered unacceptable. All connections shown on the Contract Drawings shall be labeled on both ends and these same labels shall be used for the installation process for ease of comparing the shop drawings to the actual field installation. Labels shall include the point tag name used in the software system. Each control component shall be given the unique identifier shown in the contract drawings. This identifier shall be used in the sequence of operation so that reference to the Contract Drawings can be easily made. A complete communication and power architecture drawing shall also be included on the shop drawing.

   a. Complete P&ID diagrams shall be provided for system overview of all systems and process connections.
   b. An accurate I/O Tag list shall be provided as an Excel spreadsheet.

c. Electrical wiring diagrams shall be shown on the shop drawings. Electrical wiring diagrams shall show all switches, relays, motor starters, etc. The electrical wiring diagrams shall show the correct control wiring and interlock wiring of all equipment provided under the Contract including any Sandia-furnished equipment. Each diagram shall reference the correct power source by breaker panel and circuit number or from a control transformer. If equipment shown is provided by another Contractor, then this shall be noted.

d. Control Panel fabrication drawings showing panel layout including all components shall be provided.

e. The sequence of operation for each controlled system shall be provided with reference to each associated control point tag. The sequence of operation shall break down the control operation by major function and describe it in detail the correct operation and interaction with other system functions. Use of the sequence of operation stated on the Contract Drawings is acceptable; however, it shall be modified to reflect actual control device tags and shall be expanded to include any additional control functions programmed into the system.

f. A complete bill of material listing shall be included on the shop drawings which show the device model numbers, device identifiers, quantities, manufacturers, etc., of all equipment provided under this Section. The material list shall be organized in alphabetical order so that it can be easily compared to the associated catalog data sheets. The quantities are to be provided only to confirm a general understanding of the contract requirements and will not be verified as a complete material list.

g. A program flow diagram or state diagram shall be provided to describe the dynamic nature of the system. If the system utilizes object oriented programming, a unified modeling language (UML) diagram shall be provided to describe the static nature of the software.

h. Color prints of proposed graphics with a list of points for display.

2. Catalog data sheets will be provided for each different piece of equipment provided under this Section. At a minimum the data sheet shall contain sufficient information so that compliance with the Specification can be verified. Where multiple models or options are indicated on the same catalog data sheet, the equipment proposed shall be highlighted or otherwise indicated. The catalog data sheets shall be organized in alphabetical order to match the material listing on the shop drawings.

3. Point verification forms shall be completed for all points that will be installed as part of the PECS. Once approved, these forms shall be used during the testing and startup portions of this work.

C. Provide the A/E and/or SNL, any additional information or data which is deemed necessary to determine compliance with these specifications or which is deemed valuable in documenting the system to be installed.

D. All re-submittals shall contain a cover letter restating all of the previous submittal comments made by the reviewing engineer along with a written statement by the Contractor as to the resolution of each item. Any re-submittal issued to the engineer without this cover letter will result in an automatic rejection of the submittal.

1.04 SYSTEM PROGRESS REVIEW MEETINGS

A. The contractor shall attend four (4) progress review meetings during the development of the PECS. These meetings shall be held during the following development stages. Each meeting shall last approximately four (4) hours.

1. Conceptual Development Level
2. 50% Development Level
3. 90% Development Level
4. Final Development Level

1.05 RECORD DRAWINGS

A. Record drawings shall be provided as required by the General Contract Requirements. Record drawings shall not be completed until after installation is complete. Any changes made during installation shall be recorded on the approved shop drawings as they are made so that a current record drawing is constantly being updated. These as-constructed drawings shall be available at all times for inspection by the Sandia Delegated Representative (SDR). At completion of the project, all manual changes shall be incorporated into a clean reproducible set of as constructed drawings. These as-constructed drawings shall be available for use during the training sessions.

B. With the reproducible record drawings the Contractor shall furnish complete spare parts lists, operating instructions, and maintenance literature, for proper maintenance of all control equipment.

C. Record drawing shall all be provided on DVD directly compatible with Autodesk AutoCad 2020.

D. In addition to the record drawings, the following system manuals will be delivered to the SDR. Two (2) sets of these documents will be provided prior to training beginning:

1. All information provided as submittals in Section 1.03/B shall be updated to the as-built state and provided in the final project manual.

2. Names, address and 24-hour telephone numbers of Contractors installing equipment, and the control systems and service representative of each.

3. Operators Manual with procedures of operating the control systems including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables. It shall include screen shots and description menus, controls, and indicators.

4. Programming Manual with a description of the programming language including syntax, statement descriptions including algorithms and calculations used, point database creation and modification, program creation and modification, and use of the editor.

5. Engineering, Installation and Maintenance Manual(s) that explain how to design and install new points, panels, and other hardware; preventative maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.

6. A listing of all essential files shall be provided. This list shall include all software programs, drivers, and source code locations needed to implement the control system. The final product of the essential files documentation is meant to allow the customer to be able to build the control software on a new machine with guidance from the essential files list. One set of DVDs containing files of the software and database shall also be provided.

7. Complete original issue documentation, installation, and maintenance information for all third party hardware provided including computer equipment and sensors.

8. Complete original issue media for all software provided including operating systems, operator workstation software, and graphics software.

9. Licenses and warranty documents for all equipment and systems.

E. Training Materials: The Contractor shall provide a course outline and training material for all training classes at least six weeks prior to the first class. The SDR reserves the right to modify any or all of the training course outline and training materials. Review and approval by SDR and/or A/E shall be completed at least 3 weeks prior to first class.

F. Operation and Maintenance Manuals: An updated as-built version of the control drawings and sequences of operation shall be included in the final equipment O&M manual submittal. The control drawings shall include:

1. A key to all abbreviations.

2. Graphic schematic depictions of the systems and each component with point tags.

3. Schematic system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.

4. A full points list with at least the following included for each point:

   a. Controlled system (i.e. pump, furnace, piping, test loop, etc.)

   b. Point abbreviation/ tag name

   c. Point description (level, open/close, on/off, temperature, etc.)

   d. Display units of measurement

   e. Control point or setpoint

   f. Monitoring point

   g. Intermediate point

   h. Calculated point tag name

   i. I/O location

   j. Alarm parameters

G. Detailed sequences of operation for each piece of equipment. They shall include, as applicable:

1. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.

2. All interactions and interlocks with other systems.

3. Detailed delineation of control between any packaged controls and the PECS, listing what points the PECS monitors only and what PECS points are control points and are adjustable.

4. Written sequences of control for packaged controlled equipment. Equipment manufacturers' stock sequences may be included. Provide additional narrative where needed.

5. Start-up, warm-up mode, normal operating, emergency operating and shutdown sequences.

6. Capacity control sequences and equipment staging.

7. Temperature and pressure control: setbacks, setups, resets, etc.

8. Detailed sequences for all control strategies, e.g., optimum start/stop, staging, optimization, demand limiting, etc.

9. Effects of power or equipment failure with all standby component functions.

10. Sequences for all level of alarms and emergency shut downs.
11. Seasonal operational differences and recommendations.

12. Initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by the operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.

1.06 SYSTEM TESTING

A. The controls contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to and during functional performance testing. All testing procedures and documentation shall be approved by the SDR and the Commissioning agent prior to testing. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:

1. System name.

2. List of devices.

3. Step-by-step procedures for testing each controller after installation, including:

a. Process of verifying proper hardware and wiring installation.
b. Process of downloading programs to local controllers and verifying that they are addressed correctly.
c. Process of performing operational checks of each controlled component.
d. Plan and process for calibrating valve and damper actuators and all sensors.
e. A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.

f. A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has "passed" and is operating within the contract parameters.

g. A description of the instrumentation required for testing.

h. Upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or system, provide a signed and dated certification to the SDR and GC that all system programming is complete as to all respects of the Contract Documents, except functional testing requirements.

i. List and clearly identify on the as-built piping drawings the locations of all pressure sensors (air and water pressure).

B. At the termination of the testing period, the Contractor shall provide completed point verification sheets for each point in the PECS. These sheets shall be included as a part of the closeout notebook.

C. The SDR reserves the right to participate in or assign a representative to participate in the startup, testing, programming, or any other aspect of the construction of this project at no additional cost to the SDR.

1.07 TRAINING

A. The controls contractor shall have the following training responsibilities, in addition to any listed in Division 1.

B. The standard operating manual for the system and any special training manuals will be provided for each trainee, with three extra copies left for the SDR. In addition, copies of the system manuals (Specification Section 1.05) will be demonstrated during training and one copy submitted with each O&M manual (Specification Section 1.05). Manuals shall include detailed description of the subject matter for each session. The manuals will cover all written control sequences and have a definitions section that fully describes all relevant words used in the manuals and in all software displays. Manuals will be approved by the SDR. Copies of audiovisuals shall be delivered to the SDR.

1. The training will be tailored to the needs and skill-level of the trainees.

2. The trainers will be knowledgeable on the system and its use. For the on-site sessions, the most qualified trainer(s) will be used. The SDR shall approve the instructor prior to scheduling the training.

3. There shall be two training sessions:

a. Programmer Training: The first training shall consist of 8 hours of actual training. This training shall be held on-site. This training shall review the system program and graphics development with the SDR.

b. Operators Training: The second session shall be held on-site for a period of 8 hours of actual hands-on training after the completion of system QA. The session shall include instruction on:

1) System operation through system graphics and software including the sequence of operations.
2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that to be considered, procedures for obtaining vendor assistance, etc.
3) All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.
4) Every screen shall be completely discussed, allowing time for questions.

1.08 SERVICE AND WARRANTY

A. The system supplier shall maintain a local maintenance support facility complete with system technicians, diagnostic and test equipment, and new spare components. Emergency service shall be available in the local office on a 24-hour, 7-day a week basis. The service agent shall provide a continuously monitored local service telephone number for emergency service and this number shall be provided to the SDR.

B. Warranty all work as follows:

1. Labor & materials for control system specified shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the SDR. Control System failures during the warranty period shall be adjusted, repaired, or replaced at no charge or reduction in service to the SDR. The Contractor shall respond to the SDR's request for warranty service within 24 hours during customary business hours.
2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the SDR and/or A/E, the SDR shall sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this specification. The date of SDR's acceptance shall be the start of warranty.

3. Operator workstation software, project specific software, graphics, database, and firmware updates shall be provided to the SDR at no charge during the warranty period. Written authorization by SDR must, however, be granted prior to the installation of such changes.

1.09 CODES AND STANDARDS

A. Work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of local, state and federal authorities. As a minimum, the installation shall comply with the current editions in effect 30 days prior to receipt of bids of the following codes:

National Electric Code (NEC)
International Building Code (IBC)
International Mechanical Code (IMC)
Underwriters Laboratories: Products shall be UL-916-PAZX listed.
Telecommunications Industry Alliance/Electronic Industries Alliance (TIA/EIA).

1.10 OWNERSHIP OF PROPRIETARY MATERIAL

A. All project-developed hardware and software shall become the property of the SDR. These items include but are not limited to:

1. Project graphic images

2. Record drawings

3. Project databases including point tag data base.

4. Project-specific application programming and source code.

5. All documentation provided as submittals and manuals.

PART 2 - PRODUCTS

2.01 GENERAL

A. All products required for this project shall be selected in accordance with this part of the Section. Installation of the components shall be in accordance with Part 3 of the Section. If a component is required to meet the requirements shown on the Contract Drawings and is not specified in the Part of the Specification, the supplier shall select and submit on components that meet all design requirements indicated on the Contract Drawings, stated in the sequence of operation, and elsewhere in the Contract Documents.

2.02 SYSTEM HARDWARE & SOFTWARE

A. General

1. The system shall be furnished with two separate computers and software systems. One computer shall provide the control functions for the PECS. The second computer shall provide the Data Acquisition System (DAQ) functions.

2. The systems shall be provided including all necessary hardware and software requirements described herein. The computers shall be connected to the PECS and DAQ local area networks directly.

3. The software system for both the PECS and the DAQ shall be National Instruments LABView 2010 or later. The state chart software shall not be used.

B. System Hardware Requirements

1. The minimum hardware requirements for the PECS and DAQ computers shall include the following minimum requirements but in any case shall be of adequate capacity to easily accommodate the system software:

a. Rack Mounted Computer Chassis
Two Black 4U 19"x7"x20" rack mounted chassis each with, but not limited to, the following:
1) Intel I7 980 LGA1366 processor at 3.33 GHz
2) 12GB fully buffered DDR3 2200MHz memory in matched triples.
3) Four PCIe 16 slots.
4) Two PCIe 1 slots.
5) One PCI slot.
6) Integrated SATA II controller.
7) Two 1TB SATA II Hard Drives w/64 MB cache.
8) 24x DVD-DL recorder with LightScribe.
9) Dual Imbedded Gigabit Ethernet NICs.
10) PICe Dual Gigiabit Ethernet NIC.
11) Dual Embedded IEEE 1394 (Firewire) ports.
12) SD memory card reader.
13) Six USB ports (2.0 & 3.0)
14) Dual port PCIe serial card.
15) 850 Watt ATX power supply.
16) PNY VCQ4000-PB Quadro 4000 video card.
17) Remote management controller.
18) Rack mounting kit with sliding rails.
19) Two chassis cooling fans.
20) Wired keyboard and mouse (no wireless)

b. Control Room LCD Panels with the following:
Four 21" LCD panels
6x1600x1200 UXGA resolution
1000:1 contrast ratio
Ultra-fast 8ms response
178º (H) / 178º (V) viewing angle
Integrated speakers
Integrated USB ports

c. Other Equipment
Two 24 port managed Gigabit Ethernet switches 120V.
Two four post enclosed server racks with built in cooling systems.
One power distribution unit (three phase 30A input, six 120V outputs).
CAT-5e Ethernet patch cables.

2. One (1) color LaserJet printer shall be provided for connection to the primary operator server.

3. Any and all additional interface equipment necessary to connect the computers to the PECS and DAQ communication networks.

C. System Software General Requirements

1. Basic Features: The software package shall be LabView 2018 or later.

2. Concurrent Operation: All functions as specified in this Section shall be allowed to load and run concurrently on the computer hardware configuration.

3. Modular: Future enhancements to the system shall include increasing functionality of the software package by adding new optional modules to the base system.

4. Adding points and/or modifying points, creating trends, adding nodes to the system, etc., shall be accomplished on-line. The goal is to not have to shut down for any purpose. All system functions should operate the same.

5. The system shall be capable of operating in either a normal or a virtual machine environment.

2.03 PECS SOFTWARE

A. System Data Base Configuration

1. Real-Time Data Base: The system shall collect and maintain information on data it receives from Programmable Automation Controllers (PAC) and other sources and store this information in the real-time data base.

2. Processing Per Point: Point information shall be validated and processed according to the criteria selected for each data point. Invalid criteria shall be captured in the error handler and error logging

3. Point Types: The following data acquisition point types shall be supported:

   a. Analog Input (AI): An AI represents continuous input signals, signed and unsigned bit values, floating point values, accumulated maximum/ minimum/ average points, or other information represented as an integer or floating-point number. AIs shall only be processed after exceeding a configurable deadband. AIs shall be modifiable as follows:
      - Engineering unit conversion (linear with positive and negative slopes, and custom equations).
      - Two high and two low alarm limits for each point.
      - Alarm deadband.
      - Setpoint action.
      - Gain (according to module type).
   b. Analog Output (AO): An analog output shall be defined by using the output block definition function of the software that shall support the following:
      - High data limit clamp.
      - Low data limit clamp.
      - Conversion type; linear with positive and negative slopes, and custom equations.
      - Analog values shall be configured either as 16-bit, 32-bit signed or single precision.
   c. Digital Input (DI): Points shall be Boolean inputs. Each of the states shall be comprised of:
      - The input value corresponding to a measurement or calculation.
      - An optional event message to be generated.
      - An optional alarm to be processed.
      - A color specification for graphics elements.
      - An alarm inhibit option.
   d. Digital Output (DO): Digital or discrete output (DO) information shall be managed by the software, whereby the user can define relay or control output points controlled from the software with control and/or exception report action associated with each change of state. Features shall include:
      - A two-digit integer indicating one of two digital output states.
   e. The design of the software data-processing shall allow for configuration of many types of measured and/or calculated data

processing schemes. By combining process variables with miscellaneous variables and digital variables through general (math and logic) actions, most situations shall be able to be handled.

f. Shared-Variable: Shared-variables are to be IEEE floating-point values which do not undergo alarm checks or other processing. These floating-point registers shall be useful as calculation constants, manual data-entry values, application parameters, control parameters and a variety of other miscellaneous application uses. The shared-variable's 32 character description shall be used for data entry of text messages for reports and displays.

g. Type Attributes: The data base points shall be identified by a point identification name, consisting of at least 16 alphanumeric characters to be defined by the user. All I/O data types shall have at least the following attributes:
- Sixteen-character point identification tag name.
- Thirty-two character point description.
- Eight-character scale or engineering units name.
- Point value and status.
- Security level.
- Alarm priority.
- Point alarm inhibit/enable.
- Calculated/measured.
- Scan frequency and enable/disable.
- Alarm message enable/disable.
- Channel gain.
- Min/Max value.

h. The user shall be able to configure the system parameters from a text file (*.ini file).

4. External Data Base Modifications: The system shall support the exportation of all data bases to a record element/data pairs to/from a flat ASCII file or Excel file as input.

5. The system shall allow the user to change PID (proportional, integral, and derivative) settings of the system and those parameters shall be saved and loaded from a configuration file. A separate screen shall be available for PID tuning.

6. The software package shall allow the data base to be configured via a single global data base concept.

7. Global Data Base: The configuration data necessary to support all functions relating to a given point shall be able to be entered into one data base. All applications which contain that point shall draw the required

configuration data from this one global data base (e.g., displays, alarms, updating, control, application programs, etc.).

8. Out of Range: All I/O data that is out of range shall be logged to a file if the point is an alarm or event point. Indicators shall be displayed for invalid points.

9. Data Base Generation: The data base shall be able to be generated using the standard fill-in-the-blank format.

10. Data Base Report: A utility shall be provided that prints out a summary or complete listing of the data base. The data base report shall also be able to be sent to a disk file for reference and archival purposes.

11. The minimum data base size shall be 5000 points of I/O without modification.

B. System Data Communications

1. Secure and Efficient Communications: The system's I/O driver software shall provide secure and efficient communications between the central computer system and the PACs or other systems.

2. Data Translation: The system shall compose and interpret PAC communication messages. This shall include any translation or determination of data that may be required to transfer/receive data between the system data base and the communication protocol.

3. Error Checking: The I/O driver software shall provide all the necessary error-checking and retransmission capabilities to detect and recover from data transmission errors. All errors shall be logged in the system.

4. All available PECS data shall be bundled for real time logging in the DAQ System.

C. System Supervisory Control

1. Control Actions: For discrete control, the following sequence shall be provided:

a. User selects point on display.
b. Verification message identifies point tag name.
c. Selected point shall be highlighted.
d. User selects control action.
e. Verification message identifies the particular control action to be carried out.
f. After "EXECUTE" is pressed, the following shall occur:

- The command shall be transmitted to the end device.
- A verification message shall indicate that a command has been sent to the PAC or system.
- The above message and time of occurrence shall be recorded as an event. All events shall be logged in the system.
- Read after write verification.

2. Raw or Calculated Data: Analog and floating-point outputs shall be able to be commanded manually or automatically by calculated output values resulting from control loop equations initiated by general actions (math and logic) functions or time scheduled events.

3. Control Operations: A variety of output control operations shall exist such as output range clamps, data conversions, etc. Control operations are:

   a. Initiated manually by user actuation of graphics control point.
   b. Event-triggered by digital inputs, alarms, chained digital outputs, via time-scheduled or general (math and logic) action.
   c. Initiated by user-supplied control strategies.

D. System Manual Data Entry

1. User data entry capabilities shall be provided for manually collecting and entering data into the data base. Users shall enter data directly into the data base if security cleared to access this function. The data base shall also have the ability to be opened in Excel and modified.

E. System Alarm Processing

1. Alarm Processing: The software package shall incorporate complete alarm-handling capability, including sequence of alarm indication, alarm history logging and alarm annunciator functions. The system shall provide access to displays identifying unacknowledged or all alarms. Alarm processing shall include:

   a. Modification of point value by user.
   b. Alarm enable/disable.
   c. Alarm limit modification/restore.

2. Alarmable Points: I/O points resident within the system shall be available for alarming, including:

   a. PAC points, all I/O.
   b. Software points (e.g., calculations, application programs).
   c. Operating system errors.

d. Alarm printer error message.

Refer to drawings and sequence of operations for initial point alarm spreadsheet.

3. High-Priority Alarm Window: A high-priority alarm window that contains up to five most recent unacknowledged messages shall be available on all displays to constantly monitor alarms.

4. Configurable Alarm Summary: A configurable alarm summary shall be able to be defined for a graphics display or report. Alarms shall be listed in:

   a. Reverse chronological order.
   b. By class.
   c. By severity.

5. Alarm History: The system files and displays shall include an alarm and event history files and displays. The user shall configure the number of recorded alarm/events to be recorded. The event types to be recorded shall include operator changes, alarms, diagnostic errors, user login/logout, communications and system errors.

6. Alarm Limits Per Point: High, hi-hi, low, lo-lo limits, rate of change for analog values and calculated values shall be uniquely definable on a per point basis. Limits shall be user definable.

7. Deadbanding: Limit alarms on analog data quantities shall have a tunable deadband per point such that quantities fluctuating around the alarm limit do not cause annoying repetitive alarms.

8. Triggerable Action: Provide the ability to stop alarms from being processed for both analog and digital points based on another digital point in the system being high or low and or another analog point not being within a specified range.

9. Logged Action: Type of event action logged shall include manual data entry, setpoint changes, alarm acknowledgement, alarm limit changes, alarm deletion, point value change, etc. All alarm/event messages shall be saved to a file for archival purposes and printing.

10. Priority Alarming: The software shall provide a priority alarming system, such that each point may be assigned a priority, by the user and each priority shall have a unique and readily identifiable video display message and printed message.

11. Alarm Sequences: The occurrence of an alarm/event condition shall immediately result in the following responses:

    a. Entry of a record of the alarm/event into the alarm/event summary display, including the following information:
        - Name of data base point in alarm.
        - Alarm state descriptor.
        - Time and date of occurrence.
    b. Change color and alarm status indicators in preconfigured displays, including schematic displays and the alarm/event summary display.
    c. User definable alarm response general (math and logic) action may be executed.

12. Alarm Acknowledge: Alarms can be acknowledgeable with security clearance. Upon alarm acknowledge, the following actions shall occur:

    a. A record of the acknowledge action shall be entered into the event log and printed on the printer.
    b. If the point is no longer in an alarm state prior to acknowledgement, the point shall be removed from the alarm list only following an acknowledgement.
    c. Unacknowledged alarms shall be highlighted on alarm summary screen.

13. Return to Normal: Upon return to normal of a point in alarm, the following events shall occur:

    a. The point shall be removed from the alarm summary list (only if initial alarm condition was acknowledged).
    b. A record of the event shall be entered into the event log and printed on the printer (no operator action is required).

14. Alarm Inhibits: Alarm checks can be applied to the current engineering unit’s value. There shall be two high and two lower alarm regions, each of which can trigger general (math and logic) action responses to alarms or returns from alarm. A delta alarm limit shall detect variances which exceed a specified change rate. An alarm deadband shall provide alarm filtering to reduce false alarm triggering. An alarm shall be able to be optionally inhibited to stop alarm-processing and prevent nuisance alarms. A global alarm inhibit function shall be configurable and triggerable.

15. Provide the ability to configure analog and digital points to have a time adjustable variable (seconds, minutes, hours) as a condition for the alarm processing of the point. As an example, if the point meets the alarm

parameter configuration, and the set amount of time has gone by, the alarm would then be processed through the system.

16. Repeat Alarms: Provide the ability to configure points to repeat the alarm at a configurable time duration (seconds, minutes, hours) if the alarm has not been acknowledged and or reset.

17. Provide alarming upon the loss of node connects between all nodes and processes.

18. Alarm Printing: The automatic printing of alarms shall be set up to have the ability to be turned off and on based on the requirements of the user.

19. Alarm Text: The system shall have the ability to allow alarms to be sent to designated operators/ authorized users via text messaging when certain types of alarms occur.

F. System Graphical Display Facilities

1. User Create and Modify: All displays shall be created and modified by the user using a procedure intended for non-programming personnel.

2. Display Colors: All displays shall support a minimum of 256 colors.

3. Displays shall be able to be printed on color printer via system utilities.

4. Alarm Display: The alarm display shall show the presence of both acknowledged and unacknowledged alarm conditions. Alarms shall remain in the unacknowledged alarm summary until acknowledged.

5. Display Builder: Static and dynamic displays shall be created using an interactive configuration process. This shall provide for:

   a. Graphic displays containing schematic representatives of the process and dynamically updated real-time data points.
   b. All data base items can be displayed in a variety of forms: text, bar graphs, trend, symbols, and bar symbols.
   c. Twenty predefined symbols shall be provided and a minimum of 200 symbols shall be able to be created and saved. All symbols shall be created or customized without programming. Once defined symbols shall then be referenced by number or an eight-character symbol name. A user definable symbol library shall be possible.
   d. Import of AutoCAD files allow scalable fonts and scaling of images.

6. The displays shall include the following elements:

   a. Display-paging icons for menu building
   b. User-defined general action (math and logic) icons for special actions.

7. Provide default animation colors for all points. Colors shall change according to the alarm conditions (high-2 high-1 low-1 low-2) or the status of the digital point (off/on). The defaults shall be selected on a point-by-point basis when created, rather than having to do the same animation for each point on each screen. For digital points a 0=white and a 1=green, while a PV shall have four colors associated with the four alarm conditions.

8. Terminal Auto Login: The terminals shall be configurable to automatically start a GUI login session without having to manually restart a terminal that has been rebooted for some reason.

G. System I/O Driver Software

1. ISO Standards: I/O drivers and the toolkit shall be designed to be consistent with the standards of the information processing systems - open systems interconnection - basic reference model (ISO 7498) and transport layer-connection oriented transport protocol (ISO 8073). A device driver following this structure shall be more easily ported to other communication topologies. Any third party software drivers utilized shall be provided with the system and documented in the essential files list.

2. Structured Approach: The I/O subsystem shall be structured to provide a generic interface to the I/O device-unique code and for it to contain the data needed to communicate with the outboard physical device.

3. Program Structure: The driver program structure shall be a multithreaded, serially-scheduled event processor that detects, schedules, and processes input/output events which compete for the program's resources. The toolkit shall provide a driver template program and a suggested functional design.

4. If drivers other than National Instrument drivers are used, they shall be included in the List of Essential Files (Section 1.05).

2.04 DAQ SOFTWARE

A. System Requirements

1. The user has existing Data Acquisition System (DAQ) at the site. The new DAQ system shall be designed to be similar to the existing DAQ systems in order to simplify customer training. The contractor shall review the existing systems with the SDR in order to configure the new system. The following defines some of the attributes for the existing and new DAQ systems.

2. Overview

   a. The DAQ system shall, as a minimum, acquire, calibrate, view, graph, and record any selected signal in one or both of two data acquisition sets.
   b. Each data acquisition set shall be fully configurable based upon the following requirements.

3. System Manager Window

   a. The DAQ interface shall provide a generic, flexible method to acquire, calibrate, view, and record different signal types.
   b. Test setups shall be saved for quick reuse which will save time and the learning curve for both experienced and new users.
   c. The system shall have the ability to be adapted to many different hardware configurations based on customer needs.

4. Data Acquisition Configuration Window

   a. The users shall have the ability to define both real/physical acquisition channels and virtual (calculated) channels based on both real and virtual channels.
   b. The PECS data shall be able to be bundled with the names, data, min, max, etc. and be sent to the DAQ system. The user shall have the ability to choose points from this list to graph and log in the DAQ system.

5. Edit Acquisition Signal Window

   a. Signals shall be created or edited within the same window.
   b. The changing of the “source” variable shall dictate if a signal physically exists or is virtual.
   c. The range settings shall be transmitted to DAQ drivers to set each channel to the correct hardware range for maximum resolution in the acquisition.
   d. The “Expression” fields shall give the user the ability to scale the raw value of each signal as required, or simply pass it thru unfiltered by placing the “Signal Name” in the field.
   e. The system shall have the ability to log data from the PECS or a third party controller.

6. Define Signal Expression Window

   a. The “Edit” button next to the “Expression” field shall bring up a window that shows what signals are currently configured and what the mathematical functions are available.
   b. Functions from simple to Fast Fourier Transformer (FFT) shall be performed.
   c. Expressions shall have the ability to be made from multiple “Available Acquisition Signals”.
   d. The window shall create a small amount of data manipulation the user can view in output files. It shall have the ability to use functions that take an array of data and result in a single point (integration). A single point value shall have the ability to be duplicated to keep data and time buffers correctly aligned.

7. Signal Calibration Window

   a. The signal calibration tool shall be a separate module the user can access from the main application’s menu.
   b. The signals shall be calibrated to help reduce measurement errors due to any number of variables (noisy environment, thermal drift, grounding method, etc.).
   c. There shall be no limit to the amount of calibration points the user can make,
   d. All of the calibration information shall be saved with each signal and shall populate the “Calibration Settings” of the Edit Signal Window.
   e. The ‘Uncertainty” field shall provide the user with a method to gauge the quality of the calibration.

8. Characterization of Signal Data Window

   a. The “Edit” button in the ‘Conversion” and “Uncertainty” fields shall bring up a window the user can use to help determine what form the mathematical expression shall take to best fit the calibration points.
   b. There shall be three methods for fitting the data available to the user.
   c. The results of the application fitting the data shall be graphed versus the actual points providing the user visual recognition to key in on discrepancies and make changes as required.

9. Graphical Display

   a. The graphical display shall be customized with a mix of any of the signals setup in the configuration.

b. The signals desired, table order, and graph attributes shall be saved in a file for easy recall.
c. The users shall have the ability to adjust the graph update mode and method of updating (every point vs. averaging) to improve the graph's readability.
d. The user shall have the ability to change both a signal's plot color and axis that is used to group signals of different magnitudes and avoid losing the detail.
e. The user shall have the ability to zoom in the graph. The numerical display shall continue to show updated fields while this occurs.

10. Configure Data Recording Window

a. Data recording shall allow the user to set a separate recording rate, time period if only a certain window of data is desired, and the file format to save.
b. Signals shall not be recorded by default; the user shall pick-and-choose between all or some subsets of the currently configured signal.
c. The user shall have the ability to record two separate DAQ files.
d. The recorded time shall be the computer time, not the calculated time. The user will be responsible for synchronizing computer clocks.

2.05 PROGRAMMABLE AUTOMATION CONTROLLERS

A. All Controllers shall be National Instrument:

1. Analog Input Card: 4-20mA, NI 9208, 780968-01
2. Analog Output Card: 4-20mA, NI 9266, 785047-02
3. Digital Input Card: 24 VDC, NI 9422, 779522-01
4. Digital Output Card: 24 VDC, NI 9472, 779137-01

B. The Programmable Automation Controllers (PAC) shall provide full interface with the PECS Software through an Ethernet connection on the PECS network.

C. The controllers shall have field communication ports for programming/maintenance.

D. Controllers shall be din rail mounted for quick and easy replacement.

E. All PAC controllers shall have a battery back-up feature and shall retain program in memory in the event of a power failure.

F. Module General Information

1. Wiring for all modules shall be terminated on a removable terminal at the I/O module for ease in replacement of I/O modules.

2. All I/O modules shall be rack mounted for quick and easy replacement.

G. Discrete Output Modules (DO)

1. Discrete output modules shall be capable of switching 24 VDC.

2. Each output shall be protected by current limiting circuitry to avoid potential damage from failed field devices.

3. Each DO shall have an interposing relay between it and the end device if the required voltage/ current requirements of the end device exceed the specifications of the module or as indicated on the control diagrams.

H. Discrete Input Modules (DI)

1. Discrete input modules shall be capable of accepting 24 VDC.

2. Each input shall be protected by current limiting circuitry to avoid potential damage from failed field devices.

I. Analog Input Modules (AI)

1. The analog input modules should be capable of universal channel configuration accepting 0-10 Vdc signals. If the manufacture of the device connected to the AI cannot provide a 0-10 VDC signal, then 4-20 mA signals will be accepted.

J. Analog Output Modules (AO)

1. The analog output modules should be capable of universal channel configuration sending 0-10 Vdc signals. If the manufacture of the device connected to the AO cannot accept a 0-10 VDC signal, then 4-20 mA signals will be sent.

K. Power Supplies

1. Power supplies shall be provided for each rack. Each unit shall be supplied with 120 VAC from a field installed UPS and shall output all voltages necessary to power all associated Controllers and PAC I/O modules. All 120 VAC power supplies must be mounted in a separate enclosure from the I/O hardware so that I/O cabinets may be accessed without electrical outages.

L. Communications

1. The communications module shall communicate via Ethernet/ IP at 100 Mbps.

M. Controller

1. Controllers shall be National Instruments Model CRIO-9025.

N. Chassis

1. The chassis shall be sized to hold all required modules and spare slots for an additional 4 future PAC modules. Chassis shall be National Instruments Model CRIO-9118 or CRIO-9148.

2.06 NETWORKING/COMMUNICATIONS

A. Primary Local Area Network (LAN)

1. Two new Gigabyte ETHERNET® communication networks shall be installed in the facility. ETHERNET® ports shall be installed in the building communications rack, the controller panel, and at the test stands for connection of the PECS and DAQ equipment.

2. Ethernet UTP Category 5e cable length shall not exceed 90 meters (295 feet) from rack termination patch panel to user outlets.

3. Take precautions during installation to prevent cable from being kinked, crushed, or being mishandled. Do not exceed maximum tension specified by manufacturer.

4. Route cables via conduit and pullboxes.

5. Test terminated cables and submit test report within one week of performing terminations.

6. Terminate Ethernet UTP cables with preserved wire pair twists as specified in EIA/TIA 568A.

7. Splices in Ethernet UTP cables are not permitted.

2.07 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

A. Provide interlock wiring for equipment, electrical wiring for relays (including power feed) for temperature and pressure indication. Provide interlock wiring between equipment as required for the specified sequence of operation and system integral controller(s). Do not provide interlock wiring if a dedicated digital output has been specified for the equipment or the sequence of operation requires independent start/stop.

B. Provide power wiring, conduit and connections for flow meters, temperature sensors, valves, alarms, VFD's, actuating devices for temperature, pressure and flow indication, point resets, electric heating controls, and all equipment controlled by the system. Provide all power wiring for all controls equipment not expressly shown to be powered by Div. 16. Coordinate breaker and panel requirements with Div. 16 contractor.

C. Provide all other wiring required for the complete operation of the specified systems.

D. Install and size all wiring raceway systems in compliance with the requirements of the National Electrical Code and Division16. Provide a minimum of 20% spare capacity in all wiring raceway systems for future expansion.

E. PECS Network Communication Requirements

1. Communication conduits and wiring shall not be installed closer than six feet from high power transformers or run parallel within six feet of electrical high power cables. Care shall be taken to route the cable as far from interference generating devices as possible.
2. All shields shall be ground (earth ground) at one point only, to eliminate ground loops.

3. There shall be no power wiring, in excess of 30 VAC rms, run in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, all communication wiring and signal wiring shall be run using separate twisted shielded pairs (24 AWG) with the shields grounded in accordance with the manufacturer's wiring practices. The SDR shall review grounding scheme before grounding is complete.

F. Power and Communication Wiring Transient Protection

1. The control manufacturers shall submit catalog data sheets providing evidence that all products offered by the manufacturer are tested and comply with the standard for Transient Surge withstand capabilities for electrical devices ANSI C62.41, IEEE-587-1980, Categories A and B. Such testing shall have included power and communication trunk wiring. Compliance with IEEE-587 shall imply conformance with IEEE-472 transient standards based on the stated position of ANSI and IEEE regarding applicability of the rated standards.

2. Communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection specifications of the General Semiconductor, Model #422E device.

3. The communications circuitry and input/output circuitry shall provide protection against a 1000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations. The manufacturer's catalog data sheet shall provide evidence of conformance with this requirement. Systems not complying with this requirement shall provide equivalent protection external to the controllers. Protection shall be provided for the individual communications and input/output terminations for each controller. Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.

G. Input/Output Control Wiring

1. RTD wiring shall be three-wire or four-wire twisted, shielded, minimum number 22 gage.

2. Other analog inputs shall be a minimum of number 22 gage, twisted, shielded.

3. Binary control function wiring shall be a minimum of number 18 gage.

4. Analog output control functions shall be a minimum of number 18 gage, twisted, shielded.

5. Binary input wiring shall be a minimum of number 18 gage.

6. Thermocouples shall be equipped with the manufacturer's calibrated lead wiring. All thermocouple wire shall match the thermocouple type and shall be provided with a sheath suitable for the environmental temperature and installation location. Thermocouple wire connected to temperature sensors installed on or in the piping system shall utilize fiberglass sheath. All thermocouple sensor connections shall be provided with thermocouple plug and jack connectors.

7. 120 VAC control wiring shall be #12 THHN in 3/4" conduit. Provide 20% percent fill for extra wire in each conduit.

H. Splices

1. Splices in shielded cables shall consist of terminations and the use of shielded cable couplers which maintain the integrity of the shielding. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties as specified herein.

I. Conduit and Fittings

1. Comply with all Div 16 requirements.

2. Conduit for Control Wiring, Control Cable and Transmission Cable: Electrical metallic tubing (EMT) with compression fittings, cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections.

3. Outlet Boxes (Dry Location): Sheradized or galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.

4. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.

5. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type and NEMA rating shall be suited to location.

2.08 PAC CONTROL PANELS

A. Control Panels shall be completely fabricated, panel and door mounted instruments, PAC I/O swing out wiring arms, and terminal blocks, installed and wired in the factory or shop. All wiring shall be completed and tested prior to shipment. External connections shall be by way of numbered terminal blocks as indicated on the drawings.

1. All connections for future functions shall be wired to numbered terminal blocks. Terminal blocks shall also be grouped to keep ac circuits separate from the dc circuits.
2. Panels shall have no exposed terminals that may be inadvertently touched (i.e., terminal screws shall be in wells).

3. Panel Construction:

   a. Panel cutouts for other devices shall be cut, punched, or drilled and smoothly finished with rounded edges.
   b. Panel shall be provided with fully gasketed front access door where shown. Door shall be provided with locking three-point latches. All locks to be keyed alike: keys shall be taped to inside of enclosure.
   c. All components are to be bolted to the back panel using tapped holes of the proper size recommended by the equipment manufacturer. Lock washers are to be used with all bolts and screws. All back panels shall be one piece.

d. Each panel shall include sufficient room to house all associated PLC modules, power supplies, DIN rails, wire ways, terminal strips, relays, etc.

1) Power Distribution Within Panels:
   a) Each panel will be provided with one or more 120-Vac, 60-Hz feeder circuits from the associated circuit breaker distribution panels. All transformers shall be installed in a separate enclosure from the control panel. Voltages within the panel shall be less than 50 VAC.
2) Wiring:
   a) All electrical wiring shall be in accordance with the Contract Drawings, Div. 16 Specification, and the SNL adopted version of the National Electrical Code. Wires shall be 600 volt class, PVC insulated stranded copper and shall be of the sizes required for the current to be carried, enclosed in plastic wiring duct. Provide hinge wiring for front of panel devices. Wiring shall be wrapped with plastic cable stays. Adhesive-backed cable stays need to be cemented permanently.
   b) All interconnecting wires, including spares, between panel mounted equipment and external equipment shall be terminated at numbered terminal blocks. No multi-conductor cable allowed.
3) Terminal Blocks: Terminal blocks shall be sectional plastic blocks rated for 300 volts. Terminals shall be double sided and unit shall be capable of accepting wire sizes up to AWG No. 12. Terminal blocks for thermocouple wires shall be selected to match the thermocouple type. Terminal blocks shall be provided in different colors shall be installed in groups of 10 blocks for easy identification. Terminals shall have permanent, legible identification. Elevate all terminal strips so that the top of the smallest terminal on the strip is even with the top of the adjacent wiring duct. Specific attention should be given to terminal block model numbers shown on the bill of materials as special conditions exist for specific terminals. Provide end caps for all terminal strips. Provide 20% spare terminal blocks for future expansion.
4) Nameplates, Name Tags, and Service Legends:
   a) All components provided under this Section shall be provided with permanently mounted nametags bearing the entire ISA tag number of the component. Panel mounted tags shall be plastic.

b) The Panel Drawings Refer to Nameplates and Service.

c) Service legends and nameplates shall be engraved, rigid, laminated plastic type with adhesive back. Unless otherwise noted, color shall be white with black letters and letter height shall be as specified on the Contract Drawings.

d) Each panel shall be provided with a face mounted laminated nameplate as specified above. Unless otherwise noted, color shall be white with black letters. Letter height is specified on the Contract Drawings.

e) Nameplates, name tags, and service legends attached to panels or panel components will be firmly affixed to the panel or components using stainless steel screws.

f) Wire markers shall be shrink tubing type per Division 16 specifications. Cloth or wraparound adhesive types not acceptable.

5) Transformers: Control transformers required for all control purposes including control of pilot duty relays, power supplies, valve actuators, loop-powered sensors, etc. shall be provided. Control transformers 100 VA and less may have internal secondary overload if desired but anything over 100 VA must be external fused. In no case shall a transformer have a capacity less than 65% of the attached load. All fuses shall have an LED for loss of power.

6) Heat Exchangers and Cooling Fans: Heat exchangers and cooling fans shall be provided for each control panel as required to overcome the internal heat load and maintain the temperature in the panel within the equipment manufacturer's recommendations.

B. Cabinets and Enclosures:

1. Enclosures shall be manufactured to the following industry standards:

a. UL 508 Type 4/12.
b. JIC standard EGP-1-1967.
c. IEC 529, IP65.

2. Enclosures shall be constructed as follows:

a. Fabricated from minimum 14 gauge steel.
b. Seams continuously welded and ground smooth, no holes or knockouts.

c. Strong, rigid construction with body stiffeners, three-point supporting for backplane.
d. Gasketed overlapping clear doors.
e. Three-point latching mechanism operated by oil tight key-locking handle. All panels shall be keyed alike.
f. Latch rods with rollers.
g. Heavy gauge continuous hinges.
h. Print pocket with wiring diagrams included.
i. Heavy duty lifting eyes where required.
j. Panel supports/brackets.
k. Oil-resistant door gasket attached with oil-resistant adhesive and held in place with steel retaining strips.
l. Collar studs.
m. Internal panel light.
n. Panel knockouts for raceway entry.
o. Panels may be floor or wall mounted.

2.09 CONTROL RELAYS

A. Control relay contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting silver cadmium Form C contacts, enclosed in dust-proof enclosure. Relays shall be equipped with the necessary mounting base, DIN rail, labels, termination clips, etc., and a coil transient suppression devices. Relays shall be 8 pin double pole with 24 VDC coils and contact rating of at least 10 Amps at 120 VAC. All other required relays shall have coil voltages appropriate for the installation. Relays shall be Allen-Bradley Type HK or equivalent.

2.10 CONTROL TRANSFORMERS

A. Control transformers shall be provided where shown or where required to meet the sequence of operation. Control transformers shall be fused on both primary and secondary taps. Fusing shall not exceed 80 percent of the rated transformer output. Control transformers 100 VA and less may have internal secondary overload if desired but anything over 100 VA must be external fused. Control transformers over 100 VA supplying power to a control panel shall be located external to the control panel.

2.11 CURRENT TRANSDUCERS

A. Current sensing transducers shall measure AC current of loads and shall output a 0-10 Vdc signal over the measured range selected for the motor it is installed on. Sensor shall have a minimum of 2.0 percent of full scale accuracy. Unit shall be split core design. Veris Industries or approved equivalent.

2.12 TEMPERATURE SENSORS

A. All temperature sensors shall be Type E (piping system) or Type K thermocouples. The standard process operating temperatures of the system shall be between 0 and 750°C. The maximum normal operating pressure for the system is 200 psig for a molten salt application. All sensor assemblies shall be manufactured to meet these temperature and pressure requirements. Each temperature sensor shall be provided as complete factory assembly including a NEMA 4 rated 316 stainless steel connections head, extension, and high temperature connection plug. Extensions shall be provided so that the connection head is outside the insulation of the pipe.

B. All temperature sensors installed in liquid lines and tanks shall be installed in heavy duty socket weld thermowells. Thermowells shall be constructed of Haynes H230 for the hot salt piping system and Stainless-Steel H304 for the cold salt piping system.

C. All temperature sensors used for control and monitoring of heat trace systems shall be surface mount type with 1 1/4" reference section of hot leg before the 90° bend and cold leg. Provide 304 SS weld pad for a spot weld connection of sensor to the pipe.

D. Sensors shall be manufactured by Pyromation Inc. or approved equal.

2.13 COLD SALT FLOW METER

A. Ultrasonic flow meters shall operate on the transit time (time-of-flight) principal and give an output signal directly proportional to the actual liquid rate of flow. The flow meters shall be sized for a maximum flow rate of 78GPM at 500°C on the cold salt piping system.

B. The transmitter uncertainty in measurement shall be less than or equal to 0.5% of the maximum measurable flow. This shall include the combined effects of linearity, hysteresis and repeatability. The supplier shall specify the effects produced by the uncertainty of temperature measurement and process pressures out of the process conditions (due to the direct effect on the density and hence on the mass flow). The stability shall be better than 0.1% per year.

C. The supplier shall clearly indicate the manufacturer's recommendations regarding installation, and commissioning, particularly in terms of straight sections before and after the flow tube element. The meter design shall minimize the effects on the measurement of vibration in the pipe. The provider shall specify the acceleration/maximum amplitude at a given frequency range, and not affect the measurement instrument. In the field it shall be possible to eliminate false signal fluid flow caused by vibration through the filter settings low pass, a trigger level and / or limit movement of low flow. In the factory calibration of the meter, the suppression of these features should not be fixed.

D. The ultrasonic flow sensor shall be rated for protection class NEMA 6 standard and suitable for Class I, Division 1 (explosion-proof or intrinsically safe) hazardous areas, where it applies as specified in the instrument data, and certified according to the same code. The internal wiring and terminals shall be in accordance with the IEC-228. All terminals shall be clearly identified and easily accessible. All parts in contact with the fluid will be of AISI 316. All units shall be supplied standard with a metal identification plate of stainless steel permanently attached to the meter. The Tag shall have an indelibly engraved inscription of the instrument and the corresponding service. The flow meter body shall indicate the direction of flow. The housing material of all instruments will be appropriate for environmental conditions of the plant. The protection level shall meet the IP-65 requirements as a minimum. In the case of transmitters required for area classified, the minimum protection shall be IP-66. Electrical connections shall be ½-inch NPT.

E. The ultrasonic flow sensor shall be manufactured from Hastelloy C276 for meter size 2 1/2-inch schedule 80. End connections shall be 2 1/2-inch RTJ flanged pipe. The flow meter shall be eccentric reducers with a flat bottom to allow for proper salt system drain down.

F. The ultrasonic flow sensor shall be externally mounted without any projection into the flow stream. The sensor housing shall be welded in place and have replaceable sensors, while in use without disturbing process conditions. The flow sensors shall transmit and receive the ultrasonic beam at a 90° angle to the sensor window. Sensor windows shall be parallel with each other. There shall be two (2) sensor paths for redundancy and replacement, so at all times there is a sensor monitoring the flow rate.

G. The sensor window shall withstand the maximum working pressure to allow servicing of the sensors without interruption of the process flow. The sensor housing shall allow for easy sensor replacement without involving adjustment or recalibration.

H. The ultrasonic flow sensor shall have dual beam construction, consisting of four sensors, cutting the pipe in parallel paths, 0.5 x radius and NOT through the center of the pipeline. The meter shall maintain an accuracy of +/- 0.5% of flow rate from 1.5 to 54 ft/sec, and repeatability of 0.2%, regardless of flow profile being fully Laminar or fully Turbulent. For Transitional flow profiles, the additional accuracy from 1000 to 4000 Reynolds Number shall be +/-0.1% per 100 Reynolds Number change to a maximum additional accuracy of +/-2.0% at 2,500 Reynolds Number.

I. Sensors shall operate on the piezoelectric principal at a frequency of 1 Mhz.

J. The ultrasonic flow sensor shall be able to withstand process temperatures ranging from -25 to 500 °C with remote mounted converter.

K. The supplier shall be responsible for the appropriate calculations to size the meter. The maximum flow measured by the flow meter shall be selected, whenever possible, so that the flow in normal operation is between 65% and 85% of the total flow. The Maximum operating flow shall not be greater than 90% of the total flow. The maximum flow measured shall be as great and as close to the possible total flux. The supplier shall provide a detailed calculation report which shall include at least the following:

1. Maximum flow rate measured by the flow meter (see units below)
2. Total flow meter (see units below)
3. Accuracy of the measured minimum flow (see units below)
4. Maximum speed of passage of fluid (ft/sec)
5. Pressure drop to normal and maximum flow (psig)

L. The transmitters shall be "SMART" type with power requirements of 120VAC / 60Hz signal and an output of 4-20mA HART protocol which shall be directly proportional to the variable process and the calibration of each transmitter section. The load impedance exterior shall be up to 500 ohms without compromising the signal.

M. The converter shall contain self-diagnostic, automatic data integrity checking, and be completely interchangeable with other converters of the same type without the need for recalibration. No auxiliary test meter or primary simulator shall be required for commissioning, zeroing, or interchanging of the ultrasonic flow converter. The converter shall contain the following features as standard equipment:

1. Simultaneous analog output and scaled pulse/frequency output.
2. Adjustable damping of analog signal from 0.04 to 3600 seconds in increments of 1, 0.1, or 0.01 seconds.
3. Indication of the loss of one beam.
4. Low flow cut-off
5. Forward/reverse flow measurement capabilities.
6. Integral rate of flow indicator and back lit 7-digit LCD totalizer.
7. Reprogramming of all data and functions, resetting of counters, etc., using push buttons mounted on the face or by a magnetic pin from outside without opening the housing.
8. Maintain an accuracy of 0.5% of flow rate for velocities equal or greater than 1.5 ft/sec.
9. Measurement of fluid sonic velocity for product identification.
10. Continue to measure with loss of one beam
11. Status indication output

N. Through a portable communication terminal, the operator shall be able to read the value of the variable engineering and electrical units, the tag, and do the recalibration and reconfiguration of the transmitter. The accuracy, stability and data integrity shall be comparable with the calibration performed in the workshop. The portable terminal shall be able to connect to the transmitter circuit without disconnecting the latter.

O. The operations shall be permanent. The transmitter memory shall be nonvolatile and shall permanently store the configuration information even when the power supply is removed. The transmitters shall be calibrated and adjusted at the factory but shall have the ability to be easily re-adjusted locally when necessary. The zero suppression or elevation shall be adjustable sense the transmitters are subject to atmospheric pressure. The electronics of the transmitter shall include a self-test routine so that if a major fault is detected, the output signal shall go to a maximum (> 20mA) or minimal (< 4mA) signal. Transmitters shall be factory configured with the K factor calculated from data evidence obtained during the wet calibration. In any case, it shall be possible to reconfigure the field flow easily. The instrument shall be manufactured in an ISO 9001 approved facility.

P. The electronic flow transmitter shall comply with the requirements of standard EMI/RFI Susceptibility of Electronic Equipment Standard and IEC 61000-4-3: 2002 Electromagnetic compatibility (EMC), Part 4-3: Testing and measurement techniques- Radiated, radio-frequency, electromagnetic field Immunity test. All transmitters shall carry the CE mark.

Q. Ultrasonic Flow Transmitters and equipment covered by this specification shall be subject to tests and inspections that prove their validity for the proper function and performance required. The manufacturer shall perform in factory inspections and performance testing, to achieve positive results. All costs arising shall be responsibility of the manufacturer for the equipment or components required to be replaced as a result of the tests.

R. All equipment shall be inspected prior to shipment for any possible flaws in construction or operation errors. Equipment and materials shall be subject to inspection and approval by the SDR. The inspection does not relieve the manufacturer of the responsibilities or obligations arising as a result of the implementation of equipment described in this document. The SDR may reject the equipment or components that are damaged, defective, or do not meet the specification requirements. Any item found to be defective shall be returned, repaired, or replaced with an identical component at no additional cost to the SDR. This shall be provided as necessary to get the proper functioning of equipment. A hydrostatic test shall be performed on all the transmitters according to relevant standards. The hydrostatic test duration shall be not less than 20 minutes and shall be performed with a pressure of at least 1.5 times the design pressure.

S. Calibration tests shall be performed on all equipment before delivery. Certificates shall include at least the following:
- Linearity
- Hysteresis.
- Repeatability
Calibration certificates shall be sent with each instrument. The manufacturer is responsible for providing everything needed to perform these tests, both hardware and software. All results mentioned above shall be certified as part of the Report Final Quality Assurance. Meter calibration shall be performed by a direct volumetric comparison method. A calibration certificate shall accompany each meter. The calibration facility shall be certified to 0.02% accuracy, traceable to NIST standards.

T. The instrument shall be manufactured in an ISO 9001 approved facility.

U. The ultrasonic flow sensor shall be Krohne Model UFS 500 series or approved equivalent. The converter shall be Krohne Model UFC series or approved equivalent.

2.14 HOT SALT FLOWMETER (WAVEINJECTOR)

A. The waveinjector is an ultrasonic clamp-on flow measurement for high temperature application of 720°C. The unit is for outdoor application and is protected from rain.

1. Approved Manufacturer: Flexim, Series WI-400

B. The waveinjector controller for clamp-on unit for outdoor application. The controller is capable of automatic loading of calibration data and transducer recognition, bidirectional communication and MODBUS communication technology, advanced self-diagnosis, transmitter and transducers for hazardous environment. The flow measurement is zero point stable, drift free, and independent of pipe material, process pressure, process temperature, and process fluid.

1. Approved Manufacturer: Flexim, Series FLUXUS F721

2.15 ULTRASONIC LEVEL SENSOR (SURGE TANKS)

A. The Ultrasonic level sensor shall be capable of measuring salt level within small surge tanks (see drawing for tank sizes and location of units). The technology uses the reflection principal ultrasonic sound waves. The maximum fluid temperature is 720°C. The controller can be isolated from the heat. Units shall be outdoor units or installed in a NEMA 4 weather proof enclosure.

1. Resolution: 1 mm

2. Linearity: +/-3 mm
3. Full Scale Accuracy: +/-0.2 mA (Full Scale = 20 mA)
4. Temperature Characteristics: 0.1 mm/°C
5. Response Time: 0.4 seconds minimum
6. Tank Design Pressure: Less than 0.5 psig
7. Output: 4-20 mA (Analog)
8. Material: Hastelloy C276

B. Approved Manufacturer: Keyence, Series FL

2.16 TEMPERATURE FIBER CABLE SENSOR

A. The temperature sensor cable will measure the temperature of chloride salt in molten salt storage tank approximately 22’-2” in height. The temperature detection will be every 6-inches in height from the bottom of the tank to the top of tank. The acquisition over the entire cable length is 23.9-250 Hz. The normal operating temperature range is 480°C to 740°C. Calibration is performed internally using a NIST-traceable HCN gas cell.

1. Wavelength Accuracy: 1.5 pm
2. Acquisition Rate: 100 Hz
3. Temperature Repeatability: +/-0.4°C

B. Approved Manufacturer: LUNA, Model: ODiSI-B

2.17 TANK LEVEL MEASUREMENT (HOT & COLD SALT STORAGE TANKS)

A. The level sensor is bubbler system with purge. The system shall utilize plant nitrogen gas with less than 3 ppm of moisture. The bubbler accuracy shall not be affected solids, and slurry. The bubble shall be capable of measuring molten salt with and S.G. between 1.6 and 1.7 at a temperature range of 500°C - 720°. The manufacturer shall supply all necessary components manufactured for Stainless-steel 304H for the cold salt tank and Inconel 625 or Haynes H230 which would be wetted parts. Electronic parts sensitive to high temperature will be distance offset so not to be exposed directly to the high temperatures. The system shall include NEMA 4 control panel, panel meter, pressure transmitter, flowmeter, control panel heater.

B. Acceptable Manufacturer: Lesman Instrument Co. or approved equivalent.

2.18 SALT SYSTEM PRESSURE SENSORS

A. Pressure sensors shall be capable of operating at a maximum process temperature connection of 720 ºC and maximum process pressure of 200 psig in a molten salt application.

B. Pressure sensors shall be NaK filled melt type with a flex capillary of sufficient length to provide the necessary thermal isolation. All sensors shall have a minimum accuracy of 0.5% FSO and repeatability better than 0.2% FSO. Sensor output shall be 0-10 Vdc. The pressure transducer shall be suitable for welding onto the pipe.

C. Pressure sensors shall be Gefran Model XMD05 or approved equivalent.

2.19 COMPRESSED AIR PRESSURE SENSORS

A. Electronic pressure transmitter shall be designed to measure the gauge pressure as indicated on the Contract Drawings or as required. Process connection shall be 1/8" NPT. The unit shall have an accuracy of ± 0.13% of full scale. The unit shall have stainless steel media. Setra Model C206 or equivalent.

2.20 COMPRESSED AIR AND NITROGEN GAS FLOW METER

A. Flowmeter shall be in-line thermal gas mass type. It shall be capable of measuring compressed air between 0 and 20 scfm and shall be line size. The sensor shall output a 4-20 mA signal. The unit shall have a flow accuracy of ±1.0% of reading +/- 0.2% of full scale flow rate and a repeatability of ±0.2% of full scale. Unit shall have a NEMA 4X enclosure for all electronics and shall be rated for 300 psig. Fox Thermal Instruments, Inc FT2 or equivalent.

2.21 PROCESS COOLING WATER FLOW METER

A. The flowmeter shall be in-line paddle wheel type. The flowmeter shall be furnished complete with a flow transmitter which supplies a 4-20 mA signal of flow. Meter shall have an accuracy of no less than 2% of the actual reading over the range of the meter. Meter shall be constructed of a cast bronze tee with magnetic electronics. The components for the meter shall be selected based on the measured media being 50% glycol/ water mix. Remote transmitter shall be provided with NEMA 4X enclosure. Badger Meter Series 250 meter with Series 310 Programmable Loop-Powered Analog Transmitter.

2.22 VIBRATION SENSOR TRANSMITTER

A. The vibration sensor transmitter shall be compatible with the vibration sensors furnished by the pump manufacturer. The transmitter shall output a 4-20 mA output of vibration level. The unit shall have on board fault detection circuitry which shall reduce the output to 2 mA indicating a fault condition. The unit shall be mounted in a NEMA 4X enclosure. STI Vibration Monitoring Inc. CMCP500 Series or equivalent.

2.23 SOLENOID VALVE

A. Valves shall be brass, screw type, and shall be rated at 150 psi maximum working pressure. Valves shall have stainless steel core tube, core, plugnut and springs. Valves shall be normally open with a 24VDC coil. Valve shall be line size with the lowest pressure drop available. ASCO 2/2 Series 8262 or equivalent.

PART 3 - EXECUTION

3.01 GENERAL

A. All devices, conduit, wiring, etc., shall be installed in a neat professional manner by skilled persons.

1. The installation of all aspects of the system shall comply with all applicable codes and regulations and with Division 16 Specifications.

2. The installation of all materials shall be in accordance with the published manufacturer's recommendations without exception. If for some reason a particular component cannot be installed in compliance with these recommendations, the Contractor shall advise SNL of the situation.

3. Coordinate with other trades where installation of a particular component requires other trades to be involved. Installation coordination includes location the correct placement of thermowells, flow meters, control valves, pressure sensors, control power circuits, etc. Care must be exercised to identify locations that meet the requirements of the manufacturer including upstream and downstream distances, pressures, temperatures, etc.

4. For each system, the contractor shall demonstrate the system performance and stability to the SDR, A/E, and Commissioning Agent prior to the final acceptance of the system. The contractor shall demonstrate that all control sequences of operations function as specified and the performance of each control loop is within specified limits. Record and print graphical trends for each control loop shall be provided to indicate that the loop stability is within the specified performance limits. Each trend shall be for a duration of no less than 12 hours.

3.02 SYSTEM HARDWARE & SOFTWARE

A. Install system hardware at locations indicated on the project drawings. The installation of all equipment shall be in accordance with the manufacturer’s installation requirements and project specifications.

3.03 PECS SOFTWARE

A. User Access

1. The SDR shall be interviewed and all desired passwords and password levels shall be installed at all workstations.

B. Dynamic Color Graphic Displays

1. All color graphic slides shall be developed to the satisfaction of the SDR. The contractor shall interview the SDR prior to the creation of the graphics to get specific requirements from the SDR. The slides shall include all real-time point assignments, user interactive points, and real-time alarm information.

    a. A general complete system overview graphic shall be provided. From this graphic, the operator shall have the ability to “drill” into specific equipment and systems
    b. Separate graphics shall be provided for all mechanical and controls equipment serving the system. All system graphics shall be displayed complete with all real time data relevant to the equipment being displayed including temperatures, flow rates, positions, etc.

C. Database Save/Restore/Backup

1. After all controller software, PECS software, and graphic slides have been developed, two (2) complete backup sets of this software shall be delivered to the SDR for archiving.

3.04 DAQ SOFTWARE

A. Dynamic Color Graphic Displays

1. Sample graphics will be provided by the SDR prior to the beginning of the development of the DAQ system. New DAQ system graphics shall be similar to the graphics provided by the SDR.

B. Database Save/Restore/Backup

1. After all controller software, GUI software, DAQ software, and graphic slides have been developed, two (2) complete backup sets of this software shall be delivered to the SDR for archiving.

3.05 PROGRAMMABLE AUTOMATION CONTROLLERS

A. General

1. All PACs shall be installed in accordance with manufacturer's instructions. Power shall be provided to each PAC in accordance with Division 16 and all applicable codes.

2. All PAC's shall be installed in PAC control panels.

B. Input/Output

1. All points shown on the control drawings or required to meet the Sequence of Operation shall be connected to the respective PAC in accordance with the manufacturer's instructions. Each point shall be checked for voltage, short circuit, etc., prior to termination to the PAC to prevent potential damage to the controller.

3.06 NETWORKING/COMMUNICATIONS

A. General

1. All networks shall be installed in a manner recommended by the manufacturer, SDR, based on the environment, communications speed requirements, and distance. All network media shall be installed in a manner that provides protection from physical damage and interference from RF or other electrical sources.

B. Primary Local Area Network (LAN)

1. The Contractor shall provide all conduit, cable, switches, etc., unless otherwise stated on the Contract Drawings for a complete and operating PECS and DAQ ETHERNET® communication network which connects all ETHERNET® PECS and DAQ monitored and controlled devices. All operator workstations, PECS controllers/routers, and PECS monitored Ethernet controls equipment shall be connected to the LAN.

3.07 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

A. Comply with all Division 16 installation requirements.

B. Install all low voltage wiring in conduit.

C. Conceal conduit within finished shafts, ceilings and wall as required. Install exposed conduit parallel with or at right angles to the building walls.

D. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

E. All wire-to-device connections shall be made at terminal blocks. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

F. Plug or cap all unused conduit openings and stubups. Do not use caulking compound.

G. Route all conduit to clear beams, plates, footings, cranes, hoists, and structure members. Do not route conduit through column footings or grade beams.

H. Set conduits as follows:

1. Expanding silicone firestop material sealed watertight where conduit is run between floors and through walls of fireproof shaft.

2. Oakum and lead, sealed watertight penetration through outside foundation walls.

I. Cap open ends of conduits until conductors are installed.

J. Where conduit is attached to vibrating or rotating equipment, flexible metal conduit with a minimum length of 18" and maximum length of 36" shall be installed and anchored in such a manner that vibration and equipment noise will not be transmitted to the rigid conduit.

K. Where exposed to the elements or in damp or wet locations, waterproof flexible conduit shall be installed. Installation shall be as specified for flexible metal conduit.

L. Provide floor, wall, and ceiling plates for all conduits passing through walls, floors or ceilings. Use prime coated cast iron, split-ring type plates, except with polished chrome-plated finish in exposed finished spaces.

3.08 PAC CONTROL PANELS

A. Wires shall be marked with wire tags or colored wiring. Wiring within the panels shall abide with the following color sequence:

I/O Module Type	Wire Color
24-Vdc Digital Input Card Signal	Blue
24-Vdc Digital Output Card Signal	Brown
4-20 mA Analog Input Card Signal	Yellow
4-20 mA Analog Output Card Signal	Orange
RTD Analog Input Card	Red

B. Electrical Power and Signal Wiring:

1. Control and signal wiring in control panels shall be restrained by plastic ties or ducts. Hinged wiring shall be secured at each end so that any bending or twisting will be around the longitudinal axis of the wire and the

bend area shall be protected with a sleeve. Adhesive-backed cable stays to be cemented permanently.

2. Arrange wiring neatly, cut to proper length, and remove surplus wire. Provide abrasion protection for any wire bundles which pass through holes or across edges of sheet metal.

3. Wiring shall not be spliced or taped except at device terminals or terminal blocks.

4. All tubing and wiring shall be clearly labeled with Brady-type heat shrink marker labels and run to numbered terminal strips or tubing manifolds these wire, tube, and terminal numbers shall be shown on all shop drawings. Wires and tubes shall be labeled at all connection points.

C. Provide wireway attached to interior side of panel door to house wires for panel front-mounted devices, such as switches, lights, indicators. Provide separate wireways for dc and ac signals.

D. All control devices shall be labeled with engraved phenolic tags showing device number and name, model number, setpoint, range, action, etc. Panel Face indicators shall be labeled with engraved phenolic tags identifying what is shown on indicator.

E. Hard tubing shall be brought into the panel using bulkhead fittings; tubing within the panel may be plastic.

F. Terminal strips shall be provided in all control panels for the termination of all field wiring. An additional 20% but not more than 50 terminal strips shall be provided for future use. Terminal strips shall be rated for no less than 300 VAC, 1/4" in width, track mounted, and a slot provided for labeling strips. All terminals shall be labeled as shown on the as-built drawing. No more than two conductors shall be terminated on a single terminal.

G. Control transformers shall be provided where shown or where required to meet the sequence of operation. Control transformers shall be provided with a phenolic label identifying the source of power.

3.09 CONTROL RELAYS

A. Control relays shall be field or panel mounted as indicated on the Contract Drawings. If a relay is field mounted it will be installed in a NEMA I housing.

B. Control relays shall be installed in bases and the based mounted on a DIN rail. All accessories including end clips, jumpers, etc., shall be provided. All wiring shall be labeled. Multiple conductors shall be bundled and run by classification in plastic wireways. Relays shall be labeled as indicated in the shop drawings for ease in troubleshooting.

3.10 CONTROL TRANSFORMERS

A. Control transformers shall be field mounted using a plate to mount on the associated junction box or panel using a foot-style mounting. Locations shall be as identified on the Contract Drawings or as determined by field requirements. A phenolic label on each transformer shall identify the power source by breaker panel and circuit. Fusing of the primary and secondary sides and sizing shall be as defined by the NEC. Provide means of local disconnect for transformer to allow removal.

3.11 CURRENT TRANSDUCERS

A. Current transducers shall be installed on one hot leg of either single or three phase and after the local disconnect. The transducers shall be located in the motor starter housing or motor control center and secured to the structure using sheet metal screws.

3.12 TEMPERATURE SENSORS

A. All temperature sensors installed in liquid lines and tanks, shall be installed in stainless steel thermowells welded to the pipe. The thermowells shall be supplied to the mechanical contractor for installation under other Sections of the Specification.

B. All temperature sensors installed to the liquid lines shall be installed with weld pads spot welded to the pipe.

3.13 FLOW METERS

A. Install flowmeter in accordance with manufacturer’s installation instructions and recommendations. The flow sensor assembly shall be welded into the pipe. Mount flow computer at locations shown on the drawings and connect flow sensors to flow computer/transmitter.

3.14 SALT SYSTEM PRESSURE SENSORS

A. The pressure sensor shall be welded onto the pipe and installed according to the manufacturer’s installation instructions and details.

3.15 COMPRESSED AIR PRESSURE SENSORS

A. All pressure transmitters shall be installed within ten feet of the pressure sensing ports. The transmitter shall be rigidly supported to prevent vibration if it is not directly connected to the pipe. The piping for the sensing points shall include isolation valves such that the transmitter can be removed without having to shut down the system. Access to the transmitter shall be provided.

3.16 COMPRESSED AIR FLOW METER

A. Install flow meter in accordance with manufacturer's installation instructions and recommendations.

3.17 CHILLED WATER FLOW METER

A. Install flow meter in accordance with manufacturer's installation instructions and recommendations. Mount flow transmitter next to the meter and connect flow sensor to flow transmitter.

3.18 VIBRATION SENSOR TRANSMITTER

A. Install vibration transmitter in accordance with manufacturer's installation instructions and recommendations. Connect the transmitter to the pump vibration sensor.

3.19 SOLENOID VALVE

A. The valves shall be installed by the mechanical contractor under other Sections of the Specification.

END OF SECTION 13700S

Section 26 04 75 – Primary Systems Safety Requirements

April 2016

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Section 26 04 75 – Primary Systems Safety Requirements

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.

Section 26 04 75 – Primary Systems Safety Requirements

PART 1 - General

1.1 Related Documents

A. American National Standards Institute (ANSI)

1. Z87.1 Practice for Occupational and Educational Eye and Face Protection
2. Z89.1 Requirements for Protective Headwear for Industrial Workers

B. American Society of Testing and Materials (ASTM)

1. D120 Standard Specifications for Rubber Insulating Gloves
2. D178 Standard Specifications for Rubber Insulating Matting
3. D1048 Standard Specifications for Rubber Insulating Blankets
4. D1049 Standard Specifications for Rubber Insulating Covers
5. D1050 Standard Specifications for Rubber Insulating Line Hose
6. D1051 Standard Specifications for Rubber Insulating Sleeves

1.2 Summary

A. The work covered by this specification consists of the safety aspects of performing operations during the installation or modification of the primary distribution systems. Primary distribution systems are defined as all power systems designed to be operated at more than 600 volts. It describes the minimum requirements necessary for the protection of personnel and equipment. Any additional safety requirements deemed necessary to assure personal safety shall be implemented. In no case will any of the precautions listed herein be deleted without prior approval by the Sandia Delegated Representative (SDR).

B. The requirements listed in this specification have been compiled to help prevent accidents. It is the responsibility of the contractor to ensure their personnel follow all system safety requirements. Specific requirements are listed in this specification for certain procedures. However, due to the nature of many jobs associated with the primary distribution system, not every procedure is described. It is imperative the contractor and their personnel exercise caution and good judgment in maintaining a safe work environment. No job is so important that it may be performed without due regard for personnel, equipment, and safety.

C. Related Specification: Section 01065, "Environment, Safety, and Health for Construction and Service Contracts"

1.3 System Description

A. Qualified Personnel: All primary system work shall be performed by a qualified, high voltage (HV) contractor, in a manner consistent with this specification. The contractor and his personnel performing such work shall be knowledgeable of the installation and maintenance requirements of primary systems. They shall have HV experience and shall have routinely worked on these types of systems.

1. All electrical work at SNL must be performed by a licensed entity and be in accordance with the State of New Mexico Construction Industries Division (NM CID), Title 14, Chapter 6, Part 6. The NM CID licensing requirements for commercial or industrial work at SNL must be followed. SNL requires that all entities contracting electrical work above 600V have a valid EL-1 license and work is performed by craftsmen with an EL-1J certification. This work includes installation of ductbanks, setting HV equipment, installing conduit, pulling cable and terminating cable, etc.

2. All contractor personnel shall become familiar with this specification, the referenced documents, and all state and municipal safety regulations as applicable.
3. The contractor shall designate an employee as Safety Officer on the work site who shall be responsible for implementation and supervision of all health, safety, environmental, and fire protection regulations. The requirements of Section II, Standard Terms and Conditions for Fixed Price Construction Contracts shall be included in with safety requirements listed in this specification.

B. Outage Coordination Meetings: The contractor and associated subcontractors shall attend outage coordination meetings for each and every scheduled outage associated with his/her work. A step-by-step outage procedure, including safety precautions, will be discussed at the outage coordination meeting. The contractor will be notified to attend the outage coordination meeting by the SDR.

C. Outage Notification: The SDR has a calendar of scheduled primary system outage dates. The contractor shall review these dates with the SDR and notify the SDR in writing no less than 21 days prior to the next available outage date. (This is not a guarantee the outage will occur on that date.)

D. Work Related Equipment:

1. The contractor shall furnish all the safety equipment to properly perform the work in a reliable and safe manner. The contractor shall furnish all equipment, including, but not limited to, material, personal safety equipment, plywood, barricades, warning lights, grounding clusters, "GROUND CLUSTERS INSTALLED" signs, blowers, oxygen and combustible gas monitor, generators, fire extinguishers, tools, and testers in accordance with this specification, and as required to complete the work.
2. To avoid nonproductive outages, cancellation of outages, or delays during outages, the contractor shall submit evidence to the SDR that he/she has all of the equipment and safety items available at the work location required for the primary system work.
3. It is the contractor's responsibility to maintain his equipment in a safe working condition and to ensure the equipment has been properly and routinely tested to meet and/or exceed the operations for which they were designed. At a minimum the equipment shall be inspected and tested under the conditions and at the intervals stated in the standard specification that governs the equipment's particular use.

E. All equipment shall be used per the manufacturers' instructions.

1.4 Quality Assurance

A. The latest issues of the following documents form a part of this specification as they apply to safety.

1. National Electrical Code® (NEC) (NFPA© 70)
2. National Electrical Safety Code® (NESC) – IEEE C2
3. Standard for Electrical Safety in the Workplace (NFPA 70E)
4. Occupational Safety and Health Administration (OSHA) – 29 CFR 1910 Standards regarding safety, practices, and equipment relating to high voltage work.

PART 2 - Products

2.1 High Voltage Tools and Testers

A. HV tools, testers, and their accessories shall be rated for the circuits and equipment to which they will be connected, and shall be suitable for the environment in which they will be used. Capacitive-type testers, which give a discrete analog or digital voltage reading, and are rated for the circuit voltage being tested, shall be used to test Elastimold® T-splices, and other non-shielded points, where no means exist to directly connect testers to the circuit being tested. The tool must be able to test phase-to-phase and phase-to-ground conditions. Ross Engineering Corp. High Voltage AC Voltmeter, Model VM 50D(Digital) or VM 50E (Analog) fulfill these requirements. The contractor shall check for proper operation of the test equipment immediately before and immediately after the test. If a known test source is not readily available, the contractor shall have the appropriate "test-tester" to check for proper operation of the tester.

2.2 Protective Headwear

1. Head protection shall be worn while in and working below the bucket of a bucket truck or aerial lift, when working in a substation yard, and when working inside a confined space. Hard hats shall comply with ANSI Z89.1, "Requirements for Protective Headwear for Industrial Workers". Hard hats shall be Class E minimum for work on primary systems. Class E hard hats are intended to reduce the force of impact of falling objects and to reduce the danger of contact with exposed high-voltage conductors. Representative sample shells are proof-tested at 20,000 volts phase-to-ground. Personal protective equipment (PPE) shall comply with NFPA 70E, Table 3-3.8 "Standards on Protective Equipment".
2. This voltage is not intended to be an indication of the voltage at which the headgear protects an individual. Hard hats shall be labeled on the inside of the shell to indicate compliance with this standard. This labeling shall contain the name of the manufacturer, the ANSI designation, and the class of the hard hat. The head protection shall be examined by the craftsman for chips, cracks, and any flaws in the material or workmanship prior to each use.

2.3 Eye and Face Protection

A. Protective equipment for the eyes or face shall be used where there is danger of injury to the eyes or face from electrical arcs or flashes, or from flying objects or falling objects from an electrical explosion. Eye and face protective equipment shall comply with ANSI Z87.1, "Practice for Occupational and Educational Eye and Face Protection." All protectors shall bear a legible and permanent "Z87" logo to indicate compliance with this standard. If the eye or face protection devices exhibit broken parts, heat distortion, or excessive scratches on the lens, it shall not be used. PPE shall comply with NFPA 70E, Table 3-3.8 "Standards on Protective Equipment."

2.4 Rubber Protective Equipment

A. This section lists the requirements for rubber protective equipment used for protection of workers from accidental contact with energized electrical conductors, equipment, or circuits. This includes, but is not limited to, **rubber insulating blankets, rubber insulating covers** (including insulator hoods, dead-end protectors, cable end covers, and miscellaneous covers), **rubber insulating line hose, rubber insulating matting** (for use as a floor covering), **rubber insulating sleeves, and rubber insulating gloves.** Rubber protective equipment shall be Class 1 minimum for work on circuits up to 5,000 volts phase-to-phase (Class 1 rubber protective equipment is rated for a maximum use voltage of 7,500 volts phase-to-phase, however, as an added safety factor this equipment shall not be used on circuits above 5,000 volts phase-to-phase). Class 2 rated rubber protective equipment is required for work on circuits from 5,001 volts phase-to-phase to 15,000 volts phase-to-phase (Class 2 rubber protective equipment is rated for a maximum use voltage of 17,000 volts phase-to-phase; however, as an added safety factor, this equipment shall not be used on circuits above 15,000 volts phase-to-phase). Rubber protective equipment shall comply with the latest edition of the following applicable specifications:

1. Blankets: ASTM D1048, Standard Specification for Rubber Insulating Blankets
2. PHoods: ASTM D1049, Standard Specification for Rubber Insulating Covers
3. Line Hoses: ASTM D1050, Standard Specification for Rubber Insulating Line Hose
4. Mats: ASTM D178, Standard Specification for Rubber Insulating Matting
5. Sleeves: ASTM D1051, Standard Specification for Rubber Insulating Sleeves
6. Gloves: ASTM D120, Standard Specification for Rubber Insulating Gloves

Note: Leather protectors shall be worn over rubber insulating gloves at all times.

B. Rubber protective equipment shall be marked clearly and permanently with the name of the manufacturer or supplier, the appropriate ASTM specification, type, class, and shall comply with ASTM standards for testing and testing intervals. PPE shall comply with NFPA 70E, Table 130.7(F) "Standards on Other Protective Equipment."

2.5 Grounding Clusters

A. Grounding clusters shall have ground clamps that are designed specifically for grounding the intended equipment. All ground clamps shall have been electrically tested by the grounding equipment manufacturer for its intended use. The contractor shall provide the manufacturer's certified test data upon request.

B. Grounding clusters for three-phase live front equipment shall be assembled per the manufacturer's recommendations of 6 foot (1.829m), No. 2/0 American Wire Gauge (AWG) copper ground cables, terminal block, and ground clamps. The cluster shall be rated at 21,000 Amps for 15 cycles minimum. Hastings Fiber Glass Products, Inc. grounding equipment catalog No. 6718 meets these requirements.

C. Grounding clusters for three-phase overhead conductors shall be assembled of a 3-wire ground cluster with C-Head ground clamps utilizing pressure type-bolted terminals and 6 foot (1.829m) by 1-½ inch (38.1 mm) fiberglass poles. The cluster shall be rated 21,000 Amps for 15 cycles minimum. Hastings Fiber Glass Products, Inc. grounding equipment catalog No. 11196 meets these requirements. Interconnect ground cluster and C-Head ground clamps with No. 2 AWG (minimum) copper welding conductor, length as required to properly ground the system being worked on.

D. Grounding clusters required for other equipment not listed herein (i.e. live-front and dead-front: Transformers, switchgear, panelboards, and switchboards) shall have ground clamps specifically designed for the intended equipment. These clusters shall be rated at 21,000 Amps for 15 cycles minimum.

2.6 Hot Sticks and Shot Guns

A. Hot sticks and shot gun (insulating devices) shall be used to maintain the necessary distance between the electrician and the energized circuit or equipment (consider every circuit energized until it has been tested, locked, tagged, and grounded). The hot stick and the shot gun shall have a minimum rating for the voltage being worked on.

B. Hot sticks and shot guns shall be visually inspected for:

1. Cracked or distorted end fittings
2. Hairline cracks or scars in the insulation
3. Blisters in poorly applied coatings that could trap moisture
4. If any of these conditions or other deficiencies are observed, the equipment shall not be used.

2.7 Protective Clothing

A. Protective clothing shall be used and selected in accordance with the requirements identified and in accordance with NFPA 70E, latest edition, Article 130, Personal and Other Protective Equipment.

PART 3 - Execution

3.1 General

A. No electrical work shall be performed on energized circuits unless specified on the contract drawings and as specified herein. Consider every circuit as energized until it has been locked out, tagged, tested, and grounded.

B. In addition to the requirements listed in this section the contractor shall strictly follow the requirements of NFPA 70E, Standard for Electrical Safety in the Workplace.

C. Two qualified HV journeyman electricians with valid NMCID EL1-J certification who work for a contractor are required for all energized HV operations.

D. The contractor shall not (except for a safety emergency) de-energize any portion of the HV system that will cause an outage to any SNL facility. SNL maintenance personnel will perform all HV switching.

3.2 Locking and Tagging Procedure

A. This section describes the procedure for locking out power systems for the protection of personnel and equipment. In addition, the requirements of the latest edition of NFPA 70E, Article 120, Establishing an Electrically Safe Work Condition, shall be strictly followed.

B. Note: When working with SNL personnel it is the responsibility of the contractor personnel to become familiar with SNLs PCD-005, Performing Lockout/Tagout (LOTO).

C. The SNL Maintenance organization will disconnect all power at its closest disconnect means.

D. A positive means of locking out all power at their points of disconnect shall be provided. Locks shall be used by all personnel who could be endangered by the energization of equipment they are working on or near. Padlocks shall be installed at each disconnect point prior to the time of work on the de-energized equipment. Each person shall attach his personal lock so he/she is assured the system is locked out. The locks shall be installed such that the system cannot be re-energized until all locks have been removed. If controls are located or designed to accommodate only one lock, a multiple-locking clasp or lockbox system shall be used.

E. Lockout tags listing the name and phone number of the individual authorized to place and remove the lock, date service was locked out, and why service is locked out shall be affixed at each lockout location. The lockout tags will be used only to supplement the lockout and identify the purpose. They shall not be used as a substitute for a lock.

F. Removal of a lock and tag shall be done only by the person who installed the lock and tag unless otherwise allowed per PCD-005, Performing Lockout/Tagout (LOTO).

G. Locks, lockout clasps, and lockout tags are to be supplied, installed, and removed by the contractor's personnel working on the system.

3.3 Testing and Phasing of Conductors

A. A minimum of two HV electrical contractor personnel, meeting the requirements of 1.3A(1), shall be at the specific work location for testing of conductors for energization and for phasing of circuits. The person(s) actually doing the work in this section shall wear the proper voltage rated rubber insulating gloves, eye protection, and protective headwear. Nomex® coveralls or 100 percent cotton clothing is highly recommended for testing and phasing operations.

B. Check to verify test equipment is working properly prior to, and after each use.

C. Test equipment must be rated for voltage being worked on. Test equipment must be tested for proper operation before being used.

D. Always test phase-to-phase and phase-to-ground when testing a circuit or equipment for de-energization. Test all combination of circuit paths each time you test a circuit. Fuzzing or Buzzing* is not a permissible method of testing a circuit for energization.

** Fuzzing or Buzzing is a common field technique where a wrench mounted on an insulated "hot-stick" or the metal head of a universal tool is held near a conductor.*

E. For voltages at and above 46 kV, use an approved voltage detector and a minimum of two insulating devices (insulated bucket truck and hot sticks) are required.

3.4 Grounding of Conductors

A. After the "lockout" procedures described in this specification are performed, the procedures in this section shall be followed for all conductors that are to be worked, including new cables not connected.

B. Grounding is required when working on any HV circuit.

C. The grounding of circuits and equipment is essential and no hands-on work on the circuit and equipment shall begin until the circuit and equipment has been de-energized, locked, tagged, tested, and grounded.

D. During the installation of grounding clusters, two qualified, NMCID EL-1J licensed, journeyman electricians are required when installing grounding clusters, wearing safety glasses, hard hat, properly rated HV insulated gloves and properly rated Arc-Flash clothing.

E. After the circuit has been de-energized and tested, attach one lead of the approved grounding cluster to the ground bar/conductor and tighten securely. Attach the other clamps to each phase using a shot gun if possible, and tighten securely.

F. After grounding clusters are installed, the contractor shall furnish and place a "GROUNDING CLUSTERS INSTALLED" warning sign in a conspicuous location at the grounding site.

G. When work is complete, remove the grounding cluster and the "GROUNDING CLUSTERS INSTALLED" sign. Using a shot gun, if possible, disconnect the phase connections first, and then remove the clamp from the grounding bar/conductor.

H. If it is determined by the HV crew doing the work and SNL that it is impractical or will present a safety hazard to ground a circuit or piece of equipment, the grounds can be left off but the circuit must then be worked as if it were energized.

3.5 Cutting Into Cable

A. The following steps shall be performed when cutting into cable that cannot be tested, at the specific work location, as being de-energized (for example, a cable that goes continuously through a manhole with no termination point).

B. A minimum of two NMCID EL-1J licensed journeyman HV electrical contractor personnel shall be at the specific work location for this procedure. The person(s) actually doing the work in this section shall wear rated rubber insulating gloves, eye and face protection, protective headwear, and properly rated Arc-Flash clothing.

C. The cable to be cut shall be identified as positively as possible. Lockout, tag, and ground the cable at the point of disconnect according to the requirements of this specification.

D. Utilize a suitable penetrating device such as a spiking clamp, or a remote actuated cable cutter to allow the electrician to remain outside the manhole or confined space while cutting or penetrating the cable.

E. Securely ground the penetrating device with No. 2/0 AWG copper ground cable and a ground clamp to a grounding point.

F. Use hot sticks or appropriate insulating handles to install the penetrating device around the cable and while penetrating the cable. Maintain a safe distance when performing this operation.

3.6 Confined Space and Substructure Work

A. For the purpose of this specification, confined space is defined as an area large enough and configured in such a way an individual can enter and perform assigned work, has limited or restricted means for entry or exit, and is not designed for continuous occupancy. Confined spaces include, but are not limited to, storage tanks, vessels, manholes, bins, boilers, sewers, utility vaults, tunnels, pipes, pits, vaults, and in some instances, excavations.

B. Requirements for confined space entry that shall apply are detailed under Section 01065, "Environment, Safety and Health Requirements for Construction and Service Contracts."

C. Fall Arrest and Retrieval Equipment: A full-body harness shall not be required when working in an energized electrical manhole. The Confined Space Entry Permit shall list all requirements and exceptions for fall arrest and retrieval equipment. Refer to Section 01065, "Environment, Safety and Health Requirements for Construction and Service Contracts," when fall arrest and retrieval equipment is required.

D. Fire Protection for Confined Space Work: Prior to entering any confined space containing oil-insulated equipment (i.e., transformers, switches), a 20-pound dry chemical fire extinguisher shall be made available outside the entrance. Fires in confined spaces are to be fought from the doorway or area access opening and only with the door or hatch in the open position. Personnel should immediately leave the room or area of a fire after using an extinguisher.

E. Protection of Equipment and Material in Electrical Manholes/Vaults: Contractor personnel shall not climb into or out of substructures by stepping on cable or hangers.

3.7 Work on Energized Feeders and Equipment

A. If there are no instructions on the drawings detailing work that may be done with energized feeders and equipment, adhere to the following table.

TABLE
Work on Energized Feeders and Equipment in Substructures

	Work Description	*Circuit Status During Work
1.	Checking cable current	E
2.	Inspection of cables and substructure interior	E
3.	Terminating cables into switches	R
4.	Rearranging position of cables on racks	P
5.	Splicing of cables or terminating stress cones	P
6.	Pulling in new cables	D
7.	Pulling out old cables	D
8.	General clean-up of bottom of substructure	E
9.	Pumping out water from substructure	E
10.	Working on substructure cover or ring	E
10.	Taping cables for fire protection	P
12.	Hi-pot testing of cables	P
13.	Labeling cables (if cable rearrangement is required)	P
14.	Labeling cables (if cable rearrangement is not required)	E
15.	Voltage testing of cables for phasing	N1

*CIRCUIT STATUS LEGEND

E All cables may be energized during all work.

P Only cables being worked on shall be de-energized.

R All cables attached to equipment being worked on shall be de-energized.

D Plywood (¼-inch minimum) or rubber blankets may be installed to protect existing cables when installing new cable without de-energizing the existing feeders. Factors to be considered include, but are not limited to, manhole size, and location of rigging equipment.

N1 Only feeders that are being phased will be re-energized.

END OF SECTION 26 04 75

Exceptional service in the national interest

Sandia National Laboratories

Section 26 05 13 – Medium-Voltage Cables

June 2019

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 26 05 13 – Medium-Voltage Cables

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
5/15/19	Henry Guan	Subst	Changes to references; changes/updates to connector/kit types; reformatted tables I and IV; major changes to Appendix A; three year review performed

Section 26 05 13 – Medium-Voltage Cables

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. This Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems rated 2001 volts to 15,000 volts.

1.3 References

A. Association of Edison Illuminating Companies (AEIC)

1. CS8-00, Specification for Extruded Dielectric Shielded Power Cables rated 5 through 46 kilovolt (kV)

B. American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE)

1. C2, National Electrical Safety Code®

C. American National Standards Institute/National Fire Protection Association® (ANSI/NFPA)

1. 70, National Electrical Code® (NEC)

D. American Society of Testing and Materials (ASTM)

1. B3, Standard Specification for Soft or Annealed Copper Wire
2. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard-Medium Hard, or Soft

E. Institute of Electrical and Electronics Engineers (IEEE)

1. 48, Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations
2. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
3. 404, Standard for Cable Joints for Use with Extruded Dielectric Cable Rated 5000V Through 46,000V and Cable Joints for Use with Laminated Dielectric Cable Rated 2500V through 500,000V

4. 592, Standard for Exposed Semiconducting Shields on High Voltage Cable Joints and Separable Insulated Connectors
5. 400.2, IEEE Guide for Field Testing of shielded Power Cable Systems Using Very Low Frequency (VLF) (less than 1 Hz)

F. Insulated Cable Engineers Association (ICEA)

1. S-93-639/ National Electrical Manufactures Association® (NEMA) WC74, Shielded Power Cable 5-46kV
2. S-97-682, Utility Shielded Power Cable rated 5-46kV
3. T-25-425, Guide for Establishing Stability of Volume Resistivity for Conducting Polymeric Components of Power Cables

G. Underwriters Laboratories, Inc. (UL)

1. 1072, Medium-Voltage Solid Dielectric

1.4 Definitions

A. NETA ATS: InterNational Electrical Testing Association Acceptance Testing Specification.

1.5 Action Submittals

A. The contractor shall submit a certification of attendance to the Sandia Delegated Representative (SDR) for approval, which contains the names of personnel who have successfully completed course(s) as specified in section 1.7C of this specification on the splicing and termination of medium-voltage cables approved for installation under this contract. The certificate of attendance shall be current within five years of performing any cable terminations. Persons listed by the contractor may be required to perform a dummy or practice splice and termination in the presence of the SDR before being approved as a qualified installer of medium-voltage cables. If that additional requirement is imposed, the SDR shall provide short sections of the approved types of cables along with the approved type of splice and termination kits and detailed manufacturer's instructions for the proper splicing termination of the approved cable types. The certification shall be accompanied by satisfactory proof of the training and experience of persons listed by the contractor as cable.

B. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.

C. Samples: 16-inch (400-mm) lengths of each type of cable indicated if requested.

1.6 Informational Submittals

A. Qualification Data as listed in 1.5 A.

B. Material Certificates: For each cable and accessory type, signed by manufacturers.

C. Source quality-control test reports.

D. Field quality-control test reports. Refer to appendices A and B.

E. Test Reports

1. Certified copies of production sampling and completed cable test reports described in section 1.7 of this specification shall be submitted prior to shipping cable and shall be a legible and coherent format. This data should include the X-Y plot of the partial discharge test per ICEA.
2. Test reports shall be in a legible and coherent format and reported in accordance with AEIC CS6.

F. Catalogue data: Submit catalogue data showing physical information, specifications used for manufacturing, and materials used to manufacture cable.

G. Submittal data shall include:

1. Letter stating cable meets specification and the date of cable manufacture
2. Conductor size
3. Conductor shield materials
4. Insulation material
5. Insulation thickness
6. Diameter over insulation
7. Insulation semiconductor thickness
8. Jacket material
9. Jacket thickness
10. Cable diameter
11. Weights per length of cable

1.7 Quality Assurance

A. All work performed in accordance with this specification must be in strict compliance with Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1926, Subpart N. Particular attention is directed to Safety-Related Work Practices, 1926.416, and Lockout and Tagging of Circuits, 1926.417.

B. All electrical work at Sandia National Laboratories (SNL) must be performed by a licensed entity and be in accordance with the State of New Mexico Construction Industries Division (NM CID), Title 14, Chapter 6, Part 6. The NM CID licensing requirements for commercial or industrial work at SNL must be followed. SNL policy requires that all entities contracting electrical work above 600V have a valid EL-1 license and work be performed by craftsmen with an EL-1J certification.

C. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

1. All contractors working on SNL’s high-voltage system shall require training on medium-voltage terminations.

(a) Contractor personnel terminating 600 Amp 15kV non-load-break T-splices and 200 Amp 15kV load-break connectors shall attend a minimum of four hours of a "Hands-On" training seminar conducted by an Elastimold® factory representative. Each individual shall be required to participate in the termination of the above-mentioned connectors. The training shall consist of the following items:

(i) General cable and stress relief theory
(ii) The manufacturer's recommended method for cable preparation of 15kV and 5kV tape shield ethylene propylene rubber (EPR) cable; this shall include the recommended tools and products for cable preparation.
(iii) The manufacturer's recommended method for the installation of 20MA and 30MA ground adapters, and 655CA cable adapters on a 15kV tape shield EPR cable.
(iv) The manufacturer's recommended method for the crimping of the conductor contact. The manufacturer shall review all approved tools that shall be used to crimp the conductor contact.
(v) The manufacturer's recommended method for installation of the 655LR Connector.
(vi) The manufacturer's recommended method for installation of 650BIP basic insulating and dead-end plugs. The recommended method for the installation of the 650CP connecting plug for the assembly of a two-way T-splice. The manufacturer shall review all recommended tools for this assembly.
(vii) Once a complete 600 Amp 655LR assembly has been terminated, the manufacturer shall suggest cable routing/positioning to prevent cable stress.
(viii) The manufacturer shall review the testing of a 600 Amp 655LR through the capacitive test point.
(ix) The manufacturer's recommended method for the installation of 168LR connectors on to 15kV and 5kV tape shield EPR cable. This shall include the correct method for crimping the compression lug and tightening of the probe.
(x) The manufacturer's recommended method for the insertion and removal of the 168LR connector on to or from load-break bushing. Manufacturer shall review cable routing/positioning to prevent cable stress.

(b) Each contractor personnel who terminates 5630K Series Quick Term II or 7600-S Series Quick Term III Cold Shrink Terminations connectors shall attend a minimum of four hours of a "Hands-On" training seminar conducted by a 3M factory representative. Each individual shall be required to participate in the termination of the above-mentioned connector. The training shall consist of the following items:

(i) General cable theory and stress relief theory
(ii) The manufacturer's recommended method for cable preparation of 15kV and 5kV tape shield EPR cable. This shall include the recommended tools and products for cable preparation.
(iii) The manufacturer's recommended method for the installation of a 5630K Series Quick Term II or 7600-S Series Quick Term III Cold Shrink on to tape shield EPR cable. This shall include the proper installation of the ground strap.

(iv) The manufacturer's recommended method for the crimping of the conductor lug. The manufacturer shall review all approved tools that shall be used to crimp the conductor contact.
(v) The manufacturer's recommended sealing method at the ground strap and conductor lug.
(vi) The manufacturer's suggested cable routing/positioning to prevent undue cable stress.

(c) Each contractor personnel who terminates 15kV TFT-ESG Raychem® Cold Shrink Terminations connectors shall attend a minimum of four hours of a “Hands-On” training seminar conducted by a Raychem factory representative. Each individual shall be required to participate in the termination of the above-mentioned connector. The training shall consist of the following items:

(i) General cable theory and stress relief theory
(ii) The manufacturer’s recommended method for cable preparation of 15kV and 5kV tape shield EPR cable. This shall include the recommended tools and products for cable preparation.
(iii) The manufacturer’s recommended method for the installation of a TFT-E-SG Raychem Cold Shrink on to 15kV tape shield EPR cable. This shall include the proper installation of the ground strap.
(iv) The manufacturer’s recommended method for the crimping of the conductor lug. The manufacturer shall review all approved tools that shall be used to crimp the conductor contact.
(v) The manufacturer’s recommended sealing method at the ground strap and conductor lug.
(vi) The manufacturer’s suggested cable routing/positioning to prevent undue cable stress.

2. Each attendee shall receive a certificate showing successful completion of the training class. The date of attendance and instructor must be listed

(a) The contractor shall be responsible for scheduling the training classes for each product manufacturer and for notifying SNL of the date(s).
(b) The contractor shall be responsible for furnishing all necessary cable samples and manufacturer product for a complete assembly.

D. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of NETA or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

E. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.

F. Alternating current (AC) Voltage Tests: Each factory reel length shall withstand AC voltage tests by the manufacturer at the factory in accordance with ICEA S-93-639.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to SNL, and marked for intended use.

H. Comply with IEEE C2 and NFPA 70.

1.8 Project Conditions

A. Interruption of Existing Electric Service: All work on primary conductors shall be done only when such conductors and equipment are de-energized. Unless otherwise noted on drawings, or directed, any tie-ins or connections to existing utilities or equipment that necessitate interruptions shall be performed on Saturday or Sunday, without additional contract costs. The contractor shall not interrupt any main electrical utility without a written request for an outage and a subsequent approval by Sandia National Laboratories/New Mexico.

1. Notify Sandia Designated Representative (SDR) in written request no fewer than 21 calendar days in advance of proposed interruption of electric service. Include the approximate duration the utility will be off.

2. Do not proceed with interruption of electric service without SDR’s written permission.

3. Phasing of reconnected feeders shall be identical to the existing phasing.

PART 2 - Products

2.1 General

A. All cable furnished shall be installed within 12 months of manufacture date. Labeling of cable shall be per NEMA and shall contain no less than the following information:

1. Name of manufacturer
2. NEC designation

B. Cable shall be operated at 60 Hertz, single or three phase, at system voltage of 5kV or 15kV. Suitable installations include in conduit for wet or dry locations, and in open air in sunlight.

2.2 Manufacturers

A. Available Manufacturers: Manufacturer shall have a minimum of 10 years proven and successful experience with the manufacturing of EPR-insulated cables. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following.

1. Cables

(a) Okonite Company (The)
(b) Prysmian-P

(c) Southwire Company

2. Cable Splicing and Terminating Products and Accessories:

(a) Solid Terminations:

(i) Outdoor: Thomas & Betts Corporation/Elastimold type 35 MTG with ground device for metallic shield Type 20 MA.
(ii) Indoor: 3M; Electrical Products Division, type 5630K Series Quick Term II, type 7620-S Series (5kV only) and 7690-S Series Quick Term III cold shrink Termination Kits, or Raychem TFT-E-SG.

(b) Separable Connectors:

(i) 600A (in manholes): Thomas & Betts Corporation/Elastimold. Type #K655BLR and Cooper Catalog #SSPL625AX* (where *-X is replaced by number of T-bodies).
(ii) 200A (Above ground sectionalizers and below grade pullboxes): 168LR-W*X** load-break connectors with test points mounted on Z-point load-break junction 163J-Z. Order one 168LR-W*X** and one 20MA-W* grounding device per phase.

a) *W is replaced by symbol per table in catalogue for insulation diameter. Size for cable supplied.
b) **X is replaced by symbol per table in catalogue for conductor size. Size for cable supplied.
c) ***Z is number of circuits to be terminated on to load-break junction.

2.3 Cables

A. Cable Type: [**MV105**].

B. Comply with UL 1072, AEIC CS 8

C. Conductor: [**Copper**]

D. Conductor Stranding: [**Concentric lay, Class B**] with stranding as noted below:

TABLE I

Conductor Size Range	Number of Strands
8 - 2	7
1 - 4/0	19
250 - 500	37
501 - 1000	61

E. Conductor Shield (Strand Screen):

1. The strand screen shall consist of an extruded semiconducting thermosetting compound applied over the conductor. It shall be of a material compatible with the thermal characteristics of this conductor metal and insulation, shall be uniformly and firmly bonded to the overlying insulation, and shall be free stripping from the conductor. A semiconducting

tape may be applied between the conductor and the extruded conductor screen. Okonite EPR-based semiconductor is an approved exception.

2. The D-C volume resistivity of the extruded conductor shield shall not exceed 1,000 meter-ohms at the maximum normal operating and emergency operating temperature accordance with ICEA Publication T-25-425.
3. The extruded strand shield shall have a minimum elongation of 100% after an air oven test at 121°C for seven days and a brittleness temperature not warmer than -10°C.
4. The contact area between the insulation and conductor shield shall not exhibit projections or irregularities which extend from the cylindrical surface of the conductor shield by more than five mils (.127 mm) toward the insulation or 10 mils (.254 mm) away from the insulation.

F. Conductor Insulation: Ethylene-propylene rubber.

1. It shall be contrasting in color from the extruded strand and insulation screens. It shall contain less than 5% polyethylene, and the ethylene content of the elastomer shall not exceed 72.5% by weight of ethylene to limit susceptibility to treeing. Insulation shall be homogeneous and free of gels or discolorations larger than 10 mils (.254 mm).
2. Insulation shall be for use in wet or dry locations at conductor temperatures not exceeding 105°C for continuous operation, 140°C emergency overload conditions, and 250°C short circuit conditions.
3. Insulation Thickness: [**133**] percent insulation level per Table II below:

TABLE II

Rated Circuit Voltage (kV) (Phase to Phase)	Conductor Size (AWG or kcmil)	Minimum Insulation Thickness (mils)	Maximum Insulation Thickness (mils)
5	8 - 1000	85 (2.16 mm)	120 (3.05 mm)
8	6 - 1000	135 (3.43 mm)	170 (4.32 mm)
15	2 - 1000	210 (5.33 mm)	250 (6.35 mm)

4. The interface between the insulation and insulation shield shall be free of contaminants larger than 4 mils. The insulation shall be free from contaminants, gels, and agglomerates larger than 10 mils.

G. Insulation Shield (Insulation Screen):

1. Insulation shield shall conform to ICEA S-93-639, except as modified herein.
2. The insulation screen shall consist of an extruded, semiconducting, thermosetting compound applied over and compatible with the insulation. It shall be of a material compatible with the thermal and chemical characteristics of the insulation and the overlaying metallic shield. Okonite EPR-based semiconductor material is an approved exception.
3. The thickness with corresponding minimum and maximum points shall be as specified in Table III:

TABLE III

Calculated Minimum Diameter over Insulation	Insulation Shield Minimum Point Thickness	Insulation Shield Maximum Point Thickness (mils)

(inches)		
0 - 1.000	24	60
1.001 - 1.500	32	60
1.501 - 2.000	40	75
2.001 and Larger	40	90

4. The insulation shield shall not alter its physical or electrical properties from exposure to sunlight or the elements.

   (a) The extruded insulation shield shall have a minimum elongation of 100% after an air oven test at 121°C for 7 days and a brittleness temperature not warmer than -30° C.

5. The D-C volume resistivity of the extruded insulation shield shall not exceed 75 meter-ohms, at 90°C, when tested in accordance with ICEA Publication T-25-425.
6. The insulation shield shall be free stripping from the insulation, and the tension necessary to remove the extruded insulation shield shall be 3 to 24 pounds (to 10.886 Kg), at room temperature, when tested in accordance with ICEA S-93-639.
7. The contact area between the insulation and insulation shield shall not exhibit projections or irregularities, which extends into the insulation from the insulation shield more than 5 mils and into the insulation shield from the insulation more than 7 mils.

H. Shielding: [**Copper tape or copper tape with wire shield**] helically applied over semiconducting insulation shield.

1. A copper tape with nominal thickness of 0.005 inches (.127mm) shall be applied directly over the insulation shield. The tape shall be of suitable width and shall lap at least 12.5% of its width. The tape shall be free from burrs and, where jointed, shall be made electrically continuous. (If wire shield is used, it shall be mechanically and electrically comparable.)
2. Application of tape shield or wire shield shall not deform the insulation.

I. Cable Jacket: [Sunlight-resistant polyvinyl chloride (PVC), black]

1. The average thickness of the jacket shall be not less than the values specified in the following table. The minimum thickness of the jacket at any point shall be no less than 80% of the specified minimum average thickness.

TABLE IV

Calculated Diameter of Cable under Jacket (inches)	Min. Thickness of Jacket (mils)
0.700 and Smaller	55 (1.40mm)
0.701 - 1.500	70 (1.78mm)
1.501 - 2.500	100 (2.54mm)
2.501 and Larger	125 (3.17mm)

2. Linear shrinkage of the jacket shall not exceed the linear shrinkage of the insulation.
3. The jacket shall be sunlight resistant in accordance with the requirements of UL 1072.

J. Cable Dimensions:

1. Cable dimensions shall be in accordance with ICEA S-97-682.
2. Diameters over insulation shall be in accordance with ICEA S-97-682.

2.4 Splice Kits

A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.

B. Unless specified otherwise, all splices and taps shall be as per items A and B below. Only where hand-made splices are called out on the contract documents shall Item E apply.

C. In manholes, splices for feeders shall only be 600 Amp non-load-break power distribution connectors. Approved manufacturers are Elastimold Catalog #K655BLR and Cooper Catalog #SSPL625AX* (where *-X is replaced by number of T-bodies). Order manufacturer's corresponding cable adapter and compression connector sized per phase conductor. Elastimold or Cooper insulating plug, basic insulating plug, and/or connecting plug shall be required for assembly. Manufacturer’s approved tape shield adaptors are required.

D. In above ground sectionalizing cabinets and below-grade pull boxes, splices shall be 200 Amp Elastimold 168LR-W*X** load-break connectors with test points mounted on Z-point load-break junction 163J-Z. Order one 168LR-W*X** and one 20MA-W* grounding device per phase. The Z-point load-break junction is to be mounted on a universal mounting bracket with parking stands.

1. *W is replaced by symbol per table in catalogue for insulation diameter. Size for cable supplied.
2. **X is replaced by symbol per table in catalogue for conductor size. Size for cable supplied.
3. ***Z is number of circuits to be terminated on to load-break junction.

E. Handmade splices to cable may be handmade from tape kits 3M 5700 series. Refer to manufacturer's catalogue selection guide for voltage, conductor size, and type information for ordering. Reference drawings for application of handmade splices.

2.5 Solid Terminations

A. Cable terminations shall have voltage ratings of no less than 15,000 volts (ungrounded neutral). The standard withstand test voltage of the completed terminations shall conform to IEEE Standard No. 48.

B. Outdoor, exposed to weather, such as riser poles Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector. Elastimold type 35MTG, or approved equal with the grounding device for the metallic shield (Elastimold Type 20 MA for metallic type shield) and NEMA 2-hole, long-barrel terminal connector. The connector shall be listed for copper/aluminum applications.

C. Indoor terminations that are inside equipment or weatherproof compartments of outdoor equipment, such as transformers and switchgear. Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.

   (a) It shall either be a one-piece design where high-dielectric constant stress control is integrated within a skirted insulator made of silicone rubber, gray in color, or provide for positive placement of the stress control with the installation of a stress patch. The termination shall not require heat or flame for installation. Only a NEMA 2-hole, long-barrel terminal connector shall be used. The connector shall be listed for copper/aluminum applications.
   (b) The terminations shall be 3M Brand 5630K Series Quick Term II, 7620-S Series (5kV only) or 7690-S Series Quick Term III cold shrink Termination Kits or Raychem TFT-E-SG. Only a NEMA 2-hole, long-barrel terminal connector shall be used. The connector shall be listed for copper/aluminum applications.

2.6 Separable Insulated Connectors

A. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

B. Load-Break Cable Terminators: Elbow-type units with 200-A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

C. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

D. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

E. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.7 Arc-Proofing Materials

A. Tape for First Course on Metal Objects: 10-mil- (250-micrometer-) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent 3M 77 tape, compatible with cable jacket.

C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch (13 mm) wide.

2.8 Source Quality Control

A. Test and inspect cables according to [**ICEA S-97-682**] before shipping. The cable shall be placed on the shipping reel with both ends of cable accessible for proof testing in Appendix A. Ends of cable shall be sealed with weatherproof material prior to shipment.

PART 3 - Execution

3.1 Installation

A. Install cables according to IEEE 576.

B. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Lubricate cables with Cablelube or Minerallac® cable pulling compound or the type approved by the cable manufacturer.

D. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

1. All cables in one conduit shall be pulled in together using a suitable patented grip on the conductors with a basket weave grip over the insulation, arranged so the stress of pulling is applied to the conductor and not the insulation.
2. Use a swivel between the cable grip and pulling rope.
3. Maximum pull tensions shall not exceed values recommended by the cable manufacturer or as specified on the drawings. Pulls shall be made in the directions shown on the plans.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

F. Support cables according to Section 26 05 29 "Hangers and Supports for Electrical Systems."

1. Install and terminate primary cables in accordance with the manufacturer's approved recommendations and tools suggestions. The conductors shall be free of kinks and twists, and all bends shall be formed with a smooth radius not smaller than 12 times the diameter of the cable, nor smaller than the minimum radius recommended by the manufacturer, whichever is greater. All 600 Amp and 200 Amp terminations shall be mounted to avoid any stress on the terminations.

G. In manholes and pull boxes, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag. In manholes, route cables a minimum of ¾ of manhole perimeter.

H. Install cable terminations and connectors only as indicated on the drawings.

I. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits. After cutting, if cable ends are not to be terminated in same working day cut, immediately protect cable ends from damage or moisture by sealing with cable caps and silicone sealant. Provide stress relief at all terminations. Provide correct phasing of the conductors of each circuit at all terminations. Provide proper connections of tape shield and drain wire to ground.

J. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
2. Portable Feed-Through Accessory: Three.
3. Standoff Insulator: Three.

K. Arc Proofing: Arc proof medium-voltage cable in manholes from duct entrance to duct exit held in place with 3M 69 tape. End three phase arc proofing application six feet from T-body connector, then individually wrap each conductor to T-body connector. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
3. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
4. Band arc-proofing tape with 1-inch- (25-mm-) wide bands of half-lapped, adhesive, glass-cloth tape 2 inches (50 mm) o.c.
5. Completely cover each cable and hand taped splice
6. Extend arc-proofing 1 inch onto splice/T-body connector
7. Extend arc-proofing 1inch into duct

L. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware. Connect to manhole and equipment ground systems.

M. Install cable identification tags (circuit numbers to be confirmed at the outage coordination meeting):

1. The cables shall have identification tags in manholes (at conduit entrances and splices) and at equipment terminations, indicating feeder number and routing (Example: Routing: "To MH-36", "To SW0893-1B", Feeder: "3501"). The tags shall be one-inch polypropylene plastic (Almetek EZH9), affixed to cables with plastic or nylon ties (see standard drawing WP5021STD, Example Feeder Labeling).
2. At underground riser poles where feeders make a transition from underground to overhead, the feeder number will be 2" x 2" (50.8 mm x 50.8 mm) black letters on yellow background adhesive-backed numbers. These numbers shall be attached to an aluminum strip nailed to wood or banded to steel pole above the cable terminator bracket.
3. After cables have been terminated or spliced and fireproofing tape is applied, each cable shall have a spiral wrap of colored ½" wide tape 3M #35 vinyl plastic applied over the fireproofing tape. Spiral wrap of colored tape shall be over the total length of cable, with maximum of a 5-inch (127 mm) separation between spirals. The color coding shall be as follows:

   (a) 2400 volt - No Colored Tape Required
   (b) 4160 volt - Red Tape (3M #10224)
   (c) 12470 volt - Blue Tape (3M #10240)

N. Cables of the same circuit shall have the phasing identified with color tape in manhole. Phase A with one wrap, Phase B with two wraps, and Phase C with three wraps.

O. Seal all duct runs in manholes going inside buildings with a water-tight seal.

P. The two-hole cable connectors shall be crimped with only the manufacturer's approved tool recommendations.

Q. Cable shield shall be grounded with #6 bare copper to manhole ground at all terminations to provide permanent, low-resistance bond

3.2 Field Quality Control

A. Prior to energizing the cable, testing of the cable shall be performed in the presence of the Sandia Construction Observer (SCO) in accordance with Appendix A.

B. Exposed ends of cable shall be prepared and cleaned prior to testing to minimize any leakage current.

C. Cable circuit ends must be cleaned and guarded for personnel safety during cable testing. Circuits not under test in the immediate vicinity shall be grounded.

D. Exposed circuit ends under test require a minimum separation from all elements not subjected to a test of one-inch (25.4 mm) per 10kV of test potential. After testing, cables shall be grounded for a minimum of four times as long as the test voltage was applied during the hi-potential tests to assure complete discharge.

E. When all cable, splices, and terminations have been tested in accordance with Appendix A, and test results have been accepted by the SCO, the cable system may be placed in service as per the outage procedure.

END OF SECTION 26 05 13

APPENDIX A: ACCEPTANCE TESTING OF NEW AND EXISTING CABLES

After the installation of the primary cables, the contractor shall employ an independent third party electrical testing firm to acceptance test cables per this specification. The testing firm shall be a full member company of the NETA. The testing firm shall submit proof documenting membership.

The electrical testing firm contractor shall use calibrated test equipment for performing dielectric withstand testing. Acceptable test methods are DC high potential (“Hi-pot”) or Very Low Frequency (“VLF”) tests utilizing a 0.1 Hz Sinusoidal waveform. New cables shall be tested to “Acceptance” voltage levels, whereas existing cables, or new cable runs spliced with existing cable, shall be tested to “Maintenance” voltage levels. The dielectric withstand testing times shall follow the durations defined on the appropriate Test Certificates in Appendices B and C. The contractor shall furnish all instruments and personnel required for the tests, and electrical power will be furnished to the contractor on an "as is available" basis; otherwise, the contractor supplies the generator.

- For a “Hi-Pot” test, a Cable High Potential Test Certificate (blank form, Appendix B) will be furnished to the contractor. The contractor shall fill out the appropriate information on this form at the time of making the test for approval.

- For a “VLF” test, a Very Low Frequency Test Certificate (blank form, Appendix C) will be furnished to the contractor. A Test Report with equivalent information from a test set’s factory software may be substituted for the Very Low Frequency Test Certificate.

The SDR shall file the form with the project file, and send a copy to the High Voltage Engineer or Technologist in Department 4852.

APP1.01 TEST PROCEDURE – WITHSTAND TESTING

All new medium voltage cables, and existing cables spliced to the new cables, shall be tested according to the following procedure for DC hi-potential or VLF (0.1 Hz Sinusoidal) withstand testing. (Note: This is not a grounding or switching procedure; see outage procedure for grounding and switching sequence.)

A. Field Testing of New Cables: Cable shall be tested after cable installation and installation of stress relief devices is complete. If the new cable is to be spliced to existing cable, testing of the new installed cable shall be performed prior to splicing. Both ends of the cable shall be isolated from air break switches, transformers, etc. Remove all grounds from cable to be tested. (Note: If conductors are left connected to the equipment, the test voltage shall not exceed the maximum rating of the equipment.) For cables terminated with a 200 Amp elbow connector, elbows shall be placed on an insulated parking bushing prior to test. For cables terminated with a 600 Amp T-splice connector, the T-splice shall be capped prior to test.

B. Field Testing of New Cables Jointed to Existing Cable

   1. After acceptance testing for new cables has been completed and new cables are spliced to existing cables, a second test of the entire cable run from termination to termination shall be made. This is only applicable where an existing cable is introduced into the circuit.

   2. The procedure for testing shall be the same as indicated in paragraph APP1.01(A) above, except that the test voltage will be reduced to the “Maintenance” level test values indicated on the appropriate form in Appendix B or C.

3. This test is also applicable for testing of existing 5kV and 15kV rated cable where it is important to test the integrity of the cable.

C. Dissipation of the charge build-up on the conductors shall be allowed to drain off through the test set and voltmeter circuit. After the potential drops below 95% of the test value, the conductor shall be solidly grounded. The grounds shall be left on all conductors for a minimum of four times as long as the test voltage was applied during hi-potential tests and/or as long as someone is handling the conductors.

APP1.02 FAULTY CABLE

A. Contractor Furnished: In the event that any new contractor-furnished cable fails to meet any of the above tests, the entire faulty cable shall be removed, replaced with new cable, and tested at no increase in the contract price.

- End of Appendix A -

APPENDIX B: MEDIUM VOLTAGE CABLE HI-POTENTIAL TESTING REPORT FORMS

PREPARED BY:		SANDIA NATIONAL LABORATORIES/ NEW MEXICO	FORM B-1
CHECKED BY:		**CABLE HI POTENTIAL TEST CERTIFICATE**	SPEC. NO.: 260513
DATE:	REV. C 03/19	**15KV CLASS NEW INSTALLATION**	ELECTRICAL

CONTRACT NO. ________________________ DATE ______________
CABLE OR DESIGNATION ________________________
LOCATION ________________________
____
CABLE SIZE ________________________
INSULATION AND JACKET TYPE ______________ LENGTH ______________ FT
MAX. CURRENT AFTER 100% TEST VOLTAGE APPLIED ________________________

CABLE ACCEPTABLE ______________ NOT ACCEPTABLE ______________
TEST CONDUCTED BY: ________________________
TEST WITNESSED BY: ________________________
REMARKS: ________________________
TEMPERATURE: __________ °F WEATHER CONDITIONS: ______________
____

15KV RATED, EPR, 133% INSULATION LEVEL, HI-POTENTIAL TEST FOR INITIAL INSTALLATION TEST (NEW CABLE)

STEP	VOLTAGE LEVEL**	DURATION	TIME ELAPSE	MICRO AMPS *	POLARIZATION INDEX = STEP 4 / STEP 9
1	15 kV	1 Min.	1 Min.		
2	30 kV	1 Min.	2 Min.		
3	45 kV	1 Min.	3 Min.		
4	50 kV	1 Min.	4 Min.		__________
5	50 kV	1 Min.	5 Min.		
6	50 kV	1 Min.	6 Min.		
7	50 kV	1 Min.	7 Min.		
8	50 kV	1 Min.	8 Min.		
9	50 kV	1 Min.	9 Min.		__________ = __________

* READING AT END OF 1 MIN. DURATION PRIOR TO RAISING VOLTAGE TO NEXT STEP.
** BETWEEN EACH STEP RAISE VOLTAGE UNIFORMLY.
NOTE: STOP TEST IF CURRENT STEADILY INCREASES AT CONSTANT VOLTAGE.

POLARIZATION RESULTS:
IF 1.25–2.0 GOOD
IF BELOW 1.0 FAILURE
IF 1.0–1.25 MARGINAL

PREPARED BY:		SANDIA NATIONAL LABORATORIES/ NEW MEXICO	FORM B-2
CHECKED BY:		**CABLE HI POTENTIAL TEST CERTIFICATE**	SPEC. NO.: 260513
DATE:	REV. C 03/19	**15KV CLASS EXISTING INSTALLATION**	ELECTRICAL

CONTRACT NO. ______________________ DATE ______________
CABLE OR DESIGNATION ______________________
LOCATION ______________________
____
CABLE SIZE ______________________
INSULATION AND JACKET TYPE ______________ LENGTH______________FT
MAX. CURRENT AFTER 100% TEST VOLTAGE APPLIED______________

CABLE ACCEPTABLE ______________ NOT ACCEPTABLE ______________
TEST CONDUCTED BY: ______________________
TEST WITNESSED BY: ______________________
REMARKS: ______________________
TEMPERATURE: __________ °F WEATHER CONDITIONS: ______________
____

15KV RATED, EPR, 133% INSULATION LEVEL, HI-POTENTIAL TEST FOR EXISTING CABLE AND FOR NEW CABLE SPLICED TO EXISTING CABLE.

STEP	VOLTAGE LEVEL**	DURATION	TIME ELAPSE	MICRO AMPS *	POLARIZATION INDEX = STEP 2 / STEP 7
1	15 k kV	1 Min.	1 Min.		
2	22 kV	1 Min.	2 Min.		__________
3	22 kV	1 Min.	3 Min.		
4	22 kV	1 Min.	4 Min.		
5	22 kV	1 Min.	5 Min.		
6	22 kV	1 Min.	6 Min.		
7	22 kV	1 Min.	7 Min.		__________ = __________

* READING AT END OF 1 MIN. DURATION PRIOR TO RAISING VOLTAGE TO NEXT STEP.
** BETWEEN EACH STEP RAISE VOLTAGE UNIFORMLY.
NOTE: STOP TEST IF CURRENT STEADILY INCREASES AT CONSTANT VOLTAGE.

POLARIZATION RESULTS:
IF 1.25–2.0 GOOD
IF BELOW 1.0 FAILURE
IF 1.0–1.25 MARGINAL

PREPARED BY:		SANDIA NATIONAL LABORATORIES/ NEW MEXICO	FORM B-3
CHECKED BY:		**CABLE HI POTENTIAL TEST CERTIFICATE**	SPEC. NO.: 260513
DATE:	REV. C 03/19	**5KV CLASS NEW INSTALLATION**	ELECTRICAL

CONTRACT NO. ________________________ DATE ______________
CABLE OR DESIGNATION ____
LOCATION ____
____
CABLE SIZE ____
INSULATION AND JACKET TYPE ____________________ LENGTH ______________FT
MAX. CURRENT AFTER 100% TEST VOLTAGE APPLIED______________________

CABLE ACCEPTABLE ____________________ NOT ACCEPTABLE ______________
TEST CONDUCTED BY: ____
TEST WITNESSED BY: ____
REMARKS: ____
TEMPERATURE: ____________°F WEATHER CONDITIONS: ______________________
____

5KV CABLE, HI-POTENTIAL TEST FOR INITIAL INSTALLATION TEST (NEW CABLE)

STEP	VOLTAGE LEVEL**	DURATION	TIME ELAPSE	MICRO AMPS *	POLARIZATION INDEX = STEP 5 / STEP 10
1	5 kV	1 Min.	1 Min.		
2	10 kV	1 Min.	2 Min.		
3	15 kV	1 Min.	3 Min.		
4	20 kV	1 Min.	4 Min.		
5	25 kV	1 Min.	5 Min.		____________
6	25 kV	1 Min.	6 Min.		
7	25 kV	1 Min.	7 Min.		
8	25 kV	1 Min.	8 Min.		
9	25 kV	1 Min.	9 Min.		
10	25 kV	1 Min.	10 Min.		____________ = ____________

* READING AT END OF 1 MIN. DURATION PRIOR TO RAISING VOLTAGE TO NEXT STEP.
** BETWEEN EACH STEP RAISE VOLTAGE UNIFORMLY.
NOTE: STOP TEST IF CURRENT STEADILY INCREASES AT CONSTANT VOLTAGE.

POLARIZATION RESULTS:
IF 1.25–2.0 GOOD
IF BELOW 1.0 FAILURE
IF 1.0–1.25 MARGINAL

PREPARED BY:		SANDIA NATIONAL LABORATORIES FACILITIES DEPARTMENT	FORM B-4
CHECKED BY:		**CABLE HI POTENTIAL TEST CERTIFICATE**	SPEC. NO.: 260513
DATE:	REV. C 03/19	**5KV CLASS EXISTING INSTALLATION**	ELECTRICAL

CONTRACT NO. ______________________ DATE ______________
CABLE OR DESIGNATION ______________________
LOCATION ______________________
____
CABLE SIZE ______________________
INSULATION AND JACKET TYPE ______________ LENGTH______________FT
MAX. CURRENT AFTER 100% TEST VOLTAGE APPLIED______________________

CABLE ACCEPTABLE ______________ NOT ACCEPTABLE ______________
TEST CONDUCTED BY: ______________________
TEST WITNESSED BY: ______________________
REMARKS: ______________________
TEMPERATURE: __________ °F WEATHER CONDITIONS: ______________
____

5 KV CABLE, HI-POTENTIAL TEST FOR EXISTING CABLE AND FOR NEW CABLE SPLICED TO EXISTING CABLE

STEP	VOLTAGE LEVEL**	DURATION	TIME ELAPSE	MICRO AMPS *	POLARIZATION INDEX = STEP 2 / STEP 7
1	5 kV	1 Min.	1 Min.		
2	8 kV	1 Min.	2 Min.		__________
3	8 kV	1 Min.	3 Min.		
4	8 kV	1 Min.	4 Min.		
5	8 kV	1 Min.	5 Min.		
6	8 kV	1 Min.	6 Min.		
7	8 kV	1 Min.	7 Min.		__________ = __________

* READING AT END OF 1 MIN. DURATION PRIOR TO RAISING VOLTAGE TO NEXT STEP.
** BETWEEN EACH STEP RAISE VOLTAGE UNIFORMLY.
NOTE: STOP TEST IF CURRENT STEADILY INCREASES AT CONSTANT VOLTAGE.

POLARIZATION RESULTS:
IF 1.25–2.0 GOOD
IF BELOW 1.0 FAILURE
IF 1.0–1.25 MARGINAL

APPENDIX C: MEDIUM VOLTAGE CABLE VERY LOW FREQUENCY TESTING REPORT FORMS

PREPARED BY:		SANDIA NATIONAL LABORATORIES/ NEW MEXICO	FORM C-1
CHECKED BY:		**CABLE VERY LOW FREQUENCY TEST CERTIFICATE,**	SPEC. NO.: 260513
DATE:	REV. A 03/19	**15KV CLASS NEW INSTALLATION**	ELECTRICAL

CONTRACT NO. ____________________ DATE ____________
CABLE OR DESIGNATION ____________________
LOCATION ____________________
____
CABLE SIZE ____________________
INSULATION AND JACKET TYPE ____________ LENGTH____________FT
MAX. CURRENT AFTER 100% TEST VOLTAGE APPLIED____________

CABLE ACCEPTABLE ____________ NOT ACCEPTABLE ____________
TEST CONDUCTED BY: ____________________
TEST WITNESSED BY: ____________________
REMARKS: ____________________
TEMPERATURE: ____________ °F WEATHER CONDITIONS: ____________
____

15KV RATED, EPR, 133% INSULATION LEVEL, VERY LOW FREQUENCY (0.1 HZ, SINUSOIDAL) TEST FOR INITIAL INSTALLATION TEST (NEW CABLE)

STEP	VOLTAGE LEVEL	DURATION	TIME ELAPSE	CURRENT (uA)	CAPACITANCE (nF)	RESISTANCE (GOhm)
1	5 kV	1 Min.	1 Min.			
2	10 kV	1 Min.	2 Min.			
3	15 kV	1 Min.	3 Min.			
4	21 kV	57 Min.	60 Min.			

* READING AT END OF 1 MIN. DURATION PRIOR TO RAISING VOLTAGE TO NEXT STEP.
** BETWEEN EACH STEP RAISE VOLTAGE UNIFORMLY.
NOTE: STOP TEST IF CURRENT STEADILY INCREASES AT CONSTANT VOLTAGE.

PREPARED BY:	SANDIA NATIONAL LABORATORIES/ NEW MEXICO	FORM C-2
CHECKED BY:	**CABLE VERY LOW FREQUENCY TEST CERTIFICATE**	SPEC. NO.: 260513
DATE: REV. A 03/19	**15KV CLASS EXISTING INSTALLATION**	ELECTRICAL

CONTRACT NO. ________________________ DATE ______________
CABLE OR DESIGNATION ________________________________
LOCATION ____
____
CABLE SIZE ____
INSULATION AND JACKET TYPE __________________ LENGTH ______________ FT
MAX. CURRENT AFTER 100% TEST VOLTAGE APPLIED ______________________

CABLE ACCEPTABLE ____________________ NOT ACCEPTABLE ________________
TEST CONDUCTED BY: ____
TEST WITNESSED BY: ____
REMARKS: ____
TEMPERATURE: ____________ °F WEATHER CONDITIONS: ____________________
____

15KV RATED, EPR, 133% INSULATION LEVEL, VERY LOW FREQUENCY (0.1 HZ, SINUSOIDAL) TEST FOR EXISTING CABLE AND FOR NEW CABLE SPLICED TO EXISTING CABLE.

STEP	VOLTAGE LEVEL	DURATION	TIME ELAPSE	CURRENT (uA)	CAPACITANCE (nF)	RESISTANCE (GOhm)
1	4 kV	1 Min.	1 Min.			
2	8 kV	1 Min.	2 Min.			
3	12 kV	1 Min.	3 Min.			
4	16 kV	57 Min.	60 Min.			

* READING AT END OF 1 MIN. DURATION PRIOR TO RAISING VOLTAGE TO NEXT STEP.
** BETWEEN EACH STEP RAISE VOLTAGE UNIFORMLY.
NOTE: STOP TEST IF CURRENT STEADILY INCREASES AT CONSTANT VOLTAGE.

PREPARED BY:		SANDIA NATIONAL LABORATORIES/ NEW MEXICO	FORM C-3
CHECKED BY:		**CABLE VERY LOW FREQUENCY TEST CERTIFICATE**	SPEC. NO.: 260513
DATE:	REV. A 03/19	**5KV CLASS NEW INSTALLATION**	ELECTRICAL

CONTRACT NO. ______________________ DATE ______________
CABLE OR DESIGNATION ______________________________________
LOCATION ____
____
CABLE SIZE ____
INSULATION AND JACKET TYPE ________________ LENGTH______________FT
MAX. CURRENT AFTER 100% TEST VOLTAGE APPLIED_______________________

CABLE ACCEPTABLE ________________ NOT ACCEPTABLE ______________
TEST CONDUCTED BY: ______________________________________
TEST WITNESSED BY: ______________________________________
REMARKS: ____
TEMPERATURE: __________°F WEATHER CONDITIONS: ________________
____

5KV CABLE, VERY LOW FREQUENCY (0.1 HZ, SINUSOIDAL) TEST FOR INITIAL INSTALLATION TEST (NEW CABLE)

STEP	VOLTAGE LEVEL	DURATION	TIME ELAPSE	CURRENT (uA)	CAPACITANCE (nF)	RESISTANCE (GOhm)
1	2.5 kV	1 Min.	1 Min.			
2	5 kV	1 Min.	2 Min.			
3	7.5 kV	1 Min.	3 Min.			
4	10 kV	57 Min.	60 Min.			

* READING AT END OF 1 MIN. DURATION PRIOR TO RAISING VOLTAGE TO NEXT STEP.
** BETWEEN EACH STEP RAISE VOLTAGE UNIFORMLY.
NOTE: STOP TEST IF CURRENT STEADILY INCREASES AT CONSTANT VOLTAGE.

PREPARED BY:	SANDIA NATIONAL LABORATORIES FACILITIES DEPARTMENT	FORM C-4
CHECKED BY:	**CABLE VERY LOW FREQUENCY TEST CERTIFICATE**	SPEC. NO.: 260513
DATE: / REV. A 03/19	**5KV CLASS EXISTING INSTALLATION**	ELECTRICAL

CONTRACT NO. ____________________ DATE ____________
CABLE OR DESIGNATION ____________________
LOCATION ____________________
____
CABLE SIZE ____________________
INSULATION AND JACKET TYPE ____________ LENGTH ____________ FT
MAX. CURRENT AFTER 100% TEST VOLTAGE APPLIED ____________

CABLE ACCEPTABLE ____________ NOT ACCEPTABLE ____________
TEST CONDUCTED BY: ____________________
TEST WITNESSED BY: ____________________
REMARKS: ____________________
TEMPERATURE: ____________ °F WEATHER CONDITIONS: ____________

5 KV CABLE, VERY LOW FREQUENCY (0.1 HZ, SINUSOIDAL) TEST FOR EXISTING CABLE AND FOR NEW CABLE SPLICED TO EXISTING CABLE

STEP	VOLTAGE LEVEL	DURATION	TIME ELAPSE	CURRENT (uA)	CAPACITANCE (nF)	RESISTANCE (GOhm)
1	2 kV	1 Min.	1 Min.			
2	4 kV	1 Min.	2 Min.			
3	6 kV	1 Min.	3 Min.			
4	7 kV	57 Min.	60 Min.			

* READING AT END OF 1 MIN. DURATION PRIOR TO RAISING VOLTAGE TO NEXT STEP.
** BETWEEN EACH STEP RAISE VOLTAGE UNIFORMLY.
NOTE: STOP TEST IF CURRENT STEADILY INCREASES AT CONSTANT VOLTAGE.

Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

March 2018

Effective Date: 03/22/2018
Review Date: 03/22/2021

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
03/15/2018	Tim Peterson	Admin	3-year review performed. No changes made.

Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Sections include the following:

1. Section 26 05 13 "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.

1.3 Action Submittals

A. Product Data: For each type of product indicated.

B. Shop drawings are required for any substituted equipment furnished by the Contractor that results in changes to control or power wiring as shown on contract drawings. This includes circumstances where substitute components, control schemes, or power wiring are presented and approved that cause a change in the following:

1. Size, number, or type of wires
2. Size of conduit and its routing
3. Connection changes
4. Sequence of operation

C. If any of the changes described in 1.5D occur, new shop drawings showing the following must be submitted:

1. Elementary ladder diagram
2. Conduit plan
3. Wiring diagram
4. Conduit identification schedule
5. Sequence of operation

D. Drawings must include each diagram or plan of the contract drawing that is affected.

1. Drawings must be provided of the same size as the original construction drawings, and must be reproducible copies.
2. If the changes are minor and the Contractor chooses to do so, a print of the original contract drawing can be made, and changes noted for approval. This drawing must become part of the as-built documentation submitted near the conclusion of the work.

1.4 Informational Submittals

A. Submit contractor licenses and certifications as part of the bid evaluation documents. Follow the licensing requirements in Section 1.5 E of this specification.

B. Qualification Data: For testing agency.

C. Field quality-control test reports.

1.5 Quality Assurance

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association (NETA) or is a nationally recognized testing laboratory (NRTL) as defined by the Occupational Safety and Health Administration (OSHA) in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

D. All work performed in accordance with the specifications listed in section 1.2 must be in strict compliance with OSHA regulation 29 CFR 1926, Subpart N. Particular attention is directed to *Safety-Related Work Practices,* 1926.416, and *Lockout and Tagging of Circuits,* 1926.417.

E. All electrical work at Sandia National Laboratories (SNL) must be performed by a licensed entity and be in accordance with the State of New Mexico Construction Industries Division (NM CID), Title 14, Chapter 6, Part 6. The NM CID licensing requirements for commercial or industrial work at SNL must be followed. All entities contracting electrical work above 600V are required to have a valid EL-1 license and work is performed by craftsmen with an EL-1J certification.

PART 2 - Products

2.1 Power Conductors and Cables

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

1. Alcan Products Corporation; Alcan Cable Division.
2. American Insulated Wire Corp.; a Leviton Company.
3. General Cable Corporation.
4. Senator Wire & Cable Company.
5. Southwire Company.

B. Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN.

D. Multiconductor Cable: Comply with NEMA WC 70 for armored cable, Type AC and metal-clad cable, Type MC with ground wire. All such cables must have a green, insulated, copper ground conductor; bare metal and noncopper grounds must not be used.

2.2 Power Conductors and Cables Connectors and Splices

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - Execution

3.1 Conductor Material Applications

A. Feeders: Copper Solid for No. 10 American wire gauge (AWG) and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger. Must not be smaller than No. 12 AWG copper wire.

C. The use of solid or stranded wire must meet the equipment manufacturer's installation requirements.

D. All conductors must be color-coded according to SNL Standard Drawing E-0006STD.

3.2 Conductor Insulation and Multiconductor Cable Applications and Wiring Methods

A. Service Entrance: Type THHN-THWN, single conductors in raceway

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway

E. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway

F. Feeders in Cable Tray: Type THHN-THWN, single conductors in raceway exposed branch circuits, including in crawlspaces: Type THHN-THWN, single conductors in raceway

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway

H. Metal-clad cable (MC cable) or armored cable (AC cable) can be used for branch circuit wiring of 120/208 volt receptacles, 120/277 volt lighting, and similar terminal loads such as valves, dampers, and variable-air-volume units, where it meets the following requirements:

1. The cable can be concealed in interior (nonstructural) walls and Dowcraft® wall partitions only when run vertically from locations, or above accessible ceilings where its use can be noted.
2. The cable must not be surface-mounted.
3. The cable conductors must be color-coded according to Standard Drawing E-0006STD. When the cable's integral insulation color is not in compliance with this requirement, apply colored sleeves at the accessible points.
4. The cable outer jacket can be aluminum or steel, and can further be coated with a polyvinyl chloride (PVC) or similar jacket where required for the installation conditions.
5. The maximum number of conductors allowed in a single cable assembly is limited to five, including the neutral and ground conductors.
6. The cable can be used as a flexible terminal connection when the drawings otherwise call for one in a NEMA 1 environment. Maximum length must not exceed 3 feet, except for luminaire whips.

I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway

J. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway

K. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

L. Class 1 Control Circuits: Type THHN-THWN, in raceway, No. 16 AWG copper.

M. Class 2 Control Circuits: Type THHN-THWN, in raceway, No. 20 AWG copper.

3.3 Installation of Conductors and Cables

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway. Equipment used for pulling conductors must be suited and listed for such use by the manufacturer. Before using a steel or conductive fish tape, the Contractor must first visually verify the raceway routing. If there is doubt as to the location of the far end of a conduit, nonconductive fish tape must be used for safety.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Section 26 05 29 "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to SNL Standard Drawing E-0006STD.

1. All conductors in panels must be tagged, including neutral and ground conductors. Install a Bradey slip-on label on conductors sized less than No. 6 AWG, and install a Panduit #MP-350C tag and tie wrap on conductors sized No. 6 AWG or larger. Use a Panduit marking pen PX-O or a Sharpie® permanent marker for labels. These tags must list the circuit number.
2. All conductors must be additionally tagged in every box and cabinet, including device or fixture (lighting) outlet, and light fixture compartment, with Brady slip-on labels. Wraparound stick-on labels are allowed only where slip-on labels cannot be used. These labels must identify each conductor's panel and circuit number, or terminal number.
3. Neutral and grounding conductors must be similarly tagged with all the circuits they serve in each box and at the panelboard.
4. Computer rooms and all other areas where an isolated ground conductor is required must have the ground conductor similarly identified (tagged) with all the circuits they serve in each box.
5. Box covers must not be installed until approval has been obtained from the Sandia Construction Inspector for tagging at each box.
6. A shared neutral or super-neutral must not be used with single-phase circuits that are otherwise independent. When part of a multicircuit run in a single conduit, separate neutrals must be identified by a color stripe to identify which phase they serve. A multiphase shared neutral is permitted only where shown specifically on the drawings,

and the circuit must be served by a single multiphase circuit protector with one handle or a handle tie, such that a single action disconnects all phases returning on that neutral.

G. Removal and demolition of conductors:

1. Unneeded electrical equipment, raceways, and conductors must not be abandoned in place, unless specifically required on the contract drawings for continuity of service and/or possible future use such as security systems in closed areas.
2. Conductors specifically identified on the drawings to remain must be disconnected, identified, and capped at both ends. Under no circumstances does an unused conductor remain energized.
3. Circuits serving removed loads must be removed back to the service equipment of the circuits' origin (switchgear, motor control center, or panelboard) as follows, unless specifically shown otherwise on the drawings (circuits associated with security systems in closed areas will be specifically identified as to remain in place or to be removed):

   a. Remove all conduit, conductors, switches, controllers, and related electrical equipment from the removed load back to the service equipment point of origin. If a circuit serves multiple loads, remove the conduit, conductors, switches, controllers, and related electrical equipment dedicated to the removed load back to its interconnection with the circuit to remain.
   b. Patch and paint all penetrations (including restoration of fire rating as necessary) and all anchor points for the removed conduit, conductors, switches, controllers, and related electrical equipment.
   c. If installed, remove all Facility Control System (FCS) and telecommunications wiring and conduit from the removed load to the source; for example, the FCS field interface device (FID) cabinet or telecommunications drop.
   d. Close the penetration of the service equipment and FID cabinets in accordance with National Electric Code (NEC) section 110.12(A), Mechanical Execution of Work, Unused Openings.
   e. Mark the FCS channel, panelboard circuit, or motor control center compartment as "spare." Update the equipment labels and panel schedules appropriately.

H. Class I and Class II control and signal cabling installed in conduit must not exceed the conduit fill requirements and pulling tensions of the NEC for power conductors of the same size, or the manufacturer's recommendations, whichever is less.

3.4 Connections

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

D. All wiring connections secured by split-bolts, nuts, threaded studs, bolts, screws-into-threaded-buses, and similar devices must use only listed parts designed by the manufacturer to be paired. Choose lugs, studs, and bolts so that nuts can be torqued down on the connection and have a minimum of three complete threads, but no more than ½-inch exposed on the open side of the nut. Connectors having a specified torque value for installation must be torqued to that value using a torque-metering tool listed for that use and torque range.

E. Power conductors must be continuous from outlet to outlet, and splices must not be made except within outlet or junction boxes. (Junction boxes must be used where required.)

1. Requirements of NEC Articles 374 and 390 for splicing in underfloor raceways must be strictly followed; however, under no circumstances are conductors be "looped" or "fed through."
2. Conductor color coding according to Standard Drawing E-0006STD is required in all new installations unless otherwise specified on drawings.

F. Except where approved by the Sandia Construction Manager, splices are not allowed in controls wiring, nor in wiring to life-safety devices.

G. Approved Splices and Terminations

1. For wiring below 600 volts, necessary splices can be made with insulated, screw-type connectors (Wire-Nuts® or equivalent), except for conductors sized No. 8 AWG and larger. For splices in conductors sized No. 8 AWG or larger, approved in any alarm, communication, or FCS conductors, and those in conductors serving vibrating or rotating machinery, permanent crimp-, bolt-, or solder-type connectors must be used.
2. All splicing connectors must be furnished with an insulated cover equivalent to the conductor insulation (taping alone is not acceptable). Split-bolt connectors will only be allowed when specific approval from the Sandia Construction Manager is obtained before each use.

H. A connector aid compound must be used at all splices to existing aluminum wire.

I. Terminal lugs must be used on all stranded conductors.

J. A Belleville spring washer must be used where existing aluminum terminals are connected to copper or steel terminals with steel bolts.

3.5 Sleeve and Sleeve-Seal Installation for Electrical Penetrations

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies

3.6 Firestopping

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 07 84 13 "Penetration Firestopping."

3.7 Field Quality Control

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. After the system installation is complete, and at such time as directed by the Sandia Construction Manager, the Contractor must conduct an operating test for demonstration of completion of the work. This test can be in addition to, and part of, a formal system commissioning procedure, but must not replace such commissioning event.

C. Perform tests and inspections and prepare test reports.

D. Tests and Inspections:

1. Performing NETA tests on all conductors and cables can be expensive. Consider limiting testing to a certain group of conductors, such as service entrance and feeder conductors, or to those conductors feeding critical equipment and services. To require all conductors and cables to be tested, delete option in first subparagraph below and delete associated subparagraph.

    a. After installing conductors and cables and before electrical circuitry has been energized, test when requested any designated wire, cable devices, and equipment after their installation to assure that all of the material continues to possess all the original characteristics, as required by all governing codes and standards listed in these specifications.
    b. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
    c. Electrical equipment must not be energized prior to inspection by the Sandia Construction Inspector.
    d. Ceiling tiles must not be installed prior to inspection by the Sandia Construction Inspector of any above-ceiling installed electrical equipment.

E. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

F. Remove and replace malfunctioning units and retest as specified above.

G. At the time of the operational testing, a complete set of as-built drawings must be given to the Sandia Project Manager.

END OF SECTION 26 05 19

Exceptional service in the national interest

Sandia National Laboratories

Section 26 05 26 – Grounding and Bonding for Electrical Systems

March 2018

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 26 05 26 – Grounding and Bonding for Electrical Systems

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
3/21/18	Tim Peterson	Admin	3-year review performed; no changes implemented

Section 26 05 26 – Grounding and Bonding for Electrical Systems

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section includes grounding systems and equipment.

B. Related Sections: Refer to the following sections for related work.

1. Section 26 05 43 “Underground Ducts and Raceways for Electrical Systems”

2. Section 26 41 13 “Lightning Protection for Structures”

3. Section 33 71 49.13 “Overhead Medium-Voltage Wiring”

1.3 Action Submittals

A. Product Data: For each type of product indicated.

1.4 Informational Submittals

A. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.
5. Grounding for sensitive electronic equipment.

B. Qualification Data: For qualified testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 Closeout Submittals

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals, include the following:

1. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, and grounding connections for separately derived systems based on NFPA 70B.

    a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
    b. Include recommended testing intervals.

1.6 Quality Assurance

A. Testing Agency Qualifications: Member company of InterNational Electrical Testing Association (NETA) or a nationally recognized testing laboratory (NRTL).

    1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with Underwriters Laboratory (UL) 467 for grounding and bonding materials and equipment.

PART 2 - Products

2.1 Conductors

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable code or authorities having jurisdiction.

B. Bare Copper Conductors:

    1. Solid Conductors: ASTM B 3.
    2. Stranded Conductors: ASTM B 8.
    3. Tinned Conductors: ASTM B 33.
    4. Bonding Cable: 28 kcmil, 14 strands of No. 17 American Wire Gauge (AWG) conductor, 1/4 inch (6 mm) in diameter.
    5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
    6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
    7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, [1/4 by 4 inches (6.3 by 100 mm)] in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or polyvinyl chloride (PVC), impulse tested at 5000 V.

2.2 Connectors

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which they are used and for the specific types, sizes, and combinations of conductors and other items connected.

B. Compression connectors: Must comply with Institute of Electrical and Electronics Engineers (IEEE) STD 837, ANSI/UL-467.

C. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

D. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

E. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression or exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.3 Grounding Electrodes

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m).

B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts

1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - Execution

3.1 Applications

A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger, unless otherwise indicated. Equipment ground conductors run with circuit conductors, and the grounding electrode conductor must be insulated with green outer finish, unless noted otherwise on the contract documents.

B. Corrosive environments: Use tinned or alloy-coated bare conductors in corrosive environments.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 Equipment Grounding

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
10. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

G. Metal and Wood Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.3 Installation

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage. Comply with the following:

1. UL 467, Grounding and Bonding Equipment
2. Applicable IEEE standards, such as IEEE 142, Recommended Practice for Grounding Industrial and Commercial Power Systems.
3. An equipment grounding conductor must be run with circuit conductors from the point of a separately derived service to the loads.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with bare grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any. Include a test well where shown.
2. Locate rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.

1. Test Wells: Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded or UL-list compression connections connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each indicated item, extending around the perimeter of building area or item indicated.

1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches (600 mm) from building's foundation.

J. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4/0 AWG.

1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

K. Make connections to minimize the possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Use electroplated or hot-tin-coated materials to assure high conductivity, and make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at the point of contact.
3. Coat and seal connections involving dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

L. Terminate insulated equipment grounding conductors for feeders and branch circuits with UL-approved grounding lugs. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing.

1. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing.

M. Bond electrically noncontinuous conduits at both entrances and exits with grounding bushings and bare grounding conductors.

N. See Standard Drawings E-0006STD, ES70001STD, and ES7002STD for additional grounding requirements

3.4 Labeling

A. Comply with requirements in reference Standard Drawing E006 for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.

1. Label Text: “If this connector or cable is loose or if it must be removed for any reason, notify the facility manager.”

3.5 Field Quality Control

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: [10] ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: [5] ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: [3] ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: [1] ohm(s).

H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26

Section 26 05 29 – Hangers and Supports for Electrical Systems

March 2018

Effective Date: 03/21/2018
Review Date: 03/21/2021

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 26 05 29 – Hangers and Supports for Electrical Systems

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
3/21/18	Tim Peterson	Admin	3-year review completed, no major changes to content, defined additional acronyms in definitions (Section 1.3)

Section 26 05 29 – Hangers and Supports for Electrical Systems

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.

1.3 Definitions

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. MFMA: Metal Framing Manufacturers Association.

D. MSS: Manufacturers Standardization Society.

E. NECA: National Electrical Contractors Association.

F. RMC: Rigid metal conduit.

1.4 Action Submittals

A. Shop drawings must be submitted as directed in Section 01 33 00, “Submittal Procedures,” and for all equipment furnished by the Contractor with internal wiring and controls differing from contract drawings, or not shown on contract drawings.

B. Submit contractor licenses and certifications as part of the bid evaluation documents.

1.5 Quality Assurance

A. Comply with NFPA 70.

PART 2 - Products

2.1 General

A. All electrical materials must be new and as listed by Underwriters Limited (UL), or another nationally recognized testing laboratory for the intended application, unless a specific exemption is made in the contract documents.

B. All similar materials and equipment must be the product of the same manufacturer, or listed as an assembly thereof.

C. Materials and equipment must be the standard product of manufacturers regularly engaged in the production of such material and must be the manufacturer's current and standard design.

2.2 Support, Anchorage, and Attachment Components

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Manufacturers: To be submitted on and approved by Engineer of Record. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
2. Nonmetallic Coatings: Manufacturer's standard polyvinyl chloride (PVC), polyurethane, or polyester coating applied according to MFMA-4.
3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
4. Channel Dimensions: Selected for applicable load criteria.

B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- (14-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c., in at least one (1) surface.

1. Manufacturers: To be submitted on and approved by Engineer of Record Fittings and Accessories: Products of channel and angle manufacturer, and products designed for use with those items.
2. Fitting and Accessory Materials: Same as channels and angles
3. Rated Strength: Selected to suit applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      1) Hilti Inc.
      2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
      4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      1) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti Inc.
      4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 Fabricated Metal Equipment Support Assemblies

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 05 50 00 “Metal Fabrications” for steel shapes and plates.

PART 3 - Execution

3.1 Installation

A. No employer can permit an employee to work in such proximity to any part of an electric power circuit that the employee could contact the electric power circuit in the course of work, unless the employee is protected against electric shock by deenergizing the circuit and grounding it, or by guarding it effectively by insulation or other means.

B. Fabrication, erection, and installation according to the National Electrical Installation Standards standards and the complete electrical system must be done by qualified personnel experienced in such work.

C. Conduit and equipment must be level, plumb, and true with the structure and other equipment, and in a horizontal or vertical position as intended.

D. Immediately prior to acceptance, the Contractor must clean all electrical equipment, both the exterior and interior.

3.2 Removal and Demolition

A. Unneeded electrical equipment, raceways, and conductors must not be abandoned in place, unless specifically required on the contract drawings for continuity of service and/or possible future use such as security systems in closed areas.

3.3 Supports and Anchors

A. Runs of conduit or tubing must have supports spaced not more than five (5) feet apart, unless shown otherwise.

1. Conduit and tubing must be supported on approved types of galvanized wall brackets, ceiling trapeze, strap hangers, or pipe straps, and secured by means of toggle bolts on hollow masonry units, expansion bolts in concrete or brick, machine screws on metal surface, and wood screws on wood construction. Conduit and tubing must not be hung from, nor attached to, hanger support wires used for suspended ceilings, nor suspended from wires using friction clips such as "bat-wings" or similar.
2. Conduit and tubing risers exposed in utility shafts must be supported at each floor level by means of approved U-clamp hangers.
3. Holes for electrical supports drilled in concrete, but not used, must be properly filled with concrete grout.
4. The cutting of structural members for the installation of supports is not permitted, except by prior written approval from the Sandia Construction Observer.
5. Conduit or conduit supports must not be welded directly to steel structures.
6. Wooden plugs inserted in masonry or concrete must not be used as a base to secure conduit supports.
7. Nails must not be used as the means of fastening boxes or conduits.
8. Wire or perforated strapping must not be used for the support of any conduit or tubing.

9. Conduits, conduit supports, and associated boxes must not be attached to roof-joist bridging.

B. All metal angles, channels, straps, and similar pieces used to support electrical apparatus must have all corners ground smooth, and all edges filed or ground smooth before installation.

3.4 Application

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems, except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC at five (5) feet intervals. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

END OF SECTION 26 05 29

Exceptional service in the national interest

Sandia National Laboratories

Section 26 05 33 – Raceways and Boxes for Electrical Systems

March 2018

Effective Date: 03/15/2018
Review Date: 03/15/2021

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 26 05 33 – Raceways and Boxes for Electrical Systems

Table of Contents

Change Log

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3/15/18	Tim Peterson	Admin	3-year review performed; minor change only

Section 26 05 33 – Raceways and Boxes for Electrical Systems

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Surface raceways.
5. Boxes, enclosures, and cabinets.
6. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.3 Definitions

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

1.4 Action Submittals

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

PART 2 - Products

2.1 General

A. All electrical materials must be new and as listed by Underwriters Laboratory (UL), or other nationally recognized testing laboratory for the intended application, unless specific exemption is made in the contract documents.

B. All similar materials and equipment must be the product of the same manufacturer, or listed as an assembly thereof.

C. Materials and equipment must be the standard product of manufacturers regularly engaged in the production of such material and must be the manufacturer's current and standard design.

2.2 Conduit and Tubing

A. Manufacturers: To be submitted on and approved by Engineer of Record.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Rigid Steel Conduit (RSC): Rigid, threaded, thick-walled, zinc-coated on the outside and either zinc-coated or coated with an approved corrosion-resistant coating on the inside.

D. Rigid Aluminum Conduit: Not permitted unless specified on drawings.

E. Intermediate Metal Conduit (IMC): Rigid, threaded, lightweight steel, zinc-coated on the outside and either zinc-coated or coated with an approved corrosion-resistant coating on the inside.

F. Rigid Nonmetallic Conduit: Schedule 40, high-impact polyvinyl chloride (PVC) with 5,000 psi tensile strength at 73.4 degrees F, approved for 90 degrees C, conductors.

G. Electrical Metallic Tubing (EMT): Milled steel, zinc-coated on the outside, and either zinc-coated or coated with an approved corrosion-resistant coating on the inside. EMT factory-formed with an integral locking nut and bell on one end can be used in lieu of a separate coupling, but only when the conduit sections are in a NEMA 1 environment, or as listed.

H. Flexible Metal Conduit (FMC): Commercial, galvanized steel; comply with UL 1, Flexible Metal Conduit.

I. Liquid-Tight Flexible Conduit: Flexible galvanized steel tubing with extruded liquid-tight, sunlight-resistant PVC outer jacket, compliant with UL 360, Liquid-Tight Flexible Steel Conduit.

J. Expansion Fittings: Malleable iron, hot-dipped galvanized, with factory-installed packing and a grounding ring.

K. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:

   a. Material: **Steel**.
   b. Type: compression.

3. Expansion Fittings: Steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

2.3 Metal Wireways and Auxiliary Gutters

A. Manufacturers: Subject to compliance with requirements. Provide products by one of the following:

   1. Cooper B-Line, Inc.
   2. Hoffman; a Pentair company.
   3. Mono-Systems, Inc.
   4. Square D; a brand of Schneider Electric.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, as indicated on drawings, and sized according to NFPA 70.

   1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: As indicated on drawings.

E. Finish: Manufacturer's standard enamel finish.

2.4 Surface Raceways

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Prime coated, ready for field painting.

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Mono-Systems, Inc.
b. Panduit Corp.
c. Wiremold/Legrand.

2.5 Boxes, Enclosures, and Cabinets

A. Manufacturers: To be submitted on and approved by Engineer of Record. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

C. Cast-Metal Outlet and Device Boxes:

1. Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.
2. Only zinc-coated or cadmium-plated sheet-steel boxes, of a class to satisfy the conditions for each outlet, can be used in concealed work.
3. Boxes mounted on the outside of the building walls must be cast construction, with threaded hubs and gasketed covers.
4. Switch, telephone, and receptacle outlet boxes must not be less than 4 inches square, and fitted with appropriate plaster rings where necessary to set flush within the finished surface.
5. Outlet boxes for exposed work must not be less than 4 inches square with appropriate covers for surface work. "Handy" boxes can be used in accordance with the National Electrical Code® (NEC) requirements. Cut-in boxes can be installed for nonexposed work.
6. Fixture outlet boxes on ceilings must not be smaller than the 4-inch octagonal type.

   a. Fixture outlet boxes in concrete ceilings must be of the 4-inch octagonal type, set flush with the finished surface.
   b. Fixture outlet boxes in plaster or similar ceilings must be fitted with open covers (plaster rings) set to come flush with the finished surface.
   c. Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.

7. Each box containing an equipment grounding conductor serving motors, lighting, fixtures, or receptacles must be provided with a grounding terminal. The grounding terminal must be green-colored.
8. A device plate that suits the device installed must be supplied for each outlet.

   a. All outlet cover plates on unfinished walls or on any surface-mounted devices must be zinc-coated sheet metal, having rounded or beveled edges.
   b. Unless otherwise indicated, all plates on finished walls must be ivory-colored metal or heavy-duty nylon. High-impact (flexible) plates must not be used.
   c. Screws must be metal with counter-sunk heads that match the finish of the plate.
   d. The use of sectional device plates is not permitted.
   e. For exterior outlets and switches, provide a cover that retains its weatherproof rating when the device is in use (cords plugged in and switch on).

D. Metal Floor Boxes:

1. Material: Cast metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Junction/Pull Boxes

1. Pull boxes must be constructed of code-gauge galvanized sheet metal, not less than the minimum size recommended by the NEC.
2. Boxes must be furnished with screw-fastened covers unless otherwise specified.

F. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

G. Device Box Dimensions: As indicated on the drawings.

H. Gangable boxes **are allowed**.

I. Hinged-Cover Enclosures: Where specified on the drawings, shall comply with UL 50 and NEMA 250, NEMA type as specified on the drawings. Hinged-Cover Enclosures shall have a continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

J. Cabinets:

1. Cabinet boxes must be constructed of zinc-coated sheet steel and must conform to the requirements of UL standard UL 50, Standard for Safety Enclosures for Electrical Equipment, Nonenvironmental Considerations.

   a. Trims and doors must have a suitable primer coat and a finish coat of a color specifically designated.
   b. Each cabinet box must be constructed with interior dimensions not less than those indicated on drawings.
   c. Cabinet trim must be fitted with a hinged door and flush latch.
   d. Cabinets for exterior mounting must be NEMA Type 3R/12, 3S, or 4.

2. Boxes must be provided with a ¾-inch exterior grade, single-faced, B-grade or equal plywood backboard mounted inside and painted white, unless otherwise specified on drawings.

3. Cabinets must have their identification letters shown on engraved plates as shown on Standard Drawing E-0006STD.

2.6 Handholes and Boxes for Exterior Underground Wiring

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:

   a. Armorcast Products Company.
   b. Carson Industries LLC.
   c. CDR Systems Corporation; Hubbell Power Systems.
   d. NewBasis.
   e. Oldcastle Precast, Inc.; Christy Concrete Products.
   f. Synertech Moulded Products; a division of Oldcastle Precast, Inc.

2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, title to be as indicated on the drawings.
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes Size as indicated on the drawings: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 Source Quality Control for Underground Enclosures

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
2. Testing machine pressure gauges shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - Execution

3.1 Conduit and Tubing

A. Conduit systems that are 2 inches or larger, installed outdoors, and terminate on an exterior enclosure that houses an overcurrent device (circuit breakers or fuses) must enter through the side or bottom.

B. EMT must not be installed in concrete, underground, or through roof penetrations. EMT can be used on the exterior of buildings unless otherwise specified on the drawings.

1. EMT must use UL-listed watertight compression-type threadless fittings in outdoor applications.
2. EMT box connectors must be securely fastened to all boxes and cabinets with one locknut.
3. EMT can be run horizontally concealed in interior (nonstructural) walls only when serving a multioutlet terminal branch circuit.

C. Rigid galvanized steel (RGS) conduit and IMC must be used where shown on drawings, in outdoor locations, for roof penetrations, and where required to meet NEC requirements. For roof penetrations, extend RGS and IMC a minimum of 12 inches above the roof membrane. Rigid and intermediate metal conduit must be securely fastened to all boxes and cabinets with two galvanized locknuts and one bushing installed wrench tight.

D. When raceways of Rigid, IMC and concrete encased PVC are used for underground applications such as power (below 600 V), controls, intrusion alarm, fire alarm and communications (24 fiber maximum), they shall be buried at a minimum depth of 24 inches from the top of conduit to grade. When the minimum depth cannot be met due to existing obstructions/site conditions, contact the applicable Sandia Construction Observer (SCO).

E. PVC or other types of conduit can be used only where specified on drawings.

1. When used underground (but not under a building floor slab), provide concrete encasement according to the requirements of Section 26 05 43 Underground Ducts and Raceways for Electrical Systems.
2. A mandrel ¼-inch to ⅜-inch smaller than the conduit must be pulled through each conduit. A circular wire brush the same diameter of the conduit then must be pulled through the conduit.
3. Conduit stub-outs must be RGS or IMC, capped, and not encased in concrete for future accessibility. A threaded PVC cap must be installed on both ends, except at manhole walls, to prevent moisture or debris from entering the conduit. For conduits 2 inches or larger, a ¼-inch polypropylene pull rope must be provided with 2 feet of slack at each end, with the ends secured to a ¼-20 eye-bolt securely attached to the PVC caps. See also the requirements of Section 26 05 43.
4. All empty conduits smaller than 2 inches must have a conduit measuring tape cord (Greenlee #435) provided with 2 feet of slack at each end, unless otherwise shown on plans.
5. All bends, except for communication and high-voltage duct banks, must be of steel, unless specified otherwise on drawings.

F. Flexible conduit must be used for terminal connections to all motors, inverters, and resilient-mounted equipment, and to other equipment where specified on drawings, and then only to a maximum length of 3 feet.

1. Metal-clad (MC) cable or armored cable (AC) must not be used in lieu of flexible conduit when there is no other reason to splice the conductors, and then only in NEMA 1 conditions.
2. Provide liquid-tight flexible conduit in exterior, wet, or damp locations, for connections to wet-pipe mechanical systems, or where specified on drawings.
3. All installations in demountable metal partitions (Dowcraft, VMP) must be run in flexible metallic conduit or MC cable to a junction box located above the panel.

G. All EMT, IMC, and rigid-conduit couplings must be installed wrench-tight. Threads must be brushed clean to ensure good electrical contact.

H. Install insulating type bushings, designed to prevent abrasion of wires without impairing the continuity of the conduit grounding system, on rigid-steel conduit, IMC, and rigid-aluminum conduit larger than ½-inch size.

1. Insulated bushings must be installed on all raceways for conductors No. 4 and larger at the point of entry into gutters, cabinets, boxes, or motor control centers.

I. Conduits and tubing must be concealed within the walls, above ceilings, and under slab-on-grade floors where possible, as shown on drawings. Maintain at least 6 inches distance from parallel runs of flues, steam pipes, or hot-water pipes.

J. Conduits concealed within interior walls must be run vertically to the maximum extent possible, excepting only those instances where the architecture does not permit it (such as an expanse of contiguous windows with receptacles below).

K. Conduit, cable, and tubing systems not normally requiring future maintenance nor anticipated to require ready access, and that are installed above lay-in ceilings, must be installed as high as possible above the ceiling. Runs must be parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings, with right-angle turns consisting of cast-metal fittings or symmetrical, constant-radius bends.

L. Exposed conduits must be run parallel and perpendicular to the building surface of exposed structural members, and follow the surface contours as often as practical to present a neat appearance. Exposed parallel or banked conduits must be run together to provide a neat appearance.

M. Bends and offsets must be avoided where possible, but when necessary, must be made with an approved hickey or conduit-bending machine. The use of a pipe tee or vise for bending conduit or tubing is not permitted. Use only UL-listed PVC benders to bend PVC.

N. Conduit or tubing that has been crushed, wrinkled, or deformed in any way must not be installed.

O. Each conduit that is buried in or rigidly secured to the building construction on opposite sides of a building expansion joint and each long run of exposed conduit that can be subjected to excessive stresses must be provided with an expansion fitting suitable to the degree of expansion expected.

P. The Contractor must exercise the necessary precautions to prevent the lodgment of dirt, plaster, or trash in conduit, tubing, fittings, and boxes during the course of installation.

1. Care must be taken to ensure that raceways do not contain any type of debris.
2. A run of conduit or tubing that has become clogged must be entirely freed of these accumulations before use, or must be replaced.

Q. Holes for conduit installation must not be allowed in steel or reinforced concrete structural members unless approved by the SCO.

R. All underfloor or underground conduit runs must be installed such that the last thread is exposed at least ¼-inch above the finished floor, including miscellaneous slabs, interior grade beams, finishes, and other portions of the floor.

S. Conduit must not be installed within a concrete slab.

T. All conduit under building floor slabs must be installed a minimum of 12 inches below the bottom of the slab, with a compacted fill between. Service entrance conduit runs must include a tracer wire and warning tape as stated in Section 260543, installed midway between the conduit and the bottom of the slab.

U. All steel conduits installed in direct contact with the earth must receive a protective corrosion covering in accordance with Section 26 05 43.

V. See Standard Drawing E-0006STD for conduit color-coding requirements.

W. Conduit or tubing risers must not be exposed in air shafts or ducts except when approved.

X. Exposed lengths of conduit, containing medium-voltage power conductors, and operating at more than 600 volts, must be rigid steel conduit. Paint two ½-inch wide red bands spaced 6 inches apart near each coupling, with the operating voltage stenciled in ½-inch letters between the bands.

Y. Surface Raceways:

1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

Z. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

AA. Set metal floor boxes level and flush with finished floor surface.

3.2 Outlet and Junction/Pull Boxes

A. Boxes must be installed in a rigid and satisfactory manner, either by wood screws on wood, expansion shields on concrete or filled masonry, or machine screws or self-tapping screws on steel work.

B. Outlet Boxes

1. Outlet boxes must be installed in the locations shown on drawings.

   a. Unless otherwise noted on the plans, the exact locations for outlets must be obtained by scaling drawings.
   b. Dimensions must be taken from the nearest fixed portion of the building, such as a cross wall or column line, or similar part of the structure.

C. Device Plates

1. Plates must be installed with four edges in continuous contact with finished wall surfaces, without the use of mats or similar devices.
2. Plates must be installed vertically and with an alignment tolerance of 1/16-inch.
3. Plates installed in wet locations must be approved for that use.
4. All receptacle device plates must be labeled according to Standard Drawing E-0006STD, to include panel and circuit number.

D. Relocations

1. If outlets are located improperly by more than 6 inches from the locations shown on the plans, they must be removed and reinstalled in proper locations at no additional cost to Sandia National Laboratories (SNL).
2. The Contractor must study the general building plans relative to the spaces surrounding each outlet, so the work fits the work required by these specifications.
3. When necessary, the Contractor must relocate outlets so when fixtures or other fittings are installed, they do not interfere with other work or equipment.

   a. When these relocations are required, the SCO records this new location on the record plan, and on the Contractor's plan, in red pencil.
   b. The Contractor must initial and date both plans.

   Junction/pull boxes for communication systems must be installed according to Section 27 00 05, Telecommunications.

3.3 Cabinets

A. Mount cabinets plumb and rigid without distortion of box.

B. Arrange flush-mounted cabinets so the enclosure front surface is uniformly flush with wall, and exterior door covers wall to enclosure mating surfaces. Provide for future circuits as shown on drawings.

1. If not shown on drawings, stub a minimum of four one-inch (25mm) empty conduits from cabinet into accessible ceiling space or space designated to be ceiling space in future.
2. If not shown on drawings, stub a minimum of four one-inch (25mm) empty conduits into raised floor space, or below slab other than slabs-on-grade.

C. All surface-mounted cabinets located on finished walls within office and light laboratory areas must be furred from the floor to the ceiling to provide a chase for conduits. The panels used for furring must be removable by sheet metal screws, wood screw attachment, or a similar method.

D. If the cabinet is a panelboard, switchboard, motor control center, or similar equipment with circuit switching and protection capabilities, install two paper copies of the appropriate SNL template panel schedule in a sleeve inside the door or on the side of the cabinet. The schedule must be an accurate representation of the final circuitry in the cabinet, complete with adjustable settings and equipment descriptions as shown on the template at the time of acceptance testing or commissioning. Download the current template from the SNL Engineering & Architectural Standards web site, and deliver the electronic copy to the Sandia-Delegated Representative when the paper schedules are posted.

3.4 Installation of Underground Handholes and Boxes

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.

D. Install handholes with bottom as indicated on the drawings.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 Sleeve and Sleeve-Seal Installation for Electrical Penetrations

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.

3.6 Firestopping

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

3.7 Protection

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 05 33

Exceptional service in the national interest

Sandia National Laboratories

Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems

May 2018

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
4/5/18	Tim Peterson	Admin	3-year review performed; some rewording for 3.4B; no major changes in content

Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. This Section includes the following:

1. Conduit, ducts, and duct accessories for concrete-encased duct banks, and in single duct runs.
2. Handholes and boxes.
3. Manholes.

1.3 Definition

A. RSC: Rigid Steel Conduit

B. RNC: Rigid Nonmetallic Conduit.

C. IMC: Intermediate Metal Conduit

1.4 Action Submittals

A. Product Data: For the following:

1. Duct-bank materials, including separators and miscellaneous components.
2. Ducts, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Accessories for manholes, handholes, boxes, and other utility structures.
4. Warning tape.

B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Reinforcement details.
3. Frame and cover design and manhole frame support rings.
4. Ladder details.

5. Grounding details.
6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
7. Joint details.

C. Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Cover design.
3. Grounding details.
4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 Informational Submittals

A. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer.

B. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.

C. Qualification Data: For professional engineer and testing agency.

D. Source quality-control test reports.

E. Field quality-control test reports.

1.6 Quality Assurance

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Comply with ANSI C2.

C. Comply with NFPA 70.

1.7 Delivery, Storage, and Handling

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.8 Coordination

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by the Sandia Construction Observer (SCO).

1.9 Extra Materials

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - Products

2.1 Conduit

A. Rigid Steel Conduit:

1. Comply with ANSI C80.1
2. Galvanized.
3. Polyvinyl chloride (PVC) externally coated conduit: Comply with NEMA RN1. Rigid steel conduit with external 20-mil PVC coating and internal galvanized surface.
4. Fittings and conduit bodies: ANSI/NEMA FB 1; threaded type, material to match conduit.

B. Intermediate Metal Conduit:

1. Comply with UL 1242 and ANSI C80.6.
2. Galvanized.
3. PVC externally coated conduit: Comply with NEMA RN1. Intermediate steel conduit with external 20-mil PVC coating and internal galvanized surface.
4. Fittings and conduit bodies: ANSI/NEMA FB 1; use fittings and conduit bodies specified above for rigid steel conduit.

C. Rigid Nonmetallic Conduit: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

D. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape, inert plastic film, 4 mils thick, 30-pound tensile strength, 3-inch-wide Terra Tape Standard 250 manufactured by Reef Industries, Inc., or an approved equal. Red for power.

2.2 Precast Concrete Handholes and Boxes

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

1. Carder Concrete Products.
2. Christy Concrete Products.
3. Elmhurst-Chicago Stone Co.
4. Oldcastle Precast Group.
5. Riverton Concrete Products; a division of Cretex Companies, Inc.
6. Utility Concrete Products, LLC.
7. Utility Vault Co.
8. Wausau Tile, Inc.

B. Comply with ASTM C 858 for design and manufacturing processes.

C. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.

1. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.

    a. Cover Hinges: Concealed, with hold-open ratchet assembly.
    b. Cover Handle: Recessed.

2. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
3. Cover Legend: Molded lettering, "ELECTRIC." Configuration: Units shall be designed for flush burial and have integral closed bottom, unless otherwise indicated.
4. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

    a. Extension shall provide increased depth of 12 inches (300 mm), or as noted on the drawings.
    b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

5. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.

    a. Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.

b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.

6. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

   a. Type and size shall match fittings to duct or conduit to be terminated.
   b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.

7. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.3 Handholes and Boxes Other Than Precast Concrete

A. Description: Comply with SCTE 77.

1. Color: Gray
2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC" or as indicated on the drawings.
6. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
7. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

   a. Armorcast Products Company.
   b. Carson Industries LLC.
   c. CDR Systems Corporation.
   d. NewBasis.
   e. Quazite/Hubbell Power Systems.
   f. Oldcastle.

C. High-Density Plastic Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be polymer concrete.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

a. Carson Industries LLC.
b. Nordic Fiberglass, Inc.
c. PenCell Plastics.

2.4 Precast Manholes

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work shall have documented experience in the manufacture of manholes for a minimum of three years.

B. Comply with ASTM C 858, with structural design loading as specified in Part 3 "Underground Enclosure Application" article and with interlocking mating sections, complete with accessories, hardware, and features.

1. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.

   a. Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls or floors, and not less than 24 inches from roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
   b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
   c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.

2. Precast concrete: Air-entrained, 4,000 psi minimum compressive strength at 28 days.
3. Reinforcing: AASHTO HS-20; bridge loading.
4. Manhole Shape: As indicated on drawings.
5. Inside Dimensions: As indicated on drawings.
6. Wall Thickness: AASHTO HS-20; bridge loading.
7. Joint Sealant: Ram-Nekor Kent Seal™

C. Include 40-inch diameter grooved opening in top section for frame and cover.

D. Frame and Cover Sections: 36-inch diameter clear opening.

E. Include one 12-inch drain opening and two 1-inch ground rod openings in base, one each diagonally opposite corners, not less than 6 inches or greater than 12 inches from the wall.

F. Include cable-pulling irons opposite each duct entry.

G. Include inserts for cable racks on three-foot centers.

H. Include metal ladder in manhole, steps at 16 inches on center, ladder bolted to manhole neck.

2.5 Cast-in-Place Manholes

A. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.

B. Materials: Comply with ASTM C 858 and with Section 03 30 00 "Cast-in-Place Concrete."

C. Structural Design Loading: As specified in Part 3 "Underground Enclosure Application" article.

D. All provisions of Parts 2.3 and 2.5 unless specified in this part.

2.6 Utility Structure Accessories

A. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 36 inches (660 mm).

    a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

2. Cover Legend: Cast in. Selected to suit system.

    a. Legend: "ELECTRIC" and “SNLA” for duct systems with medium-voltage cables.

3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.

    a. Chimney Rings (Grade Rings): Pre-cast concrete (4000 psi minimum compressive strength at 28 days) with inside diameter equivalent to manhole opening specified in Part 2.4. The ring shall have circumferential rebar #3 minimum with a trowel finish to provide a true plane within 1/8 inch, as determined with a 5-foot straight edge.

    b. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M may be used.

B. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.

C. Pulling Eyes in Concrete Walls: Triangular steel bar forming a triangle 9 inches per side when set. Galvanize to ANSI/ASTM A153 for irregular shaped articles. Locate opposite each duct entry.

1. Working Load Embedded in 6-inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.

D. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-

inch (13-mm) inside diameter (ID) by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (32 mm) minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.

E. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.

F. Cable Rack Assembly: Steel, hot-dip galvanized, except insulators.

1. Cable Rack Inserts: Steel channel insert with minimum load rating of 800 pounds, length to match cable rack channel. Locate 3 feet on center.

2. Stanchions: channel; 1-1/2-inch (57-mm) nominal size; punched with holes on 1-1/2-inch (38-mm) centers for cable-arm attachment. 48 inches in length.
3. Arms: Steel channel, ANSI/ASTM A659, 1-1/2 inches (38 mm) wide, 3/4 inch wide, 14 inches long. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
4. Insulators: Fiberglass or high-glaze, wet-process porcelain arranged for mounting on cable arms.

G. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 degrees F (2 degrees C). Capable of withstanding temperature of 300 degrees F (150 degrees C) without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

2.7 Fixed Manhole Ladders:

A. Arranged for attachment to grade ring or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from hot-dip galvanized steel. Ground Rods: 3/4-inch x 10-foot Copperweld.

2.8 Source Quality Control

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Strength tests of complete boxes and covers shall be by either an independent testing agency or the manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
2. Testing machine pressure gauges shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to National Institute of Standards and Technology (NIST) standards.

PART 3 - Execution

3.1 Underground Duct Application

A. Ducts for Electrical Cables Over 600 V: RNC, NEMA Type EPC-80 or EPC-40 PVC, in concrete-encased duct bank, as indicated on the drawings.

B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80 or EPC-40 PVC, in concrete-encased duct bank, or RGS or IMC as indicated on the drawings.

C. Ducts for Electrical Branch Circuits: RGS or IMC, in direct-buried duct bank, unless otherwise indicated.

D. Underground Ducts Crossing Driveways, Roadways, and Railroads: RNC, NEMA Type EPC-40-or EPC-80 PVC, encased in reinforced concrete.

3.2 Underground Enclosure Application

A. Handholes and Boxes for 600 V and Less

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 or Polymer concrete, SCTE 77, Tier 15 structural load rating.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 or Polymer concrete units, SCTE 77, Tier 8 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.

B. Manholes: Precast-in-place concrete.

1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.

3.3 Earthwork

A. Where underground crossings are known, field verify horizontal and vertical locations prior to excavation and placement of conduit. Notify the Sandia Construction Observer (SCO) of any deviations to the drawings. Any profile changes and existing utility line crossings are to be as built on drawings showing type of line, size, and depth below the surface.

B. Conduits and duct runs shall be installed on compacted soil when entering a manhole or building foundation and/or crossing a road, railroad track, or bridge abutment to prevent shear stress on the conduit.

C. All paving and concrete cuts shall be made with a concrete saw. All surfaces and structures to be replaced shall match existing.

D. Conduit or duct banks shall maintain 1 foot vertical and 1 foot horizontal separation from other utility lines where possible.

E. Excavation and Backfill: Comply with Section 31 20 00 "Earthwork," but do not use heavy-duty, hydraulic-operated, compaction equipment.

F. Excavate, install base material, and compact base material. Compact to 95% density or as required by manufacturer.

G. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

H. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 32 92 00 "Turf and Grasses" and Section 32 93 00 "Plants."

I. Cut and patch existing pavement in the path of underground ducts and utility structures.

3.4 Duct Installation

A. Slope: Pitch ducts a minimum slope of 2 inches for every 100 feet of length down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.

B. Curves and Bends: For vertical stub-ups, horizontal bends, and any off-sets greater than 22° in primary electrical conduit runs, use PVC-coated rigid steel or IMC factory bends. The minimum radius shall be 24 inches for conduit smaller than 3-inches, 36 inches for 3-inch conduit, and 48 inches for 4-inch and larger conduit, unless noted otherwise on the drawings. Standard radius conduit can be used for secondary electrical conduit if so specified on drawings.

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

D. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
3. Grout end bells into structure walls from both sides to provide watertight and gas tight entrances.

E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet (3 m) outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified drawings.

F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

G. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.

1. Between manholes, secure a minimum of two feet of test nylon to a suitable structure (not a conductor) inside each manhole.
2. Conduit stub-outs other than in manholes shall be RGS or IMC and <u>not</u> encased in concrete for future accessibility. A <u>threaded</u> PVC cap shall be installed on each stub-out to prevent moisture or debris from entering the duct system, except for stub-outs inside panels or switchgear. A 1/4-inch polypropylene pull rope shall be provided in each duct, with at least 2 feet of slack at each end. The ends of the rope shall be secured to a 1/4-20 eye-bolt securely attached through the PVC cap.
3. Empty ducts not running between two manholes (i.e., between switchgear and a manhole, or switchgear and a transformer, etc.) shall be labeled at both ends with a Panduit® Marker Plate (Model # MP350-C). The label shall be marked with a Sharpie® permanent ink pen and secured to the pull rope on the inside of the duct so as to indicate destination of the duct.

H. Where above-grade marking of underground utilities is indicated on drawings, the marking shall be in accordance with Standard Drawing WU5006STD, *Utility Markers for Buried Pipe and Cable*.

I. Concrete-Encased Ducts: Support ducts on duct separators.

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than **5** spacers per 20 feet (6 m) of duct. Secure, with #16-gauge wire, separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches (150 mm) between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
2. Unless otherwise noted on drawings, 40-inch conduit shall have an approximately 7.5-inch spacing center-to-center, both horizontally and vertically; 5-inch conduit shall have an approximate 8.56-inch spacing center-to-center. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

   a. Soil backfilling of the excavation shall not occur until the concrete has set for 5 hours. Conduit shall be not covered with backfill until the installation approval is obtained from the SCO.
   b. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
   c. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.

3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

    a. For concrete encased conduits, provide minimum 3-inch concrete cover at bottom, 4-inch at top, and minimum of 4- to a maximum of 6-inch cover at sides of conduit or ductbank.

4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups. Duct bank crossing streets with less than 2′-6″ of earth cover shall be reinforced with four #4 rebar equally spaced at the bottom of the duct bank.

5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
6. Minimum Space between Ducts: 3 inches (75 mm) between ducts and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 12 inches (600 mm) between power and all other utilities.
7. Depth: Install top of duct bank at least 36 inches (900 mm) below finished grade. If site conditions do not permit this depth of burial, contact the SCO for instructions.
8. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
    b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of base. Install threaded insulated grounding bushings on terminations at equipment. If spare duct, install threaded PVC cap to prevent moisture or debris from entering the duct system.

9. Ground Wire: A 4/0 stranded bare copper ground wire shall be installed in the bottom of the duct bank and between manholes. The 4/0 ground is to be connected to the 4/0 ground bus in the manhole with an exothermic connection or approved Underwriters Laboratory (UL) mechanical connector.

10. Warning Tape: A warning tape shall be installed one foot above duct. The warning tape shall be of inert plastic film 4 mils thick specifically formulated for prolonged use underground, resistant to alkalis and acids found in soil. It shall have a tensile strength of 30 pounds per 3-inch-wide strip. The tape shall bear a continuous printed message repeated every 36 inches. The tape shall be Terra Tape Standard 250 manufactured by Reef Industries, Inc., or an approved equal. The tape shall be colored in accordance with American Public Works Association® (APWA) recommended color code for marking buried lines of all types. Current recommended colors are red for power lines.

11. Tracer Wire: Install by direct burial a tracer wire one foot above and centered across the conduit or duct. This may be coincident with the warning tape specified herein. Use

#10AWG stranded copper wire with red RHW insulation, with no breaks along its length. Bring the tracer wire 12 inches above grade adjacent to the point of stub-out through a ½-inch PVC sleeve, and secure to the stub-out at an accessible location. If the stub-out is to rise inside switchgear or other enclosure which cannot be opened safely while energized, bring the tracer wire outside the equipment footprint and secure it there. For pad-mount transformers, bring the secondary conduit tracer wires up into the secondary compartment. Label the tracer wire as to its function, the ductbank or conduit run it follows, and the location of the far terminus. Cap the ends with a Wirenut® or similar protective cover. Insure the tracer wire is not grounded at any point.

J. Direct-Buried Duct Banks:

1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than **5** spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches (150 mm) between tiers.
3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Section 31 20 00 "Earthwork" for pipes less than 6 inches (150 mm) in nominal diameter.
4. Install backfill as specified in Section 31 20 00 "Earthwork."
5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches (100 mm) over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Section 31 20 00 "Earthwork."
6. Install ducts with a minimum of 3 inches (75 mm) between ducts for like services and 12 inches (150 mm) between power and any other utility.
7. Depth: Install top of duct bank at least 36 inches (900 mm) below finished grade, unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.
9. Corrosion Protection

    a. One application, half-lapped, of Minnesota Mining and Manufacturing Company "Scotchwrap" No. 51, Plymouth Rubber Co. "Plywrap 20" or Westape, Inc. 20 mil Pipe Wrap, or equivalent, shall be applied. A "Scotch Coat" No. 101 pipe coating resin treatment, or equivalent, will also be accepted.

        1) All elbows or bends shall have the wrap applied after the conduit is bent.
        2) Fittings shall have two separate applications of the above, half lapped and extending one tape width onto the adjoining ducts.

    b. Factory coated PVC on rigid conduit.

10. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

3.5 Installation of Concrete Manholes, Handholes, and Boxes

A. Cast-in-Place Manhole Installation:

1. Finish interior surfaces with a smooth-troweled finish.
2. Windows for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches (38 to 50 mm) thick, arranged as indicated.
3. Cast-in-place concrete, formwork, and reinforcement are specified in Section 03 30 00 "Cast-in-Place Concrete."

B. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891, unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches (380 mm) below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
3. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
4. Where indicated, cast handhole cover frame integrally with handhole structure.

D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

E. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.

   a. Install a 1-foot-wide concrete (3,000 psi, 3/4-inch aggregate) collar around the manhole or pull box cover, unless noted otherwise on drawings.
   b. As a minimum the height of the concrete collar should go from the top of the manhole or pull box cover to eight inches below grade.

c. The top of the concrete collar shall slope down away from the cover so that no water will accumulate around the cover.

F. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

G. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

H. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

I. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (98 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

J. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.

3.6 Installation of Handholes and Boxes Other Than Precast Concrete

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.7-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

E. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

F. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Section 03 30 00 "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: [10 inches wide by 12 inches deep (250 mm wide by 300 mm deep)]

3.7 Grounding

A. Install 2 ground rods with top protruding 4 inches above manhole floor. Connect ground rods with 4/0 bare copper run around perimeter of inside manhole at floor. Copper conductor connection to ground rod to be exothermic, or UL-listed mechanical connection.

B. Ground underground ducts and utility structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.8 Field Quality Control

A. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.9 Cleaning

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

1. Swab the duct at completion of construction. A mandrel 1/4-inch to 3/8-inch smaller than the conduit shall be pulled through each conduit. A circular wire brush the same diameter of the conduit shall be pulled through the conduit. After cleaning, install caps as herein specified, to protect against the entry of dirt or moisture.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 26 05 43

Section 26 05 74 – Overcurrent Protective Device Arc-Flash Study

April 2016

Effective Date: 04/22/2016
Review Date: 04/22/2019

U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

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Section 26 05 74 – Overcurrent Protective Device Arc-Flash Study

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/22/16	Tim Peterson	Subst	Updated formatting.

Section 26 05 74 – Overcurrent Protective Device Arc-Flash Study

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. Refer to Chapter 9, Section 9.14.4, “Protective Device Evaluation and Coordination Study” in Man-004, *Design Standards Manual,* for additional documents.

1.2 Summary

A. Section includes an SKM Power Tools based arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 Definitions

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 Action Submittals

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from FMOC Electrical Engineer for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

3. Arc Flash Data Files: Provide PTW files used in final study on a CD and in ProjectWise folder per the requirements of Chapter 9 of the Design Manual.
4. Copies of certificates showing training in PTW Software.

1.5 Closeout Submittals

A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

B. Operation and Maintenance Procedures: Provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.6 Quality Assurance

A. Studies shall use the latest version of SKM Power Tools for Windows. Manual calculations are unacceptable.

B. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer. Engineer must have training in PTW Software.

C. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, or that is acceptable to authorities having jurisdiction.

PART 2 - Products

2.1 Computer Software Developers

A. Software Developers:
1. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

2.2 Arc-Flash Study Report Content

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, ATS, UPS, and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output

F. Protective Device Coordination Study Report Contents

G. Arc-Flash Study Output:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated symmetrical fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. No AC Decrement (NACD) ratio.
    e. Equivalent impedance.
    f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.3 Arc-Flash Warning Labels

A. The contractor and AE will follow the Arc flash process outlined in Appendix A. An SKM generated AF spreadsheet shall be supplied to the FMOC Electrical Engineer who will provide Arc flash labels to the Inspector for the contractor to affix to designated equipment. Labels shall be provided for all equipment which may be serviced while energized. The contractor must install Arc flash labels per requirements of drawing E_0006STD before final acceptance

PART 3 - Execution

3.1 Examination

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 Arc-Flash Hazard Analysis

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Comply with Chapter 9 of Sandia's Design Standards Manual.

C. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 Power System Data

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings and in "Arc-Flash Hazard Analysis" Article. Call discrepancies to the attention of FMOC Electrical Engineer
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field and as dictated by Chapter 9 of SNL's Design Standards Manual.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.

7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
13. Motor horsepower and NEMA MG 1 code letter designation.
14. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
15. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

END OF SECTION 26 05 74

Appendix A: Arc Flash Process

1. During Design:
    a. AE to field verify existing equipment and overcurrent device settings if modifying existing equipment. This will require SNL support to de-energize equipment to remove covers as necessary.
    b. AE to request starting fault current levels as required for the project from the SNL Infrastructure SE. Allow one week for response.
    c. AE to perform short-circuit coordination and arc flash studies to properly specify breakers and over current devices per Chapter 9 of the Sandia *Design Standards Manual*.
    d. SNL PM to distribute preliminary studies to SNL SE and Infrastructure SE for review and comment as soon as a preliminary study has been performed to allow for comments and SNL required changes.

2. During Construction:
    a. Contractor to submit equipment planned to be installed.
    b. AE and FMOC Electrical Engineer to review submittal. AE to revise coordination study prior to approving submittal. If over current devices can be properly set to achieve coordination, submittal can be approved.
    c. Equipment arrives on site and contractor verifies it matches the submittal.
    d. Contractor submits RFI for coordination settings and AFH labels. Allow 14 days for response. Labels must be installed prior to energizing for new installations.
    e. When AE receives this RFI, AE to verify that equipment matches submittal as equipment is being installed prior to equipment being energized. If equipment is different, AE to rerun calculations to verify that overcurrent devices can be coordinated.
    f. AE submits (revised if necessary) calculations to PM (through the project). AFH Calculations Package to include the following (per DM sect 9.14.5):
        i. Construction one-line
        ii. PTW model one-line
        iii. PTW project file
        iv. AFH calculations
        v. TCCs and settings
        vi. Power plan or site drawing
    g. SNL PM to distribute to SE and Infrastructure Engineer for review.
    h. SNL SE and Infrastructure Engineer to review. If there are comments, provide to AE through SNL PM.
    i. AE revises calculations and resubmits to SNL PM, if necessary.
    j. PM forwards submittal to SE and Infrastructure SE for review and approval
    k. SE reviews and forwards submittal to Electrical Technologist for review. If acceptable, SE approves submittal, and Electrical Technologist prints labels.
    l. SNL PM to provide approved coordination study to contractor for setting breakers.
    m. Electrical Technologist to notify Construction Observer that AFH labels are ready for pickup and installation.

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Section 26 06 20 – Schedules for Low-Voltage Electrical Distribution

April 2016

Effective Date: 04/22/2016
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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 26 06 20 – Schedules for Low-Voltage Electrical Distribution

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/22/16	Tim Peterson	Subst	Updated formatting.

Section 26 06 20 – Schedules for Low-Voltage Electrical Distribution

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. This procedure provides instructions to properly reserving circuits for future use, redlining panel schedules, and ensuring up-to-date panel schedules are placed in panels and in ProjectWise.

1.3 Coordination

A. This procedure applies whenever a modification is proposed for an existing electrical panel such as the installation, removal, or refeeding of a load. All work in electrical panels must be coordinated through the Sandia Designated Representative (SDR).

A&E firms must request circuits using ProjectWise. Contractors must request circuits by submitting red-lined panel schedules with outage requests prior to beginning construction. Availability of circuits, panel capacity, and phase balance must be verified prior to beginning construction.

<u>Projects – Design</u>
During design, the Architecture & Engineering firm (A/E) shall reserve circuits by placing a copy of the panel schedule in the 'Future' folder of its respective building. This copy shall include a description of the load next to the circuit(s) requested along with a respective revision letter in the 'REV' column. In the upper right corner of the panel schedule, include the current month and year in the 'DATE' column, project number in the 'BY' column, and revision letter in the 'LETTER' column. Note 1: After a panel schedule has been in the 'Future' folder for more than one year, SNL will delete such files. Note 2: Requestor shall field verify circuit in electrical panel is available before reserving circuit.

<u>Projects - Construction</u>
Prior to construction, the Contractor shall submit an outage request with a red-lined panel schedule 21 days prior to the requested outage date. After approving the outage request, the SNL Operations Engineer (OE) will update the master panel schedule, delete any associated files in the 'Future' folder and send a copy of the updated panel schedule to the Outage Desk. The Outage Desk will then send the updated panel schedule(s) to the Contractor and Inspector and the Contractor shall place two (2) copies of the updated panel schedule in the panel. The Inspector will verify copies are placed in panel.

Projects – As-Builts

For as-built panel schedule redlines needing to be addressed, the following process shall be followed. Contractor shall redline paper copy and leave in panel, scan a copy of the redlined panel schedule(s) and route to Technical Assistant (TA). The TA will route as-built package to Inspectors. After as-builts have been reviewed and approved by Inspector, the TA will send panel schedules to CAD. CAD will update panel schedules, notify Project Manager (PM), TA, & A/E, and unflag the 'Master' folder panel schedules. TA will send updated panel schedules to Inspector, who will place two (2) copies in panel.

1.4 Responsibilities

A. Design Engineer/Requester

1. Obtain a circuit assignment by reviewing available circuits in the panel schedule 'Future' folder of respective building in ProjectWise.
2. Identify requested circuits in the panel schedule 'Future' folder by using instructions in section 1.3.
3. Evaluate the proposed design for panel load capacity and phase balance.

B. Construction Contractor

1. Obtain a circuit assignment from the Design Engineer or SE prior to beginning construction.
2. Verify the circuit being requested is available and usable by visual inspection, and/or the circuit to be removed can be pulled from the panel (circuit breaker may or may not remain). PPE must be worn as required.
3. Request timely inspection of completed construction and verification of redlines by Inspector.
4. Provide redlined panel schedule with outage request to Outage Desk
   a. If as-builts require redlines, leave red-lined copy in panel and provide copy to TA.
5. Place two (2) copies of the final, updated panel schedule in the panel.

C. Systems Engineer

1. Review red-lined panel schedules submitted with outage requests.
2. Coordinate circuit request by cross referencing red-lined panel schedules with relevant schedules in the future folder.
3. Update master panel schedules, remove associated panel schedules from 'future folder' and send updated panel schedule to the outage desk.
4. Ensure all relevant drawings are updated as required.
5. Clarify any panel schedule related questions from CAD.

D. CAD

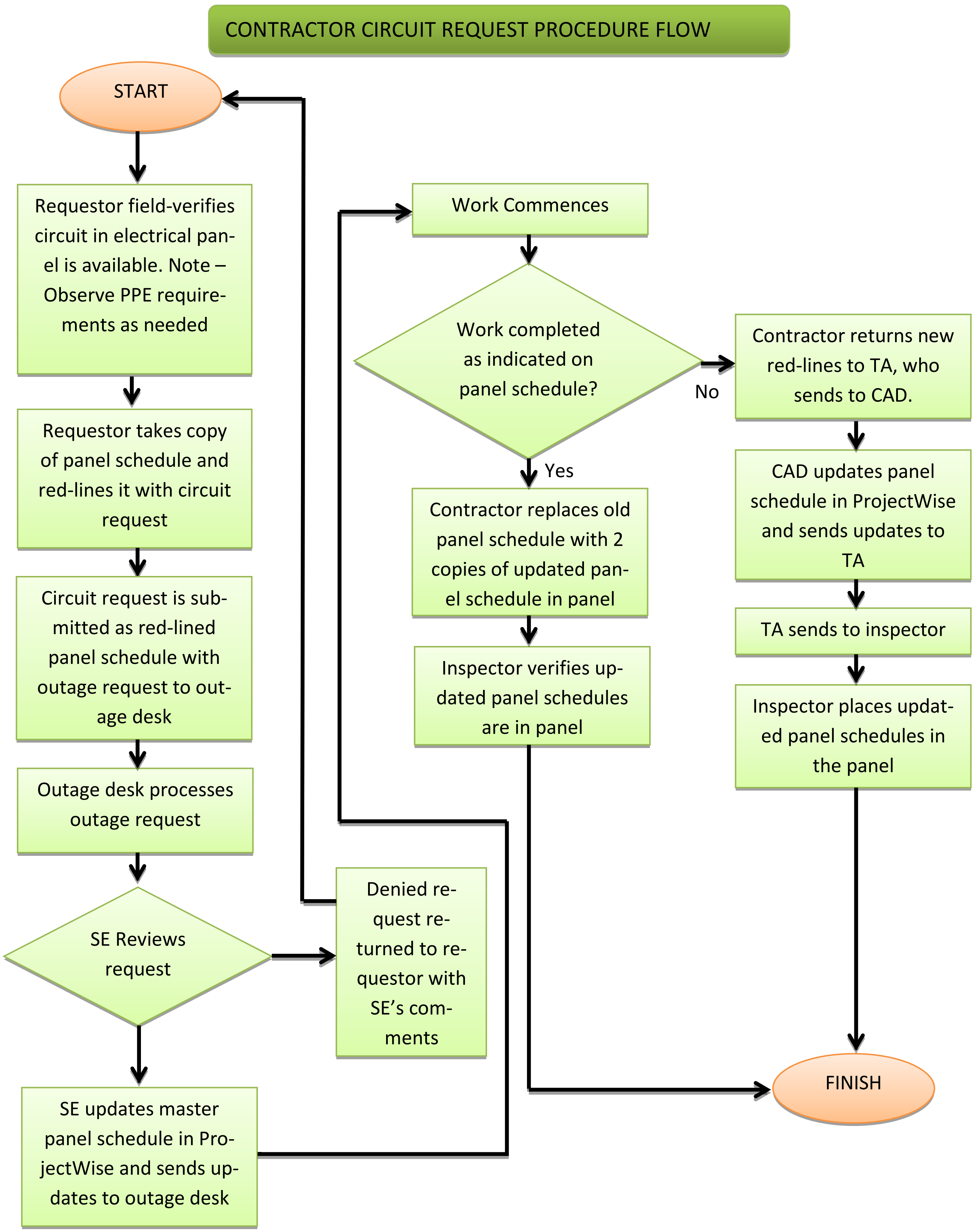
1. Update post-construction red-lined panel schedules.
2. Return updated copies to TA so they can give them to the inspector.

E. Inspector

1. Verify construction work is complete and two (2) copies of updated panel schedules are in panel.
2. For as-built panel schedules, place (2) copies of the updated panel schedule in the panel.

1.5 Execution

A. Panelboards, switchboards, motor control centers, or similar equipment with circuit switching and protection capabilities, shall have two paper copies of the appropriate SNL template panel schedule in a sleeve inside the door or on the side of the cabinet. The schedule must be an accurate representation of the final circuitry in the cabinet, complete with adjustable settings and equipment descriptions as shown on the template at the time of acceptance testing or commissioning. Download the current template from ProjectWise web site and deliver the electronic copy to the SDR when the paper schedules are posted.


CONTRACTOR CIRCUIT REQUEST PROCEDURE FLOW
START
Requestor field-verifies circuit in electrical panel is available. Note – Observe PPE requirements as needed
Requestor takes copy of panel schedule and red-lines it with circuit request
Circuit request is submitted as red-lined panel schedule with outage request to outage desk
Outage desk processes outage request
SE Reviews request
Denied request returned to requestor with SE's comments
SE updates master panel schedule in ProjectWise and sends updates to outage desk
Work Commences
Work completed as indicated on panel schedule?
No
Yes
Contractor replaces old panel schedule with 2 copies of updated panel schedule in panel
Inspector verifies updated panel schedules are in panel
Contractor returns new red-lines to TA, who sends to CAD.
CAD updates panel schedule in ProjectWise and sends updates to TA
TA sends to inspector
Inspector places updated panel schedules in the panel
FINISH

END OF SECTION 26 06 20

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Section 26 12 00 – Medium-Voltage Transformers

April 2016

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 26 12 00 – Medium-Voltage Transformers

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.

Section 26 12 00 – Medium-Voltage Transformers

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. SNL Facilities Standards Drawing WP3003STD – Transformer Fire Barrier Wall

C. SNL Facilities Standards Drawing WP4001STD – Plan and Profile for Transformer Pad

1.2 Summary

A. This specification is written for three-phase, 60 hertz, 65°C temperature rise, liquid filled, self-cooled, pad mounted, live-front, compartmentalized distribution transformers, rated 1,500 kVA and below, radial feed.

B. Pad mounted transformers shall be provided and installed in accordance with the details and ratings on the working drawings and in accordance with this specification.

1.3 Definitions

A. NETA ATS: Acceptance Testing Specification.

1.4 Action Submittals

The following shall be submitted in accordance with Division 1, Section 01 33 00, “Submittal Procedures."

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.

B. Shop Drawings: Outline drawings including overall height, overall width, overall depth, base dimensions, arrangement of bushings, and other appurtenances, and compartment dimensions.

C. Weights of the tank, oil, and total transformer.

D. Volume of oil, gallons.

1.5 Informational Submittals

A. Qualification Data: For testing agency.

B. Source quality-control test reports.

1. Certified statement of compliance with short circuit capability requirements of Paragraph 2.2F.

2. Certification of tamper resistant design with complete test data.

C. The manufacturer shall perform all routine tests as defined in ANSI C57.12.00 (latest edition).

D. The manufacturer shall perform production line high voltage and low voltage impulse tests on each unit as defined in ANSI C57.12.00 (latest edition).

E. The manufacturer shall provide Sandia with the following certified data by transformer serial number for each transformer shipped.

a. Excitation loss, watts.
b. Impedance, % Z.
c. Total loss, watts @ 85º C.

F. Manufacturer shall certify that all transformers supplied under this specification contain less than 1 ppm PCB.

G. Field quality-control test reports.

H. Follow-up service reports.

I. No individual transformer shall be shipped with losses that exceed quoted losses by more than the tolerances in ANSI C57.12.00 (latest edition), Table 18, line 2, without written approval of Sandia National Laboratories/New Mexico (SNL/NM). Refer to Appendix 1 for Loss Evaluation Information.

1.6 Closeout Submittals

A. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

1.7 Quality Assurance

A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of transformers and are based on the specific system indicated

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C2, National Electrical Safety Code (NESC).

E. Comply with:

1. IEEE C57.12.10, IEEE Standard Requirements for Liquid-Immersed Power Transformers.
2. IEEE C57.12.28, IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
3. IEEE C57.12.70, IEEE Standard for Standard Terminal Markings and Connections for Distribution and Power Transformers
4. IEEE C57.12.80, IEEE Standard Terminology for Power and Distribution Transformers
5. IEEE C57.12.00, IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
6. IEEE C57.12.90, IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
7. ANSI C57 12.22, American National Standard for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers With High-Voltage Bushings, 2500 kVA and Smaller; High Voltage, 34 500 GrdY/19 920 Volts and Below; Low Voltage, 480 Volts and Below

F. Comply with NFPA 70.

G. Manufacturer shall provide a warranty on each unit stating that the unit will be free of defects in workmanship and material for a period of twelve (12) months from the date of initial installation or eighteen (18) months from the date of manufacture, whichever shall occur first.

1.8 Delivery, Storage, and Handling

A. Store transformers so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

1.9 Project Conditions

A. Service Conditions: IEEE C37.121, usual service conditions except for the following:

1. Exposure to significant solar radiation.
2. Altitudes above 3300 feet (1000 m).

3. Exposure to fumes, vapors, or dust.

1.10 Coordination

A. Coordinate size and location of concrete bases with SNL drawing WP4001STD.

B. Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

PART 2 - Products

2.1 Manufacturers

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB Power T&D Company
2. Cooper Industries; Cooper Power Systems Division.
3. GE Electrical Distribution & Control.
4. Howard Industries

2.2 Pad-Mounted, Liquid-Filled Transformers

A. Description: IEEE C57.12.00, IEEE C57.12.22, pad-mounted, 2-winding transformers.

B. Kilovolt-ampere ratings shall be 75, 150, 300, 500, 750, 1000, or 1500.

C. Insulating Liquid: Mineral oil, complying with ASTM D 3487, Type II, and tested according to ASTM D 117.

D. Insulation Temperature Rise: 65 deg C when operated at rated kVA output in a 40 deg C ambient temperature. Transformer shall be rated to operate at rated kilovolt ampere in an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C without loss of service life expectancy.

E. Basic Impulse Level: See Table below

TABLE 1

High Voltage Rating (Volts) Delta	BIL Rating (kV)	Low Voltage Rating (Volts) Wye	kVA Rating	High Voltage Taps Required
2,400	45	208Y / 120	75 - 1500	2½% Above & Below
2,400	45	480Y / 277	75 - 1500	2½% Above & Below
4,160	60	208Y / 120	75 - 1500	2½% Above & Below
4,160	60	480Y / 277	75 - 1500	2½% Above & Below
12,470	95	208Y / 120	75 - 1500	2½% Above & Below
12,470	95	480Y / 277	75 - 1500	2½% Above & Below

F. Full-Capacity Voltage Taps: Four 2.5 percent taps, 2 above and 2 below rated high voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp. Operating handle to be located in the high voltage compartment or in the secondary compartment above its respective bushings. Set the tap changer on the 100% tap at the factory and secure to prevent inadvertent change from this position.

G. TRANSFORMER IMPEDANCES

Minimum impedances shall be in accordance with Table 2 below:

TABLE 2

Secondary Voltage
*Minimum AC Impedance %

kVA	208Y / 120	480Y / 277
75	2.9	2.6
150	3.0	2.6
300	4.7	2.6
500	4.7	4.3
750	5.75	5.75
1,000	5.75	5.75
1,500	N/A	5.75

*ANSI Standard Tolerance (±7.5 %)

H. SHORT-CIRCUIT CAPABILITY

1. Mechanical short-circuit capability shall be demonstrated by design compliance with ANSI C57.12.90 (latest edition).
2. Thermal short-circuit capability shall be demonstrated by design compliance with ANSI C57-12.00 (latest edition).

I. CORE DESIGN

Transformers shall be of five-legged core design and connected delta-wye. A fully insulated, neutral bushing will bring the secondary winding neutral to the outside of the tank and a ground pad will be provided on the outside tank wall and will be connected to the neutral bushing with a removable ground strap.

J. CONSTRUCTION

A. Description

1. Transformers shall be designed to protect people against accidental contact of energized parts, discourage unauthorized access to or climbing upon the unit by the public, and protect against weather.

2. The pad mounted transformer shall consist of the transformer tank, high-voltage cable terminating compartment, and the low-voltage cable terminating compartment. The transformer tank and compartment shall be assembled as a rain tight compartment,

outdoor, and tamper-resistant integral unit suitable for mounting on a flat surface. The transformer design shall not use gasketing to meet this requirement.

3. There shall be no exposed screws, bolts, or other fastening or hinging devices (other than the pentahead bolt specified in 2.08 D.5) that are externally removable. There shall be no opening through which foreign objects such as sticks or wires might be inserted to contact energized parts. Suitable means for padlocking the compartment door(s) shall be provided. Normal entry shall be possible only with the use of proper access tools.

4. The high- and low-voltage compartments shall be located side by side on one side of the transformer tank. When facing the compartment, the low voltage compartment shall be on the right.

5. Construction of the unit shall be such that it can be lifted, skidded, and slid into place on the mounting pad without disturbing the entrance cables.

6. All external surfaces shall be constructed of steel, 13 USS gauge or thicker.

7. The transformer and compartment hoods shall be crowned to insure water run off or manufactured with a full weather cover.

B. Bottom Protection

1. The transformer tank base shall be raised above the pad to protect the bottom finish during installation and to minimize corrosion due to moisture accumulation. The base shall be cross-braced to permit rolling in two directions.

2. All external surfaces of ferrous material used in the construction of the assembly shall have undercoating over the regular finish, applied to the bottoms of the components and extending up the side to a point one to two inches above the bottom of their bases in a straight edge.

C. Protective Coating

1. The finish coat shall be light gray (ANSI Color No. 70).

D. High- and Low-Voltage Compartments

1. Terminal compartments shall be full height, air-filled compartments with separate hinged doors. The compartments shall be completely isolated from each other by a steel barrier without opening or discontinuity of any kind.

2. The edges of the access doors and hoods shall be formed to provide a close fitting mating surface, with internal insertion-prevention lip that will be shaped to resist entry or prying by screwdrivers, wrecking bars, tire irons, single-socket lug wrenches or other readily accessible tools.

3. Hinges and hinge pins shall be passivated American Iron and Steel Institute Type 304 stainless steel or equivalent corrosion-resistant metal.

4. There shall be a threaded fastening device for the high voltage door, accessible only through the low voltage compartment. Screen door latches with wing nuts and gravity hooks are acceptable. The low-voltage compartment door shall have a minimum of three-point latching and the handle shall have provisions for padlocking.

   The padlocking provision shall be so designed and located as to resist prying or breaking off by screwdrivers, wrecking bars, tire irons, single-socket lug wrenches, or other readily accessible tools and to inhibit removal of the padlock with a bolt cutting device or hacksaw.

5. In addition to the regular locking provision above, the access doors shall be secured by a captive, recessed pentahead bolt as depicted in Figure 11, ANSI C57.12.26-1987 (or the latest edition). Bolts and associated hardware must be rust and corrosion resistant. The design shall minimize the possibility of misalignment and cross threading. The design must be such that wire entry through the bolthole into the compartment(s) is prohibited when the bolt is removed. The non-rotating cup shall be permanently attached.

   a. The captive pentahead bolt shall be coordinated with the latch and padlock to prevent unlatching and insertion of the padlock into the hasp when and until the bolt is completely threaded, respectively.

   b. The captive pentahead shall also function as an interlock device to pin the latch closed.

6. Both compartment doors shall be equipped with stops for holding each door in a 90° open position. The stops shall be captive to prevent loss of the device.

7. Doors on the high- and low-voltage compartments shall be of sufficient size to provide adequate working space when open.

8. The bottom edge of the transformer shall provide for flush mounting on a flat rigid surface to prevent wire entry into the high- or low-voltage compartments.

K. OVERCURRENT PROTECTION

Overcurrent protection devices shall not be supplied in radial feed transformers.

L. High-Voltage Terminations and Equipment: Live front with externally clamped porcelain bushings and cable connectors suitable for terminating primary cable.

M. Maximum Size

1. Transformer sizes shall not be larger than the “A” and “B” dimensions on the transformer pad dimensions shown on Sketch “A.”

N. Accessories:

1. The following accessories are required on all transformers and located in the low-voltage compartment in such a manner as to not interfere with low-voltage terminals:

   a. Pressure relief device.

b. Upper filter valve or plug.
c. One-inch combination drain, lower-filter valve, and sampling device. Combination drain plug and sampling device may be substituted

2. The following accessories are required on all transformers rated 500 kVA and above located in the low-voltage compartments, above terminals:

   a. Dial-type top oil thermometer.
   b. Liquid-level gauge.

O. JACKING, ROLLING, LIFTING, AND MOUNTING FACILITIES

1. Suitable jack bosses or equivalent jacking facilities shall be provided on the tank. Vertical clearance for jack shall be 1½ inches (38.1 mm) minimum, 3½ inches (88.9 mm) maximum.
2. Transformer base shall be arranged for rolling in two directions: parallel to and at right angles to the centerline of the high-voltage bushings.
3. Lifting lugs shall be adequately strengthened, sized, and arranged on the tank to provide a suitable lift for the completely assembled unit.
4. 3/4 inch (19.05 mm) minimum and 1½ inch (38.1 mm) maximum integral flange shall be provided at the base of the high-voltage and low-voltage compartments to provide means of anchoring the unit to the pad.

2.3 Identification Devices

A. Nameplates: Engraved, metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates to be provided and located per IEEE C57 12.00.

1. Instruction nameplate shall be located on the inside of the low-voltage compartment door.

2.4 High Voltage Bushings and Terminals

A. Bushings arrangement for live front, radial feed transformers shall comply with the latest revision of ANSI C57.12.22.

B. High voltage bushings are to be made of wet-process porcelain and clamped externally to the wall of the transformer. Reusable nitrite rubber gaskets shall seal the bushing to the tank wall in the terminals to the porcelain.

C. Transformer sizes of 75-1500 kVA, shall have 2-hole blade terminals with 9/16-in. (14.30 mm) diameter holes, with NEMA hole spacing.

D. High-voltage cable terminals shall be oriented for vertical take-off of primary cables entering the compartment from below in accordance with Figure 4, ANSI C57.12.22.

E. Transformer design shall allow field replacement of high voltage bushing wells and low voltage bushings by means of common hand tools and oil handling equipment, without totally untanking the transformer.

2.5 Low Voltage Bushings and Terminals

A. Electrical characteristics of completely assembled low-voltage terminations shall comply with Table 3 of ANSI C57.12.26-1987 (or the latest edition) unless otherwise stated herein.

B. All low voltage terminals shall be insulated from the tank with 1.2 kV class bushings. Terminals of low-voltage windings shall be arranged to the specific dimensions shown in Figure 2 and 3 (a) ANSI C57.12.22-1989 (or latest edition). In line arrangements are unacceptable.

C. The low-voltage neutral shall be a fully insulated bushing. A ground pad shall be provided. A removable copper ground strap shall be provided and connected between the neutral bushing and ground pad. The ground strap shall be capable of carrying a line to ground fault of the magnitude and duration defined in ANSI C57.12.00 (latest edition).

D. Low-voltage terminals shall be 2-hole spades with NEMA hole spacing to provide the number of holes given in Table 3.

TABLE 3

Secondary Terminals

	Transformer kVA Size						
Secondary Voltage	75	150	300	500	750	1000	1500
208Y / 120	4	6	6	8	8	8	N/A
480Y / 277	4	6	6	6	6	8	8

2.6 Oil Preservation

A. Transformers shall be of sealed tank construction, so designed that the interior is sealed from the atmosphere and the gas plus oil volume remains constant. The transformer shall remain effectively sealed for all temperatures to plus 105°C top oil.

2.7 Tanks

The tank will be of sufficient strength to withstand a pressure of 7 psi (48.26 kPa) gauge, without permanent distortion.

A. Welded main cover construction shall be provided. Access to internal connection for test purposes shall be provided by means of a hand hole, accessible only from the padlocked compartments.

B. Tank grounding provision shall consist of:

1. 500 kVA and below - two steel pads, each with a 1/2 inch (12.7 mm) 13 NC tapped hole, 7/16 inch (11.13 mm) deep.

2. Above 500 kVA - two unpainted copper-faced steel or stainless-steel pads, 2 inches x 3½ inches (50.8 mm x 88.9 mm) each with two holes spaced on 1¾ inch (44.45 mm) centers and tapped for 1/2 inch (12.7 mm) - 13 NC thread. The minimum thickness of

the copper facing shall be 0.015 inch (.381 mm). Minimum threaded depth of holes shall be 1/2 inch (12.7 mm).

C. These ground pads shall be welded on the transformer base or on the tank wall near the base, one in the high-voltage compartment and one in the low-voltage compartment.

2.8 Source Quality Control

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90.

B. Factory Tests: Perform the following factory-certified tests on each transformer:

1. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.
2. Ratios on rated-voltage connection and on tap extreme connections.
3. Polarity and phase relation on rated-voltage connection.
4. No-load loss at rated voltage on rated-voltage connection.
5. Excitation current at rated voltage and 110% rated voltage on rated-voltage connection.
6. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.
7. Applied potential.
8. Induced potential.
9. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class OA/FA or Class AA/FA rating.

    a. Temperature test is not required if record of temperature test on an essentially duplicate unit is available.

10. Owner may witness all required factory tests. Notify SDR at least 14 days before date of tests and indicate their approximate duration.

PART 3 - Execution

3.1 Examination

A. Examine areas and conditions for compliance with requirements for medium-voltage transformers.

B. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and that requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

F. The following visual and mechanical inspections shall be performed on each transformer prior to energization:

1. Inspect for physical damage, cracked insulators, leaks, tightness of connections, and general mechanical and electrical conditions.
2. Check tightness of accessible bolted electrical connections.
3. Verify proper liquid level in tank.

3.2 Installation

A. Install transformers on concrete bases.

1. Anchor transformers to concrete bases according to manufacturer's written instructions and seismic codes at Project.
2. Construct concrete bases of dimensions indicated on Sandia Standard drawing WP4001STD.
3. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Sandia Standard drawing WP4001STD.

B. Clearances

1. Provide a minimum of 5 feet working clearance in front of doors accessing primary and secondary terminations.
2. Additionally, maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

C. Touch up scratched or marred surface to match original finish.

D. Two-hole compression cable connectors shall be used on the primary and secondary cables. They shall be crimped only with the approved manufacturer’s recommended tool.

E. Energization of primary circuits and transformer shall be in accordance with Division 26, Section 26 04 75, "Primary System Safety Requirements," and contract drawings.

F. Upon energization of the transformer, the phase rotation shall be verified and secondary voltages measured, line-to-line and line-ground, on all phases.

3.3 Identification

A. IDENTIFICATION TAGS

All transformers shall have 3¼" (82.55 mm) high intensity reflective black on yellow labels, manufactured by "Electromark", Catalog # Intens - 3.0 - KY - X (where X is the letter or digit ordering). The labels shall read "TF-XXXX-Y"; X will indicate building number and Y will indicate its number at the building site. Refer to construction drawings for exact transformer number.

3.4 Connections

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems" and Sandia Standard drawing WP4001STD.

B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.5 Field Quality Control

A. The following electrical tests shall be performed by SNL prior to energization. The SDR shall be notified to coordinate and schedule the electrical testing.

B. Perform the following field tests and inspections and prepare test reports:

1. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

D. Test Reports: Prepare written reports to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.

E. The following electrical tests shall be performed prior to energization by SNL. The SDR shall be notified to coordinate and schedule the electrical testing.

1. Perform insulation-resistance tests, winding-to-winding, and winding-to-ground [(high-low and ground) and (low-high and ground)] utilizing a megohmeter with test voltage output as follows:

Transformer Insulation-Resistance Test Voltages

Transformer Coil Reading	Minimum DC Test Voltage	Recommended Minimum Insulation Resistance in Megohms
0 - 600 volts	1,000 volts	100
600 - 5,000 volts	2,500 volts	1,000
5000 - 15,000 volts	5,000 volts	5,000

2. Perform a turns-ratio test (TTR) between windings at all tap positions.
3. Sample insulating oil and perform a dielectric breakdown voltage test.

APPENDIX 1

LOSS EVALUATION

A. Transformers bid under this specification will be evaluated for no load losses and load losses using the present worth method. Each type of loss is associated with a demand charge and an energy charge. The present value of carrying charges associated with each of the charges are multiplied by the appropriate loss figure supplied by the manufacturer for each unit then added to each unit bid transformer price to obtain the total evaluated cost (TEC) per unit:

TEC = T$ + PVDC x NLL + PVEC x LL; where:

TEC = Total Evaluated Cost

T$ = Unit bid transformer price, $

PVDC = Present worth value of demand charges per kilowatt of no load losses, $/KW.

PVEC= Present worth value of energy charges per kilowatt of load losses, $/KW.

NLL = Transformer no load losses, KW.

LL = Transformer load losses, KW.

Current Values:

PVDC = $8134.00

PVEC= $3326.00

B. In the event actual losses exceed the losses guaranteed, SNL shall have the right to either reject the equipment or to accept the equipment for a reduced price. The amount due SNL shall be calculated as follows:

Price Reduction = (NLLA - NLLQ) x PVDC +(LLA - LLQ) x PVEC; where:

NLLA = Actual transformer no load losses, KW.

NLLQ = Quoted transformer no load losses, KW.

LLA = Actual transformer load losses, KW.

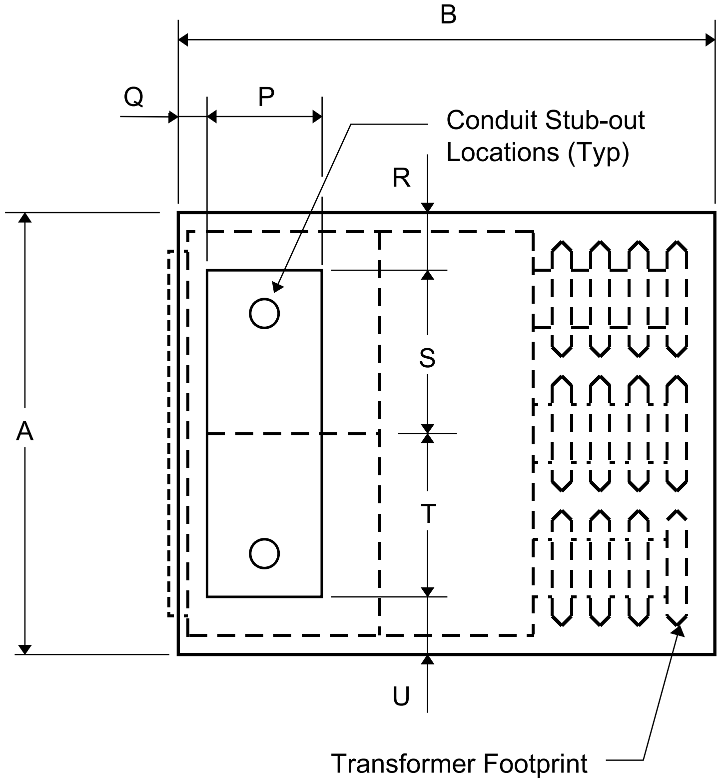
LLQ = Quoted transformer load losses, KW.

END OF SECTION 26 12 00

ATTACHMENT

SKETCH "A"

Transformer Pad Dimensions



ENLARGED PLAN VIEW

TRANSFORMER PAD DIMENSIONS										
XFMR kVA	Gallon Oil	Total Fluid Vol. Ft^3 (V_c)	A	B	P	Q	R	S	T	U
75	130	34.507	6'-11"	5'-8.5"	1'-1.5"	0'-9.5"	1'-8"	2'-2"	1'-5"	1'-8"
150	140	36.319	6'-11"	5'-10"	1'-1.5"	0'-9.5"	1'-8"	2'-2"	1'-5"	1'-8"
300	185	44.139	7'-4"	6'-3.5"	1'-1.5"	0'-9.5"	1'-4.5"	2'-2"	1'-5"	2'-0.5"
500	185	46.111	7'-8"	6'-5.5"	1'-1.5"	0'-9.5"	2'-1/2"	2'-2"	1'-5"	2'-0.5"
750	380	73.993	8'-0"	7'-0.5"	1'-1.5"	0'-9.5"	2'-0"	2'-3"	2'-2"	1'-6.5"
1000	400	78.917	8'-0"	8'-5.5"	1'-1.5"	0'-9.5"	1'-4"	2'-11"	2'-2"	1'-6.5"
1500	490	95.431	8'-6"	8'-8.5"	1'-1.5"	0'-9.5"	1'-8"	3'-0"	2'-3"	1'-7"

Exceptional service in the national interest

Sandia National Laboratories

Section 26 13 00 – Medium-Voltage Switchgear

April 2016

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Review Date: 04/18/2019

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 26 13 00 – Medium-Voltage Switchgear

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.

Section 26 13 00 – Medium-Voltage Switchgear

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. The extent of the switchgear work is indicated by the construction drawings and by requirements of this specification.

B. The Contractor will be responsible for the entire installation and testing of the S & C type switchgear.

C. Related Documents:

1. Sandia's Standard Specifications
   a. Section 31 20 00, "Earthwork"
   b. Section 26 05 43, "Underground Ducts and Utility Structures Power"
   c. Section 03 30 00, "Cast-In-Place Concrete"
   d. Section 26 05 13, "Medium Voltage Cable"
   e. Section 26 04 75, "Primary Systems Safety Requirements"
2. Sandia's Standard Drawings
   a. WP5019STD – S&C Switchgear Configuration and Clearance
   b. WP5020STD – S&C Pad Mount Switchgear Details
   c. WP6010STD – S&C Pad Mount Equipment List and Details

1.3 Definitions

A. ATS: Acceptance Testing Specifications.

B. GFCI: Ground-Fault Circuit Interrupter.

1.4 Quality Assurance

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

C. Contractor Qualified with at least ten years of successful installation experience on projects with electrical installation work similar to that work required for project. Contractor must also meet qualification requirements per 260475, Primary Systems Safety Requirements.

D. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with IEEE C2.

1.5 Coordination

A. Coordinate layout and installation of switchgear and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.

B. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.6 Extra Materials

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Fuses will be SNL furnished.
2. Touchup Paint: Three containers of paint matching enclosure finish, each 0.5 pint (250 mL).

PART 2 - Products

2.1 The switchgear will be manufactured by S & C Electric Company.

A. The 15KV metal enclosed stand-up switchgear will usually be the System II modular type and the padmount switchgear will usually be the PMS or the PMH type.

2.2 The type and the options, such as motor operated switch, will be indicated on the drawings.

PART 3 - Execution

3.1 General

A. All construction work shall be done in a thorough and conscientious manner in accordance with the Specifications and Construction Drawings.

B. Install switchgear and accessory items in accordance with the manufacturer's written installation instructions.

C. Install switchgear so that the installation complies with requirements of applicable NEMA, IEEE, and NFPA-70 standards.

D. The Contractor shall follow the primary systems safety procedures as specified in Section 26 04 75, "Primary System Safety Requirements."

E. The Contractor must examine areas and conditions under which the switchgear is to be installed and notify the SDR in writing of those conditions detrimental to proper completion of the work. Do not proceed with the work until satisfactory conditions have been corrected in a manner acceptable to the contractor.

3.2 Examination

A. Examine elements and surfaces to receive switchgear for compliance with requirements for installation tolerances, required clearances, and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 Switchgear Delivery, Storage and Handling

A. The Contractor will deliver switchgear from a SNL designated location within Sandia National Laboratories/Kirtland Air Force Base to the job site. Contractor shall provide all lifting and transporting equipment. Contractor shall contact SDR for location of switchgear.

B. The Contractor will notify the SDR prior to moving if there is any damage to switchgear.

C. Handle switchgear carefully to prevent internal damage, breakage, denting, and scoring of enclosure finish.

D. Protect units from dirt, fumes, water construction debris and traffic.

3.4 Concrete Work

A. Coordinate size and location of concrete pads per construction drawings.

B. Install concrete pads per requirements of Section 03 30 00, "Cast-In-Place Concrete."

3.5 Conduit and Cable

A. Coordinate size of conduit and cable per construction drawings.

B. Install conduit per requirements of Section 26 05 43, "Underground Ducts and Utility Structures" and 31 20 00, "Earth Moving" and per Standard Drawings WP5019STD, WP5020STD, and WP6010STD.

C. Install medium voltage cable per requirements of Section 26 05 13, "Medium Voltage Cables."

3.6 Grounding

1. Install ground grid and ground rods per construction drawings.
2. Ground switchgear ground bus and enclosure per manufacturer's recommendations, construction drawings and Standard Drawing WP5020STD.DGN.

3.7 Installation

A. Assemble switchgear units and components per manufacturer's recommendations.

B. The stand-up switchgear must be aligned properly. Make sure that the switchgear-bay doors open and close without binding. Binding indicates enclosure distortion that must be corrected by additional shimming.

C. Tighten bus connections and mechanical fasteners. Do not tighten factory-made connections employing Belleville washers unless they are visibly loose.

D. Adjust S & C switchgear operating mechanism per S & C's recommendations.

E. On stand-up type switchgear, strip heaters shall be connected to an adequate power source and energized before placing switchgear in service.

F. Upon completion of installation, touch up scratches and mars of finish to match original finish.

G. Anchor switchgear per manufacturer's recommendations and per construction drawings.
   1. Concrete Bases: per SNL Standard drawings referenced in paragraph 1.2C. Extend base no less than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchgear, unless otherwise indicated or unless required for seismic anchor support.

H. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchgear units and components.

3.8 Identification

A. The contractor shall label switchgear with 3-7/8" pressure sensitive reflective black and yellow flat foil-type labels, manufactured by "Almetek." Refer to Standard Drawing WP5019STD for label location on padmounted switchgear. Refer to construction drawings for switch numbers.

3.9 Connections

A. Cable terminations at switchgear are specified in Section 26 05 13 “Medium-Voltage Cables.”

B. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values.

C. Ground equipment according to Section 26 05 26 “Grounding and Bonding for Electrical Systems” and standard drawing, WP5020STD.DGN.

D. Connect wiring according to Section 26 05 19 “Low-Voltage Electrical Power Conductors and Cables” and Section 26 05 13 “Medium-Voltage Cables.”

3.10 Field Quality Control

A. INSPECTION AND TESTING

The Contractor shall inspect and test all Contractor-furnished or SNL-furnished switchgear as follows:

1. Compare equipment nameplate information with latest single line diagram and report discrepancies.
2. Check for proper anchorage, required area clearances, physical damage, and proper alignment. Refer to Standard Drawing WP5019STD for proper clearances for PMH/PMS type switchgear.
3. Inspect all doors, panels and sections for paint, dents, scratches, fit, and missing hardware.
4. Contractor shall furnish and install one set (3 per set) of fuse refills and also provide one set of spare fuse refills per each fused section or cubicle. The fuse refill size will be per construction drawings. This requirement applies to SNL furnished and contractor furnished switchgear.
5. Inspect all bus connections for high resistance. Use low resistance ohmmeter, or check tightness of bolted bus joints by calibrated torque wrench method. Do not tighten factory-made connections employing Belleville washers unless they are visibly loose. Refer to manufacturer's instructions for proper torque levels.

6. Test all electrical and mechanical interlock systems for proper operation and sequencing.

   a. Closure attempt shall be made on locked open devices. Opening attempt shall be made on locked closed devices.
   b. Key exchange shall be made with devices operated in off-normal positions.

7. Clean entire switchgear using manufacturer's approved methods and materials.
8. Inspect insulators for evidence of physical damage or contaminated surfaces.
9. Verify proper barrier and shutter installation and operation.
10. Exercise manually operated and power-operated switches.
11. Inspect all indicating devices for proper operation.
12. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit. Test continuity of each circuit.

    NOTE: Before performing tests, make certain that the high-voltage conductors are not connected (i.e., are de-energized and properly isolated). Test for voltage and isolate and tag all circuits in accordance with established system-operating procedures. In addition, if applicable, remove the primary fuses and disconnect all secondary connections from all voltage transformers and disconnect all surge arrestors.

    Values of insulation resistance less than specified below shall be investigated.

Voltage Rating	Minimum Test Voltage	Recommended Minimum Insulation Resistance In Megohms
5,000 V	2,500 V DC	1,000
15,000 V	2,500 V DC	5,000

13. Visually check integrity of ground.

B. The Contractor shall arrange and pay for the services of a factory-authorized S & C representative to perform tests and inspect the installation of power operated stand-up or padmounted switchgear unless noted otherwise.
As a minimum, the tests should include the following:

1. Perform all inspection and tests as described in 3.10, A.
2. If secondary control wiring is specified, all terminals should be checked for tightness, and the jumpers between terminal blocks of adjacent bays should be reconnected at points where "shipping splits" occur.
3. Verify operation of all auxiliary equipment.
4. Test protective relays on power operated switchgear per manufacturer's recommendations to assure settings as indicated on construction drawings.
5. The S & C factory representative will verify that the switchgear is ready to energize.
6. The factory-authorized S & C representative shall submit written reports of observations and tests to the SDR. The report shall include any defective material or workmanship.

C. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

D. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:

a. Switchgear.
b. Protective relays.
c. Instrument transformers.
d. Metering and instrumentation.
e. Surge arresters.

E. Remove and replace malfunctioning units and retest as specified above.

3.11 Adjusting

A. Set field-adjustable, protective-relay trip characteristics according to engineer’s overcurrent protective device coordination study.

3.12 Cleaning

A. On completion of installation, inspect interior and exterior of switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

3.13 Training

A. The Contractor shall arrange and pay for the services of a S & C factory-authorized service representative to train SNL's maintenance personnel on the power operated stand-up or padmounted switchgear unless noted otherwise.

B. Conduct a minimum of four hours training operation and maintenance of the power-operated switchgear. The training should include both operations and maintenance procedures.

C. Schedule training with the SDR with at least fourteen days advance notice.

END OF SECTION 261300

Exceptional service in the national interest

Sandia National Laboratories

Section 26 22 00 – Low-Voltage Transformers

April 2018

Effective Date: 04/03/2018
Review Date: 04/03/2021

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 26 22 00 – Low-Voltage Transformers

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
4/3/18	Tim Peterson	Admin	3-year review performed; basic copyediting changes; no major changes to content

Section 26 22 00 – Low-Voltage Transformers

Part 1 – General

1.1. Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. Summary

A. Section Includes: Distribution dry-type transformers rated 600 V and less, with capacities up to 1500 kVA.

1.3. Action Submittals

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.4. Informational Submittals

A. Seismic Qualification Certificates: For transformers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Qualification Data: For testing agency.

C. Source quality-control reports.

D. Field quality-control reports.

1.5. Closeout Submittals

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6. Quality Assurance

A. Testing Agency Qualifications: Member company of InterNational Electrical Testing Association (NETA) or a nationally recognized testing laboratory (NRTL).

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7. Delivery, Storage, and Handling

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

Part 2 – Products

2.1. Manufacturers

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include but are not limited to the following:

1. ACME Electric Corporation; Power Distribution Products Division.
2. Challenger Electrical Equipment Corp.; a division of Eaton Corp.
3. Eaton Electrical Inc.; Cutler-Hammer Products.
4. General Electric Company.
5. Magnetek Power Electronics Group.
6. Siemens Energy & Automation, Inc.
7. Sola/Hevi-Duty.
8. Square D; Schneider Electric.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2. General Transformer Requirements

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

E. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Aluminum unless noted otherwise on the drawings.

F. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

G. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3. Distribution Transformers

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces.

C. Cores: One leg per phase.

D. Enclosure: Rating as indicated on the drawings.
E. Transformer Enclosure Finish: Comply with NEMA 250.
1. Finish Color: Gray

F. Taps for Transformers 3 kVA and Smaller: None

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

I. Insulation Class, Smaller than 30 kVA: 185 degrees C, Underwriters-Laboratory-(UL-) component-recognized insulation system with a maximum of 115-degrees C rise above 40-degrees C ambient temperature.

J. Insulation Class, 30 kVA and Larger: 220 degrees C, UL-component-recognized insulation system with a maximum of 150 degrees C rise above 40-degrees C ambient temperature, unless noted otherwise on the drawings.

K. K-Factor Rating: Transformers indicated on the drawings to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
2. Indicate value of K-factor on transformer nameplate.
3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.

L. Electrostatic Shielding (Only as noted on the drawings): Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

M. Neutral: Rated 200 percent of full load current for K-factor rated transformers.

N. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9 kVA and Less: 40 dBA.
2. 30 to 50 kVA: 45 dBA.
3. 51 to 150 kVA: 50 dBA.
4. 151 to 300 kVA: 55 dBA.
5. 301 to 500 kVA: 60dBA.
6. 501 to 750 kVA: 62 dBA.
7. 751 to 1000 kVA: 64 dBA.
8. 1001 to 1500 kVA: 65dBA.

2.4. Identification Devices

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Standard Drawing E006STD.

2.5. Source Quality Control

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.
2. Ratio tests at the rated voltage connections and at all tap connections.

3. Phase relation and polarity tests at the rated voltage connections.
4. No load losses, and excitation current and rated voltage at the rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation Resistance Tests:
   a. High-voltage to ground.
   b. Low-voltage to ground.
   c. High-voltage to low-voltage.
9. Temperature tests.

Part 3 – Execution

3.1. Examination

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. Installation

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer

   1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.

B. Install transformers level and plumb on a 3.5-inch high concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface. Refer to SNL Standard Drawing SB1001STD.

C. Construct concrete bases according to Section 03 30 00 "Cast-in-Place Concrete," and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.3. Connections

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4. Field Quality Control

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specifications (ATS) for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

E. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

G. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5. Adjusting

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6. Cleaning

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 22 00

Exceptional service in the national interest

Sandia National Laboratories

Section 26 24 12 – Switchboards – Service Entrance

April 2016

Effective Date: 04/18/2016
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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 26 24 12 – Switchboards – Service Entrance

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
7/7/16	Erika Barraza	Admin	Updated Section 3.3B.
4/6/17	Tim Peterson	Admin	Small updates in 1.1, 1.4, 2.1, 2.4 mostly regarding names of items

Section 26 24 12 – Switchboards – Service Entrance

PART 1 - General

1.1 Requirements

A. The Contractor shall furnish and install, where indicated, a NEMA 1 or 3R/12 per the drawings free-standing, dead-front type low voltage distribution switchboard, utilizing group mounted circuit protective devices as specified herein, and as shown on the contract drawings. This will be designed to be installed at Sandia National Laboratories at 5500 feet above sea level.

1.2 References

A. Related Sections: Refer to the following Sections for related work.

1. Division 1, Section 01 33 00, "Submittal Procedures"
2. Division 9, Section 09 90 00, "Painting
3. Division 26, Section 26 05 19, "Low Voltage Electrical Power Conductors and Cables"
4. Division 26, Section 26 05 26, "Grounding and Bonding for Electrical Systems"
5. Refer to E-0006 STD Electrical Standard Symbols List
6. Division 26, Section 26 43 13, "Surge Protective Devices for Low-Voltage Electrical Power Circuits"
7. Division 26, Section 26 28 16, "Enclosed Switches and Circuit Breakers"
8. Division 26, Section 26 05 74, "Overcurrent Protective Device Arc-Flash Study"
9. Division 26, Section 26 06 20, "Schedules for LV Electrical Distribution"

1.3 Summary

A. Section includes:

1. Service entrance switchboards rated 600 V and less.
2. Disconnecting and overcurrent protective devices.
3. Instrumentation.
4. Control power.
5. Accessory components and features.
6. Identification.

1.4 Submittals

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data: For each type of switchboard, overcurrent protective device, surge protective device, ground-fault protector, accessories, and components indicated, include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

C. Shop Drawings: For each switchboard and related equipment

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Equipment anchorage details.
4. Detail bus configuration, current, and voltage ratings, and cable terminal sizes.
5. Detail short-circuit current rating of switchboards and overcurrent protective devices.
6. Include descriptive documentation of barriers specified for electrical insulation and isolation.
7. Detail provisions for voltage and current input connections to separately enclosed power meter.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Include selectable ranges for each type of overcurrent protective device.
10. Manufacturer’s schematic wiring diagram.
11. Point-to-point control wiring diagram: Differentiating between manufacturer-installed and field-installed wiring (may be submitted upon delivery of switchboard).
12. Schematic and wiring diagram for signal wiring.
13. Key interlock scheme drawing and sequence of operations where required by construction documents.

D. Certified production test reports

E. Report of field tests and observations certified by the testing organization

F. Installation and maintenance data.

1.5 Quality Assurance

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. The low voltage distribution switchboards and all components shall be designed, manufactured, and tested in accordance with the latest applicable following standards:

1. NEMA PB-2
2. UL Standard 891

C. Independent testing firm qualifications: The testing organization must demonstrate that it has the experience and capability to conduct the testing indicated satisfactorily. Acceptance will be based on evaluation of organization-submitted criteria conforming to ASTM E 699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

D. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.6 Delivery, Storage, and Handling

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Where switchboards will be stored outdoors for periods exceeding one day, provide suitable protection to avoid condensation or other weather damage.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.7 Coordination

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

PART 2 - Products

2.1 General

A. The electrical switchboard shall be new and listed by the Underwriter's Laboratories, Inc., (UL) or other nationally recognized testing laboratory for the application, except as otherwise specified herein.

B. The equipment outlined in this specification will consist of a metal-enclosed switchboard with all necessary compartments, service conductor termination section, bus works, metering, circuit breakers, and miscellaneous equipment for the application.

C. The voltage, amperage, wiring configuration, NEMA rating, and available fault current rating shall be not less than indicated on the drawings.

D. Design the switchboard to withstand the mechanical stresses caused by rough handling during shipping in addition to the electrical and mechanical stresses which will occur during operation of the switchboard.

E. Assemble, connect, and wire the switchboard at the factory so that minimal work will need to occur at the construction site.

F. Thoroughly clean, phosphatize, and paint the metal surfaces at the factory with primer and baked enamel or lacquer ANSI-61 light gray finish.

G. The main breaker shall be drawout-mounted, unless otherwise approved by SNL engineer.

H. The branch breakers shall be drawout-mounted, unless otherwise approved by SNL engineer.

I. Buses and Connections: Three phase, four wire unless otherwise indicated.

2.2 Equipment

A. Switchboards must be provided from the following approved manufacturers:

1. Eaton

2. Siemens

B. Switchboard Structure:

1. The switchboard shall be suitable for use as service entrance equipment and be labeled in accordance with UL requirements.
2. Switchboard shall be completely self-supporting structure of the required number of vertical sections bolted together to form one metal-enclosed switchboard 90 inches high. Sides, top, and rear covers shall be code gauge steel, bolted to the switchboard structure. The frame structure members shall be die-formed 12-gauge steel bolted together and reinforced at external corners. The switchboard frame is to be suitable for use as floor sill. Switchboard shall be front accessible.
3. Devices shall be front removable via a drawout mechanism.
4. Removal of deadfront covers shall not be required prior to removal of drawout devices.
5. Molded-case circuit breaker load connections shall be front-accessible enabling switchboard to be mounted against a wall.
6. Provide each drawout circuit breaker unit with a rotary drawout mechanism. The breaker cassette shall positively align the breaker in the stationary structure during insertion and removal operations, and provide the operator with indication of breaker position (connected/disconnected). Space for future device shall include all necessary bus, device supports and mounting brackets, and connections.
7. Line and load connections for molded case circuit breakers up to 1200 amps shall remain with the breaker cassette base inside the switchboard when the breaker drawout element is removed. Designs that require removal of line or load conductors to remove the drawout element are not acceptable.
8. Each drawout unit shall be equipped with two (2) grab handles to facilitate safe handling. Handles shall be mounted to the drawout unit deadfront cover.

9. Provide non-defeatable interlocks to block operation of the drawout mechanism when circuit breaker contacts are closed.
10. Switchboard is to be provided with adequate lifting means and be capable of being rolled or moved into installation position and bolted directly to the floor without the use of floor sills.
11. The switchboard shall have facilities for current transformers and multi-function circuit monitor as indicated on the power one-line diagram.
12. Die-pierce holes for connecting adjacent sections to insure alignment and facilitate future additions.
13. Bolts, nuts, and washers shall be rustproof metal.
14. Spaces within the section shall be suitable and adequate for the equipment and cables.
15. For outdoor switchboards, provide interchangeable filters on the vents to minimize dust entry into the switchboard.
16. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
17. Removable, Hinged Rear Doors and Compartment Covers: Secured by standard bolts, for access to rear interior of switchboard.
18. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

C. Bus Bars:

1. The main bus and riser bus shall be silver-plated copper of 98% conductivity and shall be braced to withstand mechanical forces exerted during short circuit conditions.
2. Current density of the bus shall not exceed 1,000 amperes per square inch cross section.
3. The main bus, riser buses, and horizontal bus shall be sized for 3 phase, 4 wire, rated per the drawings.
4. All feeder device line and load connection straps shall be rated to carry the full continuous current rating of the device frame. Load connection straps shall extend beyond the main bus.
5. A copper ground bus system, consisting of a 2" X 1/4" minimum continuous copper bus bar, shall be thoroughly bonded to the switchboard frames and equipment cases, and shall extend to the entire length of the switchboard.
6. A-B-C-type bus arrangement (left-to-right [referenced from the front], top-to-bottom, and front-to-rear) shall be used throughout to assure convenient and safe testing and maintenance. Where special circuitry precludes this arrangement, bus bars shall be labeled.
7. A 100 percent capacity neutral bus will be carried with the phase buses in addition to the ground bus.
8. Bus bar and interconnection joints shall be silver-plated, constant high pressure type with high strength copper-silicon alloy bolts, nuts, and Belleville-type spring-cup washers, or shall be made by approved welding.

D. Nameplates:

1. For each of the circuit breaker switch compartments and other items which will not be readily identifiable, install an identification sign which will clearly indicate the information required by the people who will use and maintain the items.
2. The signs shall be laminated black phenolic resin with a white core, 1" x 2-1/2" minimum, and engraved lettering which is not less than 3/16" high.

2.3 Disconnecting and Overcurrent Protective Devices

A. All breakers rated 1200A and below shall be Molded-Case Circuit Breakers (MCCB). Circuit breakers rated above 1200A may be Insulated-Case Circuit Breakers (ICCB): All breakers shall be solid state breakers with RMS sensing, field replaceable rating plug, or field replaceable electronic trip and the following field-adjustable settings. Provide factory installed padlocking devices on all circuit breakers.

1. MCCB & ICCB Features and Accessories:

   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
   c. Microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
      1) Instantaneous trip.
      2) Long- and short-time pickup levels.
      3) Long- and short-time time adjustments.
      4) Ground-fault pickup level, time delay, and I^2t response where required.
   d. Provide manufacturer’s test kit for all circuit breaker types and functions used.

2. Main Circuit Breaker

   a. Install main circuit breaker in a dedicated compartment in switchboard, with suitable barriers to isolate circuit breaker component from arc flash hazard at switchboard bus and to allow downstream switchboard components to be serviced while main circuit breaker is open.
   b. Include push-button operators for both opening and closing the circuit breaker.
   c. Include provisions on the circuit breaker for temporary installation and operation of a remote operating device. The device may be either mechanical or electrical to be operated a safe distance away for both opening and closing the main circuit breaker.
   d. All breakers shall be provided with an electronic trip test set to allow for future breaker testing.

2.4 Instrumentation

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: ABB type CMV sized for the application.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.

B. Provide a Schneider Electric (Square-D) Powerlogic PM5563RD power meter with remote display in a stand-alone factory assembled enclosure separate from the switchboard. The factory assembled enclosure shall include a network interface card and suitable isolation blocks for metered voltage, current, and control power to allow meter to be serviced while switchboard is energized.

1. A 4-wire, wye connected, 3-CT metering configuration will be used. CTs shall be installed in the switchboard with CT leads terminating at a terminal block.

2. Metering input and control power voltages shall be derived from a dedicated circuit 20A breaker in the Switchboard.

3. Provide with meter (1) RS-485 terminator, Square D Class 3020, Model MCTAS-485. See wiring diagram on drawing.

4. Refer to Sandia standard drawing EI6006STD.DGN for metering equipment list.

C. Provide surge suppression device (SPD) per SNL Standard Specification 26 43 13.

1. Preferred External Installation: Install surge suppression device in an external enclosure mounted to switchboard, with a dedicated breaker mounted in switchboard to allow SPD to be serviced while switchboard is energized

2. Optional Integral Installation: Install surge suppression device in a dedicated SPD compartment in switchboard, with suitable barriers to isolate SPD components from arc flash hazard at switchboard bus and to allow SPD to be serviced while switchboard is energized

2.5 Factory Testing:

A. Test the switchboard at the factory to insure that there are no electrical or mechanical defects.

2.6 Control Power

A. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

B. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

PART 3 - Execution

3.1 Examination

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Verify each overcurrent device matches the approved submittal. Information to verify is:

1. Model or part number
2. Frame size
3. Overcurrent rating, including sensor and plug if equipped

4. Overcurrent functions and setting ranges (e.g.: Long time pickup/delay, short time pickup/delay, instantaneous, ground fault pickup/delay)

D. Submit Request for Information (RFI) to obtain overcurrent device settings and arc flash hazard labels. Allow two weeks for response.

E. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the work.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Installation

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 3.5-inch nominal thickness.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to switchboards.

5. Provide #4 rebar 18” O.C. in both directions on concrete pad.

6. Provide 1” chamfer on all sides of concrete pad.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Install filler plates in unused spaces of panel-mounted sections.

E. Install overcurrent protective devices, surge protection devices, and instrumentation.

3.3 Field Quality Control

A. Testing Agency: Testing must be performed by a third-party testing firm, meeting all qualifications stated in the latest edition of the ANSI/InterNational Electrical Testing Association (NETA) document, *ANSI/NETA Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems* or an agency approved by the SNL Electrical Engineering Group.

B. Tests and Inspections

1. All acceptance testing must be performed in accordance with the latest edition of *ANSI/NETA Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems*.

2. Testing of breakers shall be per Standard Specification 262816, *Enclosed Switches and Circuit Breakers.*

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

4. Acceptance test report shall be provided to SNL Electrical Engineer prior to energizing the switchboard.

3.4 Adjusting

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker functions per response to RFI requested per item 3.1 D above.

C. Install arc flash hazard labels obtained from SNL per RFI response per item 3.1 D above.

END OF SECTION 26 24 12

Exceptional service in the national interest

Sandia National Laboratories

Section 26 24 16 – Panelboards

April 2016

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U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 26 24 16 – Panelboards

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
7/7/16	Erika Barraza	Admin	Updated Section 1.2A and Section 3.3A and B.
5/1/17	Michael Smith	Admin	Updated Section 2.2. bullet E, Section 2.3 bullet A, Section 2.5 bullet 1 (a &B) and 2 (b), and Section 3.3 bullet B (1).

Section 26 24 16 – Panelboards

PART 1 - General

1.1 Summary

A. This Section describes lighting and appliance and power panelboards rated at 600 volts or less and 800 amperes or less. Panelboards larger than 800 Amps shall not be installed unless approved in writing by SNL engineer.

1.2 References

A. Related Sections: Refer to the following Sections for related work.

1. Division 1, Section 01 33 00, “Submittal Procedures”
2. Division 9, Section 09 90 00, “Painting”
3. Division 26, Section 26 05 19, “Low-Voltage Electrical Power Conductors and Cables”
4. Division 26, Section 260526, “Grounding and Bonding for Electrical Systems”
5. Division 26, Section 26 43 13, “Surge Protective Devices for Low-Voltage Electrical Power Circuits”
6. Division 26, Section 26 28 16, “Enclosed Switches and Circuit Breakers”
7. Division 26, Section 26 05 74, “Overcurrent Protective Device Arc-Flash Study”
8. Division 26, Section 26 06 20, “Schedules for LV Electrical Distribution”

B. Related Drawings: Refer to Standard Drawing E-0006STD, Standard Symbols List and General Notes for panelboard identification requirements.

C. National Electrical Manufacturers Association (NEMA®)

1. PB 1 Panelboards
2. PB 1.1 General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 V or Less
3. 250 Enclosures for Electrical Equipment (1000 V Maximum)

D. Underwriters Laboratories, Inc.® (UL)

1. 50 Enclosures for Electrical Equipment

2. 67 Panelboards

3. 486A Wire Connectors

4. 489 Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

1.3 Submittals

A. General: Submit the following in accordance with Conditions of Contract and Division 1, Section 01 33 00, "Submittal Procedures."

B. Product data for each type of panelboard, accessory item, and component specified.

C. Shop Drawings: Include the following for all panelboards.
1. Manufacturer type, style and model number as applicable.
2. Voltage, phase, and current rating, and neutral if required.
3. Short-circuit current rating of panelboard.
4. Main circuit breaker size and type, or main lugs only and location.
5. Tabulation of all branch circuit breakers including type, size, location in panelboard, and circuit numbering.
6. Enclosure dimensions.
7. Enclosure side gutter dimensions (reference 2.3 E).
8. All modifications and additional equipment, including but not limited to copper bus, ground bus bonded to box, circuit breaker locking devices, door-in-door cover, and UL Service Entrance Label as required.

1.4 Quality Assurance

A. Comply with NFPA 70.

B. All panelboards must be designed, manufactured, and assembled in accordance with the referenced standards.

C. Listing and Labeling: All panelboards must be listed and labeled by Underwriters Laboratories, Inc., or another nationally recognized testing laboratory (NRTL).

D. Service Entrance panelboards must be UL/NRTL labeled as suitable for that purpose.

E. Single-Source Responsibility: Provide panelboard products that are new and from the same manufacturer for each building or job. Panelboard components must be from the same manufacturer, or listed as an assembly thereof.

F. Independent testing firm qualifications: The testing organization must demonstrate that it has the experience and capability to conduct the testing indicated satisfactorily. Acceptance will be based on evaluation of organization-submitted criteria conforming to ASTM E 699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

1.5 Delivery, Storage, and Handling

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.6 Project Conditions

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

   a. Ambient Temperature: Not exceeding [minus 22 deg F (minus 30 deg C)] [23 deg F (minus 5 deg C)] to plus 104 deg F (plus 40 deg C).
   b. Altitude: 5500 feet (1700 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. The contractor shall not interrupt any main electrical utility without a written request for an outage and a subsequent approval by Sandia National Laboratories/New Mexico.

   a. Written request for outages shall be submitted 21 calendar days in advance of the outage date. This request will delineate the particular circuit or service interrupted and the approximate hours the utility shall be off.

2. The work to be performed during an interruption of electrical utilities will be preceded by all possible preparation and will be carefully coordinated to minimize the duration of the interruption. Work will proceed continuously until the system is restored to normal.

3. Comply with NFPA 70E.

1.7 Coordination

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces.

Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

PART 2 - Products

2.1 Manufacturers

A. Panelboards must be provided from the following approved manufacturers:

1. Eaton
2. Siemens
3. Square D

B. Panelboards from a manufacturer other than those listed above require a special specification and prior approval from Sandia National Laboratories (SNL).

2.2 General

A. Voltage and current rating, as indicated on panel schedules.

B. Ampere-interrupting capacity (AIC) as indicated on panel schedules. Series AIC ratings are not acceptable.

C. Main circuit breaker (MCB) or main lug only (MLO) as indicated on panel schedules. Double or dual main lugs or subfeed lugs are not acceptable.

D. Panelboards must be in a single enclosure. Two-section panels are not acceptable.

E. Provide panelboards with size and number of single, double, or triple-pole circuit breakers as indicated on panel schedules. When multipole breakers are scheduled for multipole loads, provide same with a single-operating handle. For existing systems furniture application, where the neutral is shared, handle-tied, single-pole breakers shall be used. Single-handle, multipole breakers must not be substituted for handle-tie requirements.

F. Arrange and number circuit breakers exactly as shown on drawings and panel schedules. Single-branch-mounted or subfeed breakers are not acceptable.

G. Where the word “space” occurs on panel schedules, provide all necessary hardware in the space, including connection straps, mounting brackets, and filler plates, so only the addition of a future circuit breaker is required. Connection straps must be rated a minimum of 100A in panelboards of 400A rating or less and a minimum of 225A in panelboards above 400A rating, unless otherwise noted on panel schedules.

H. Provide Micarta® buttons, small window-frame, or permanent-strip-type identification labels on interior trim to identify circuit number. Do not use adhesive-backed fabric or paper labels alone.

2.3 Enclosures

A. Must be NEMA-type enclosure as indicated on panel schedules. For exterior panelboards a dual-rated NEMA 3R/12 shall be furnished. Where one piece hinged “door-in-door” front cover for exterior-rated panelboards is not available, consult SNL engineer for an exception.

B. Provide flush or surface cover, as indicated on panel schedules.

C. Front cover must be factory manufactured, UL/NRTL listed, one-piece, hinged “door-in-door” type with the following:

1. Interior hinged door with hand-operated latch or latches as required to provide access to circuit breaker operating handles only; not to energized parts.

2. Outer hinged door to provide access to the entire enclosure, including deadfront and all wiring gutters.

3. Outer door must be securely mounted to the panelboard box with factory bolts, screws, clips, or other fasteners requiring a tool for entry; hand-operated latches are not acceptable.

4. Both inner and outer doors must be hinged on the right to open left to right.

D. Include one-piece, removable, inner deadfront cover independent of the panelboard cover.

E. Provide enclosure with the following side gutter dimensions:

1. Left side: minimum 4” measured from inside lip of the box to the installed deadfront.

2. Right side: minimum 4” measured from inside lip of the box to the installed deadfront. With the door-in-door cover in place: minimum 3” from installed outer door hinge to the installed deadfront.

F. Prepare, prime, and paint front trim cover with light gray enamel electro-deposited over phosphatized steel, or baked-on polyester coating.

G. Incoming Mains Location: As indicated on panel schedules.

2.4 Bus:

A. Phase buses must be hard-drawn 98% conductivity copper.

B. Neutral Bus

1. Must be hard-drawn 98% conductivity copper.

2. Must be 100% rated (current rating same as phase buses).

3. Must provide a screw terminal for each breaker position, in addition to the feeder neutral lug.

C. Grounding Bus

1. Must be hard-drawn 98% conductivity copper.

2. Must be factory installed, bonded to enclosure.

3. Must provide a screw terminal for each breaker position, in addition to the feeder grounding conductor lug.

4. Must be adequate for feeder and branch circuit equipment grounding conductors.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Mechanical type.
3. Ground Lugs and Bus-Configured Terminators: [Mechanical] type.

E. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.

2.5 Disconnecting and Overcurrent Protective Devices

A. General: Provide circuit breakers as integral components of panelboard with indicated features, ratings, characteristics, and settings.

B. Mounting: Each circuit breaker must be bolted into position in the panelboard, whether by direct bolted connection to the bus or by being bolted to the panelboard frame. Each circuit breaker must be replaceable without disturbing adjacent units. Plug-on circuit breakers held in place only by the spring force of the bus lug and the pressure of the deadfront are not acceptable.

C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Characteristics: Frame size, trip rating, voltage, frequency, number of poles, and short-circuit interrupting capacity rating as indicated on panel schedules.
   a. All 120/208V and 240V breakers rated 225A and above shall be solid-state breakers with Root Mean Square (RMS) sensing, electronic trip, and have field adjustable long-time, short-time, and instantaneous pickup settings.
   b. All 277/480V breakers rated 100A and above shall be solid state breakers with RMS sensing, electronic trip, and have field adjustable long-time, short-time, and instantaneous pickup settings.

2. Tripping Device: Quick-make, quick-break toggle mechanism with inverse-time delay and instantaneous overcurrent trip protection for each pole.

a. Multipole molded-case circuit breakers must include common internal tripping of all poles.

b. Circuit breakers with “handle ties” are not acceptable, except in existing systems furniture applications.

c. Half-size circuit breakers with two circuits occupying a single position on the same phase bus are not acceptable.

3. Terminal Lugs: Provide load side of circuit breaker with front-connected UL-listed lugs for copper cable at full frame rating. Provide terminals rated for minimum 75°C.

4. All single-pole circuit breakers must be switching-duty rated.

5. All multipole circuit breakers must be HACR-duty rated.

6. Provide factory-installed circuit breaker handle padlocking devices on all multipole circuit breakers.

7. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

8. Electronic trip circuit breakers with RMS sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

a. Instantaneous trip.

b. Long- and short-time pickup levels.

c. Long- and short-time time adjustments.

d. Ground-fault pickup level, time delay, and I2t response.
   1) Provide only when specified on drawings and/or panel schedule.

9. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.

D. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

E. Portable Test Set: For setting and testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - Execution

3.1 Installation - General

A. Furnish labor, materials, services, equipment, supplies, and perform operations necessary to install complete, functional electrical panelboards in accordance with this Section, drawings, panel schedules, and manufacturers' instructions.

B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

C. Verify each overcurrent device matches the approved submittal. Information to verify is:
1. Model or part number
2. Frame size
3. Overcurrent rating, including sensor and plug if equipped
4. Overcurrent functions and setting ranges (e.g.: Long time pickup/delay, short time pickup/delay, instantaneous, ground fault pickup/delay)

D. Submit Request For Information (RFI) to obtain overcurrent device settings and arc flash hazard labels. Allow two weeks for response.

E. Wiring must be trained neatly in wiring gutters. Form wiring to right angles at circuit breaker connections.

F. Panelboard Identification: Refer to Standard Drawing E-0006STD.

G. Conductor Identification: All conductors in panel must be tagged, including neutral and ground conductors.

1. Tags must indicate circuit number.

2. Install a Brady® slip-on label on conductors sized less than #6 AWG and install a Panduit® #MP-350C tag and tie-wrap for conductors sized #6 AWG or larger.

3. Use a Panduit marking pen PX-O or a Sharpie® permanent marker for labels.

3.2 Mounting

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Mount panelboards plumb and rigid without distortion of box.

C. Arrange flush panels so that enclosure front surface is uniformly flush with wall, and exterior door covers wall to enclosure mating surfaces.

D. Mount panelboards so that distance from floor to center of top panel does not exceed 6'-6" unless otherwise noted on Drawings.

E. Grind smooth corners, and file or grind smooth edges of metal angles, channels, straps, and other similar items to be used to support electrical panelboards. Paint to match panelboards, per requirements of Section 09 90 00, "Painting."

3.3 Field Quality Control

A. Testing Agency: Testing must be performed by a third-party testing firm, meeting all qualifications stated in the latest edition of the ANSI/InterNational Electrical Testing Association (NETA) document, *ANSI/NETA Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems* or an agency approved by the SNL Electrical Engineering Group

B. Tests and Inspections

1. All acceptance testing must be performed in accordance with the latest edition of *ANSI/NETA Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems and the SNL panelboard inspection checklist at a minimum*.

2. Testing of breakers shall be per Standard Specification 262816, Enclosed Switches and Circuit Breakers.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

4. After testing, a report documenting results of the tests must be provided to the SNL project manager and SNL electrical systems engineer prior to energizing.

3.4 Adjusting

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker functions per response to RFI requested per item 3.1 D above.

C. Install arc flash hazard labels obtained from SNL per RFI response per item 3.1 D above.

END OF SECTION 26 24 16

Exceptional service in the national interest

Sandia National Laboratories

Section 26 27 26 – Wiring Devices

March 2018

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 26 27 26 – Wiring Devices

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
7/7/16	Erika Barraza	Admin	Updated Section 2.2D.
3/9/18	Tim Peterson, Michael Smith	Admin	3-year review performed; minor changes made, including slight change to 3.1E
12/10/18	Michael Smith	Admin	Removed a bullet in Section 1.2

Section 26 27 26 – Wiring Devices

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section Includes:

1. Receptacles, receptacles with integral ground-fault circuit interrupter (GFCI), and associated device plates.
2. Twist-locking receptacles.
3. Isolated-ground receptacles.
4. Unless specified elsewhere, this section may apply to Sandia National Laboratories (SNL) medical department.
5. Weather-resistant receptacles.
6. Snap switches and wall-box dimmers.
7. Solid-state fan speed controls.
8. Pendant cord-connector devices.
9. Cord and plug sets.
10. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

1.3 Definitions

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

1.4 Administrative Requirements

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 Action Submittals

A. Product Data: For each type of product.

B. Shop Drawings must be submitted as directed in Section 01 33 00 “Submittal Procedures” and for all equipment furnished by the Contractor with internal wiring and controls differing from contract drawings, or not shown on contract drawings.

1. Note: Control wiring must not be installed before these drawings have been submitted and approved.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.6 Informational Submittals

A. Field quality-control reports.

1.7 Closeout Submittals

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - Products

2.1 Manufacturers

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper) - Arrow-Hart
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand (Pass & Seymour). These manufacturers are approved.

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 General Wiring-Device Requirements

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with Underwriters Laboratory (UL) 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

D. For all exterior outlets and switches, provide a metallic "extra duty" rated cover that retains its weatherproof rating when the device is in use (cords plugged in and switch on).

2.3 Straight-Blade Receptacles

A. Receptacles: All receptacles must be industrial specification grade (commercial specification grade not allowed) of the type shown on Standard Drawing E-0006STD, or as specifically described on the drawings.

B. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include, but are not limited to, the following**:

   a. Cooper; 5361V (single), AH5362V (duplex).
   b. Hubbell; HBL5361I (single), HBL5362I (duplex).
   c. Leviton; 5361-I (single), 5362-I (duplex).
   d. Pass & Seymour; 5361I (single), 5362I (duplex).

C. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Products: Subject to compliance with requirements, **provide one of the following**:

   a. Cooper; AHIG5362V.
   b. Hubbell; IG5362I.
   c. Leviton; 5362-IGI.
   d. Pass & Seymour; IG5361I.

2. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.4 GFCI Receptacles

A. General Description:

1. Straight blade, **feed**-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, **provide one of the following**

    a. Cooper; SGF20FV.
    b. Hubbell; GF20ILU.
    c. Pass & Seymour; 2097TRI.
    d. Leviton; MGFN2-I.

2.5 Hazardous (Classified) Location Receptacles

A. Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.

1. Manufacturers: Subject to compliance with requirements, **available manufacturers offering products that may be incorporated into the Work include but are not limited to the following**:

    a. Cooper Crouse-Hinds.
    b. EGS/Appleton Electric.
    c. Killark; Division of Hubbell Inc.

2.6 Twist-Locking Receptacles

Receptacles: All receptacles must be industrial specification grade (commercial specification grade not allowed) of the type shown on Standard Drawing E-0006STD, or as specifically described on the drawings.

1. Building-mounted singlephase and multiphase twist-lock and other special receptacles up to 50 amps per phase must be chosen from approved National Electrical Manufacturers Association (NEMA) configurations as shown on the drawings.
2. Building-mounted multiphase receptacles rated for more than 50 amps per phase must be of the pin-and-sleeve type, with a sleeve length sufficient to conceal the pins during make and break operation, and provided with a 15° back box and hub.

B. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

    a. Cooper; AHL520R.
    b. Hubbell; HBL2310.
    c. Leviton; 2310.
    d. Pass & Seymour; L520R.

C. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Cooper; IGL520R.
b. Hubbell; IG2310.
c. Leviton; 2310-IG.
d. Pass & Seymour; IGL520R.

2. Description:

a. Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.7 Pendant Cord-Connector Devices

A. Description:

1. Matching, locking-type plug and receptacle body connector.
2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
3. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.8 Cord and Plug Sets

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.9 Toggle Switches

A. Switches must be industrial specification grade (commercial specification grade not allowed), fully-rated for 20 amps at 120/277 volts.

B. Where light switches with pilot lights are indicated in drawings, provide switch as specified in 2.9F.1 with an integral neon or LED light that is illuminated when in the "on" position, unless specifically noted otherwise.

C. Where three-way or other special switches are required, they must be made by the same manufacturer and of the same quality as the single-pole switches.

D. Comply with NEMA WD 1, UL 20, and FS W-S-896.

E. Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

1) Single Pole:
2) Cooper; AH1221V.
3) Hubbell; HBL1221I.
4) Leviton; 1221-2I.
5) Pass & Seymour; PS20AC1I.
6) Two Pole:
7) Cooper; AH1222V.
8) Hubbell; HBL1222I.
9) Leviton; 1222-2I.
10) Pass & Seymour; PS20AC2I.
11) Three Way:
12) Cooper; AH1223V.
13) Hubbell; HBL1223I.
14) Leviton; 1223-2I.
15) Pass & Seymour; PS20AC3I.
16) Four Way:
17) Cooper; AH1224V.
18) Hubbell; HBL1224I.
19) Leviton; 1224-2I.
20) Pass & Seymour; PS20AC4I.

F. Pilot-Light Switches, 20 A:

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Cooper; AH1221LTV for 120 and 277 V.
b. Hubbell; HBL1201PL for 120 and 277 V.
c. Leviton; 1221-PLR for 120 V, 1221-7PR for 277 V.
d. Pass & Seymour; PS20AC1RPL for 120 V, PS20AC1RPL7 for 277 V.

2. Description: Single pole, with neon-lighted handle, illuminated when switch is "off."

G. Key-Operated Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, **available products that may be incorporated into the Work include but are not limited to the following**:

a. Cooper; AH1221L.
b. Hubbell; HBL1221LI.
c. Leviton; 1221-2IL.
d. Pass & Seymour; PS20AC1IL.

2. Description: Single pole, with factory-supplied key in lieu of switch handle.

   a. Still in use at SNL (high bay lighting).

2.10 Wall Plates

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: **Smooth, high-impact thermoplastic**
3. Material for Unfinished Spaces: **Smooth, high-impact thermoplastic**. Stainless steel should be retained for installation in hard usage locations such as: Hallways, Common Areas, Lobbies, Equipment Rooms, Break Areas, Labs.
4. Material for Damp Locations: **Thermoplastic** with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant**, die-cast aluminum** with lockable cover.

2.11 Floor Service Fittings

A. Type: Modular, **flush-type**, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: **Rectangular** with satin finish.

D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

E. Voice and Data Communication Outlet: **Blank cover with bushed cable opening**.

2.12 Poke-Through Assemblies

A. Manufacturers: Subject to compliance with requirements, **available manufacturers offering products that may be incorporated into the Work include but are not limited to the following**:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Pass & Seymour/Legrand.
3. Square D/Schneider Electric.
4. Thomas & Betts Corporation.
   Wiremold/Legrand.

B. Description:

1. Factory-fabricated and -wired assembly of below-floor junction box with multi-channeled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.

2. Comply with UL 514 scrub water exclusion requirements.
3. Service-Outlet Assembly: **Pedestal type with services indicated**.
4. Size: Selected to fit nominal cored holes in floor and matched to floor thickness. Size as indicated on drawings.
5. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
6. Closure Plug: Arranged to close unused cored openings and reestablish fire rating of floor. Size as indicated on drawings.
7. Wiring Raceways and Compartments: For a minimum of four No. 12 American Wire Gauge (AWG) conductors.

2.13 Prefabricated Multioutlet Assemblies

A. Manufacturers: Subject to compliance with requirements, **available manufacturers offering products that may be incorporated into the Work include but are not limited to the following**:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Wiremold/Legrand

B. Description

1. Two-piece surface metal raceway, with factory-wired multioutlet harness.
2. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: **Metal, with manufacturer's standard finish**.

D. Multioutlet Harness:

1. Receptacles: NEMA configuration as indicated on drawings.
2. Receptacle Spacing: Spacing as indicated on drawings.
3. Wiring: No. 12 AWG solid, Type THHN copper, quantity of circuits as indicated on drawings.

2.14 Service Poles

A. Description:

1. Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
2. Poles: Nominal 2.5-inch- (65-mm-) square cross section, with height adequate to extend from floor to at least 6 inches (150 mm) above ceiling, and with separate channels for power wiring and voice and data communication cabling.
3. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
4. Finishes: **Manufacturer's standard painted finish and trim combination**.
5. Wiring: Sized for minimum of No. 12 AWG power and ground conductors accommodating quantity of circuits as indicated on drawings.

6. Power Receptacles: 20-A, straight-blade receptacles complying with requirements in this Section. Quantity as indicated on drawings.
7. Voice and Data Communication Outlets: **Blank insert with bushed cable opening** complying with requirements in Section 27 00 05 "Telecommunications."

2.15 Finishes

A. Device Color:

1. Wiring Devices Connected to Normal Power System: **White** unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: **Red**.
3. Isolated-Ground Receptacles: **Orange**.
4. Wiring devices connected to temporary generator circuit: Blue

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - Execution

3.1 Installation

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.

c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Match ground pin orientation of vertically mounted receptacles to existing receptacles with the building. If none exists, mount with ground pin up.

F. Unless specified elsewhere, may apply to SNL medical department. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturer's device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI Receptacles

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 Identification

A. Comply with standard drawing E-0006STD.

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with **black**-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 Field Quality Control

A. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

B. Wiring device will be considered defective if it does not pass tests and inspections

C. Prepare test and inspection reports.

END OF SECTION 26 27 26

Exceptional service in the national interest

Section 26 28 16 – Enclosed Switches and Circuit Breakers

September 2018

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Section 26 28 16 – Enclosed Switches and Circuit Breakers

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
7/7/16	Erika Barraza	Admin	Updated Section 2.1H and 3.4C.
3/14/18	Michael Smith	Subst	Added “K” to Section 2.2; three-year review performed
8/30/18	Michael Smith	Subst	Added content under 2.2B; minor changes and copy editing

SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Receptacle switches.
4. Molded-case circuit breakers (MCCBs).
5. Enclosures.

1.3 Definitions

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

D. SCO: Sandia Construction Observers

E. SDR: Sandia Delegated Representative

F. SNL/NM: Sandia National Laboratories, New Mexico

1.4 Action Submittals

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.

5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

C. Shop drawings are required for any substituted equipment furnished by the Contractor that results in changes to control or power wiring as shown on contract drawings. This includes circumstances where substitute components, control schemes, or power wiring are presented and approved that cause a change in the following:

1. Size, number, or type of wires
2. Size of conduit and its routing
3. Connection changes
4. Sequence of operation

D. If any of the changes described in 1.4C occur, new shop drawings showing the following must be submitted:

1. Elementary ladder diagram
2. Conduit plan
3. Wiring diagram
4. Conduit identification schedule
5. Sequence of operation

E. Drawings must include each diagram or plan of the contract drawing that is affected.

1. Drawings must be provided of the same size as the original construction drawings, and must be reproducible copies.
2. If the changes are minor and the Contractor chooses to do so, a print of the original contract drawing can be made, and changes noted for approval. This drawing must become part of the as-built documentation submitted near the conclusion of the work.

F. Overcurrent Coordination Study: Provide for all new or modified electrical equipment to include fuses and circuit breakers. After providing submittals of equipment to be purchased, the Contractor shall obtain Overcurrent Coordination Study (via the Request for Information process) from the Engineer of Record. The information provided should clearly identify manufacturer, product number, frame rating, trip setting, number of poles, voltage rating, and short circuit withstand (a.k.a. Symmetrical Ampere Rating or Ampere Interrupting Capacity [AIC] Rating).

1.5 Informational Submittals

A. Submit contractor licenses and certifications as part of the bid evaluation documents. Follow the licensing requirements in Section 1.7H of this specification.

B. Qualification Data: For qualified testing agency.

C. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.6 Closeout Submittals

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 33 00 "Submittal Procedures," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.7 Quality Assurance

A. Testing Agency Qualifications: Member company of International Electrical Testing Association (NETA) or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

1. Materials and equipment must be the standard product of manufacturers who regularly engage in the production of such material and must be the manufacturer’s current and standard design.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

F. All electrical materials must be new and as listed by Underwriters Laboratory (UL), or other nationally recognized testing laboratories for the intended application, unless specific exemption is made in the contract documents.

G. All work performed in accordance with this specification must be in strict compliance with Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1926. Particular attention is directed to the requirements of the electrical subpart.

H. All electrical work at SNL must be performed by a licensed entity and be in accordance with the State of New Mexico Construction Industries Division (NM CID), Title 14, Chapter 6, Part 6. The NM CID licensing requirements for commercial or industrial work at SNL must be followed. All entities contracting electrical work above 600V must have a valid EL-1 license, and work is performed by craftsmen with an EL-1J certification.

1.8 Project Conditions

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 degrees F (minus 30 degrees C) and not exceeding 104 degrees F (40 degrees C).
2. Altitude: 5500 feet (1680 m).

B. Interruption of Existing Electric Service:

1. Work to be performed during an interruption of electrical utilities must be preceded by all possible preparation, and must be carefully coordinated to minimize the duration of the interruption. Work must proceed continuously until the system is restored to normal.

2. The Contractor must not interrupt any main interior or exterior electrical utility without written request for an outage and subsequent approval by SNL personnel, nor interrupt any branch circuit to an outlet or item of equipment without verbal approval from the SCO.

   a. Written request for outages must be submitted using the Outage Request Worksheet, according to the instructions and advance notice requirements on the worksheet.
   b. Unless otherwise noted on drawings, or directed, any tie-ins or connections to existing utilities or equipment that necessitate interruptions of service must be performed on a Saturday or Sunday, without additional contract costs.

3. Unless otherwise directed, the manipulation of existing main valves to isolate piping, and the shutdown of fans, pumps, and other equipment, will be done by SNL/NM Maintenance personnel.
4. Indicate method of providing temporary electric service, if required by SCO.
5. Comply with NFPA 70E.

1.9 Coordination

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - Products

2.1 Fusible and Nonfusible Switches

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial – Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Utilize the following chart to provide motor disconnecting means requirements.

Motor Type		Disconnecting Means
3 phase		
≥1HP		Heavy Duty Safety Switch
<1HP	>240 V_{LL} [1]	Heavy Duty Safety Switch
	≤240 V_{LL} [1]	General Duty Safety Switch
1 phase		
≥1HP	use not permitted	
<1HP	120V	**S**PST toggle switch [2]
	208V	**D**PST toggle switch [2]
	240V	**D**PST toggle switch [2]

Note 1: Refers to line-to-line voltage
Note 2: Provide 20A motor rated extra heavy duty industrial series. Refer to standard drawing E-0006STD for snap switch part number information. Toggle (snap) switches shall be provided with lockout wall plates. In outdoor locations, cast aluminum while-in-use weatherproof covers shall be added.

C. National Electrical Manufacturers Association (NEMA) Type HD, Heavy Duty.

D. Voltage as specified on drawings.

E. Horsepower rated if a motor is served by the device.

F. Integral provisions for lockout/tagout (LOTO).

G. UL 98 and NEMA KS-1.

H. All exterior-mounted switches and disconnects shall be NEMA Type 3R/12, 3S. When installing the NEMA 3R/12, the drain hole shall be opened. Opening this drain hole negates the NEMA 12 rating; however, SNL personnel approve such installation.

I. Receptacle Switches:

1. Voltage and current rating, as specified on drawings.

2. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.

3. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

J. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
2. Fuses, where specified on drawings:

   a. Furnish a complete set of fuses
   b. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
   c. Dual-element
   d. Time-delay

3. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.2 Molded-Case Circuit Breakers

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

1. All 120/208V and 240V breakers rated 225A and above shall be solid-state breakers with Root Mean Square (RMS) sensing, electronic trip, and field adjustable long-time, short-time, and instantaneous pickup settings.

2. All 277/480V breakers rated 100A and above shall be solid state breakers with RMS sensing, electronic trip, and field adjustable long-time, short-time, and instantaneous pickup settings.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 200 A and smaller.

D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, RMS sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time delay adjustments.
4. Ground-fault pickup level, time delay, and I^2t response.

F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

G. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

H. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

I. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

J. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type high-intensity fluorescent (HID) for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts; "b" contacts operate in reverse of circuit-breaker contacts.
8. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.
9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
10. Integral provisions for LOTO.
11. The Contractor must obtain the services of the device manufacturer to install or replace the trip plug of an electronic-trip circuit breaker if the existing plug rating does not match the coordination study. The NRTL listing and device warranty must be preserved. The Contractor must request the trip setting from the SDR a minimum of 10 working days prior to adjustment. The adjustment of the trip setting on electronic-trip circuit breakers and adjustable molded-case circuit breakers must be the responsibility of the Contractor.

K. Mounting: Each circuit breaker must be bolted into position. Plug-on circuit breakers held in place only by spring force on the bus lug and the pressure of the enclosure cover are not acceptable.

2.3 Enclosures

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, NEMA 3R/12.
3. Kitchen/Wash-Down Areas: NEMA 250, Type 4X stainless steel
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
6. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7 or Type 9 based on the hazard classification.

PART 3 - Execution

3.1 Examination

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Installation

A. Enclosed switches must not be used as pull boxes or junction boxes, unless otherwise noted on drawings.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Enclosed switches and circuit breakers must be installed at an accessible location in an accessible orientation. This placement must be coordinated with all other construction disciplines to ensure accessibility

D. Enclosed switches and circuit breakers must be installed to comply with the minimum working clearance dimensions of NEC Article 110.26 and Table 110.26 (A)(1).

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

F. Install fuses in fusible devices.

G. Comply with NECA 1.

3.3 Identification

A. All enclosed switches must have a label affixed according to Standard Drawing E-0006STD. The label must identify the circuit feeding the safety switch, and the equipment served by the safety switch.

3.4 Field Quality Control

A. Perform tests and inspections.

1. After installing equipment and before electrical circuitry has been energized, test when requested any designated wire, cable devices, and equipment to assure that all the material continues to possess all the original characteristics, as required by all governing codes and standards listed in these specifications

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. All circuit breakers larger than 200 amps and all breakers located in service entrance equipment that are greater than 20 amps must be tested per NETA Acceptance Testing Standards (ATS), Inspection and Test Procedures for Molded-Case Circuit Breakers.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. After testing, a report documenting results of the tests must be provided to the SNL project manager and SNL electrical systems engineer prior to energizing.

3.5 Adjusting

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges.

1. The trip settings shall be requested from the SDR a minimum of 10 working days prior to adjustment.

END OF SECTION 26 28 16

Exceptional service in the national interest

Sandia National Laboratories

Section 26 29 13 – Enclosed Controllers

January 2019

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 26 29 13 – Enclosed Controllers

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
12/19/18	Mike Smith	Subst	Removed much content from Section 1.4; added significant content to Section 2.2-2.5; removed some content from Sections 2.7, 3.2, and 3.5; 3-year review performed

Section 26 29 13 – Enclosed Controllers

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section includes the following enclosed controllers rated 600V and less:

1. Full-voltage manual.
2. Full-voltage magnetic.
3. Reduced-voltage magnetic.
4. Reduced-voltage solid state.
5. Multispeed.

B. Related Section:

1. Section 26 29 23 "Variable-Frequency Motor Controllers" for general-purpose, alternating current (AC), adjustable-frequency, and pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 horsepower.

1.3 Definitions

A. CPT: Control power transformer.

B. MCP: Motor circuit protector.

C. N.C.: Normally closed.

D. N.O.: Normally open.

E. OCPD: Overcurrent protective device.

F. SCR: Silicon-controlled rectifier.

G. SCO: Sandia Construction Observer

H. SDR: Sandia Delegated Representative

I. SNL/NM: Sandia National Laboratories, New Mexico

1.4 Action Submittals

A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

1. Show tabulations of the following:

    a. Each installed unit's type and details.
    b. Factory-installed devices.
    c. Nameplate legends.
    d. Short-circuit current rating of integrated unit.
    e. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.

2. Wiring Diagrams: For power, signal, and control wiring.

1.5 Informational Submittals

A. Submit contractor licenses and certifications as part of the bid evaluation documents. Follow the licensing requirements in Section 1.7 of this specification.

B. Qualification Data: For qualified testing agency.

C. Field quality-control reports.

D. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arranged to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

E. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

1.6 Closeout Submittals

A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. Include the following:

1. Routine maintenance requirements for enclosed controllers and installed components.
2. Manufacturer's written instructions for testing and adjusting MCP trip settings.
3. Manufacturer's written instructions for setting field-adjustable overload relays.
4. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.

1.7 Quality Assurance

A. Testing Agency Qualifications: Member company of International Electrical Testing Association (NETA) or a nationally recognized testing laboratory (NRTL).

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. All electrical materials must be new and as listed by Underwriters Laboratory (UL), or other NRTL for the intended application, unless specific exemption is made in the contract documents.

E. All similar materials and equipment must be the product of the same manufacturer or listed as an assembly thereof.

F. Materials and equipment must be the standard product of manufacturers who regularly engage in the production of such material and must be the manufacturer's current and standard design.

G. All work performed in accordance with this specification must be in strict compliance with Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1926. Particular attention is directed to the requirements of the electrical subpart.

H. All electrical work at SNL must be performed by a licensed entity and be in accordance with the State of New Mexico Construction Industries Division (NM CID), Title 14, Chapter 6, Part 6. The NM CID licensing requirements for commercial or industrial work at SNL must be followed. All entities contracting electrical work above 600V are required to have a valid EL-1 license, and work is performed by craftsmen with an EL-1J certification.

1.8 Delivery, Storage, and Handling

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.9 Project Conditions

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 degrees F (minus 30 degrees C) and not exceeding 104 degrees F (40 degrees C).
2. Altitude: 5500 feet (1680 m).

B. Interruption of Existing Electrical Systems:

1. Work to be performed during an interruption of electrical utilities must be preceded by all possible preparation and must be carefully coordinated to minimize the duration of the interruption. Work must proceed continuously until the system is restored to normal.

2. The Contractor must not interrupt any main interior or exterior electrical utility without written request for an outage and subsequent approval by SNL personnel, nor interrupt any branch circuit to an outlet or item of equipment without verbal approval from the SCO.

   a. Written request for outages must be submitted using the Outage Request Worksheet, according to the instructions and advance notice requirements on the worksheet.
   b. Unless otherwise noted on drawings, or directed, any tie-ins or connections to existing utilities or equipment that necessitate interruptions of service must be performed on a Saturday or Sunday, without additional contract costs.

3. Unless otherwise directed, the manipulation of existing main valves to isolate piping, and the shutdown of fans, pumps, and other equipment, will be done by SNL/NM Maintenance personnel.

4. Indicate method of providing temporary utilities, if required by SCO.

5. Comply with NFPA 70E.

1.10 Coordination

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - Products

2.1 General

A. All controllers must conform to the adopted standards and recommended practices of the Industrial Control Standards (ICS) of the National Electrical Manufacturers Association (NEMA) and Underwriters Laboratories, Inc.

B. All starters must be combination type with motor circuit protector, contactor, and lockout/tagout provisions.

C. Each motor or group of motors requiring a single control must be provided with a suitable controller and devices that must perform the functions as specified for the respective motors in other sections of these specifications.

1. Each motor, except those with an impedance high enough to prevent overheating because of failure to start, such as clock motors, must be provided with overload protection, either integral with the motor or controller, or mounted in a separate enclosure.

    a. Unless otherwise specified, protective devices must be of the manual reset type. Manual controllers for motors larger than ¼ horsepower must be specifically designed for the purpose and must have a horsepower rating adequate for the motor.

    b. Where overloads are supplied with controllers, these must be sized after receipt of the equipment to be protected in accordance with nameplate data.

    c. Overload protection for substituted multispeed motors must be arranged to protect all windings and must be designed so that if an overload occurs in one winding, all windings are disconnected simultaneously.

2. Motor controllers must have 120V light-emitting diode (LED) pilot lights as follows:

    a. The color for indicating the motor is operating must be red; for stopped, it must be green; unless indicated otherwise on the drawings or in the Motor Control Center Special Construction Specifications.

    b. Additional lights for low and high speeds must be included as indicated on the drawings or in the Motor Control Center Special Construction Specifications. Pilot light assemblies shall be supplied with removable lenses allowing lamps to be replaced from controller exterior.

    c. Include “push-to-test” feature on all pilot lights.

3. When automatic control devices such as thermostats, floats, or pressure switches are substituted by the Contractor for specified devices, and they control the starting and stopping of motors directly, they must be designed for the purpose and have adequate horsepower ratings.

    a. When the automatic control device does not have such a rating, a magnetic starter must be used, with the automatic control device actuating the pilot control circuit.

4. Circuit protectors, contactors, overload blocks, and all accessories must be NEMA construction.

5. Provide Hand-Off-Auto (HOA) in cover.

6. Provide overload reset button in cover.

7. Provide minimum 2-N.O. and 2-N.C. auxiliary contacts.

8. Provide individual CPT, if controller is above 150V to ground, sized for 100VA extra capacity, and include two primary fuses and one secondary fuse for 120V control.

2.2 Full-Voltage Controllers

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
b. Siemens Energy & Automation, Inc.
c. Square D; a brand of Schneider Electric.

2. MCP Disconnecting Means:

a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Melting Alloy Overload Relays:

a. Inverse-time-current characteristic.
b. Class 20 tripping characteristic.
c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

6. Bimetallic Overload Relays:

a. Inverse-time-current characteristic.
b. Class 20 tripping characteristic.
c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.

7. Solid-State Overload Relay:

   a. Switch or dial selectable for motor running overload protection.
   b. Sensors in each phase.
   c. Class 20 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing

2.3 Reduced-Voltage Magnetic Controllers

A. General Requirements for Reduced-Voltage Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A; closed-transition; adjustable time delay on transition.

B. Combination Reduced-Voltage Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   b. Siemens Energy & Automation, Inc.
   c. Square D; a brand of Schneider Electric.

2. MCP Disconnecting Means:

   a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

   a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Melting Alloy Overload Relays:

   a. Inverse-time-current characteristic.
   b. Class 20 tripping characteristic.
   c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

6. Bimetallic Overload Relays:

   a. Inverse-time-current characteristic.
   b. Class 20 tripping characteristic.

c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.

7. Solid-State Overload Relay:

a. Switch or dial selectable for motor running overload protection.
b. Sensors in each phase.
c. Class 20 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing

2.4 Reduced-Voltage Solid-State Controllers

A. General Requirements for Reduced-Voltage Solid-State Controllers: Comply with UL 508.

B. Reduced-Voltage Solid-State Controllers: An integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

C. Combination Reduced-Voltage Solid-State Controller: Factory-assembled combination of reduced-voltage solid-state controller, OCPD, and disconnecting means.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
b. Siemens Energy & Automation, Inc.
c. Square D; a brand of Schneider Electric.

2. MCP Disconnecting Means:

a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

2.5 Multispeed Magnetic Controllers

A. General Requirements for Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Combination Multispeed Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
c. Rockwell Automation, Inc.; Allen-Bradley brand.
d. Siemens Energy & Automation, Inc.
e. Square D; a brand of Schneider Electric.

2. MCP Disconnecting Means:

a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

a. Operating Voltage: Depending on contractor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Melting Alloy Overload Relays:

a. Inverse-time-current characteristic.
b. Class 20 tripping characteristic.
c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

6. Bimetallic Overload Relays:

a. Inverse-time-current characteristic.
b. Class 20 tripping characteristic.
c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
Ambient compensated.

7. Solid-State Overload Relay:

a. Switch or dial selectable for motor running overload protection.
b. Sensors in each phase.
c. Class 20 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing

2.6 Enclosures

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 12.
2. Outdoor Locations: Type 3R/12.
3. Kitchen or Wash-Down Areas: Type 4X stainless steel
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
6. Hazardous Areas Indicated on Drawings: Type 7 or Type 9.

2.7 Accessories

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty type.

   a. Push Buttons: Unguarded types; momentary as indicated.
   b. Pilot Lights: LED types; colors as indicated; push to test.
   c. Selector Switches: Rotary type.

PART 3 - Execution

3.1 Examination

A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Installation

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 26 05 29 "Hangers and Supports for Electrical Systems."

B. Floor-Mounted Controllers: Install enclosed controllers on 4-inch (100-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 03 30 00 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Controllers must be installed at an accessible location in an accessible orientation. This placement must be coordinated with all other construction disciplines to ensure accessibility.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Section 26 28 13 "Fuses."

F. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

G. Comply with NECA 1.

3.3 Identification

A. Label enclosed controllers, components, and control wiring, according to Standard Drawing E-0006STD. The label must identify the circuit feeding the safety switch, and the equipment served by the safety switch.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved nameplate.

3.4 Control Wiring Installation

A. Install wiring between enclosed controllers and remote devices and facility's control system (FCS). Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 Field Quality Control

A. Perform tests and inspections.

1. After the system installation is complete, and at such time as directed by the SCO, the Contractor must conduct an operating test for demonstration of completion of the work. This test can be in addition to, and part of, a formal system commissioning procedure, but must not replace such commissioning event.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Controllers must not be energized prior to inspection by the SCO.
2. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
3. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
4. Test continuity of each circuit.
5. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify the SCO before starting the motor(s).
6. Test each motor for proper phase rotation.
7. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
8. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed controllers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 Adjusting

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B. Adjust the trip settings of MCPs with adjustable instantaneous trip elements.

1. The trip settings shall be requested from the SDR a minimum of 10 working days prior to adjustment.
2. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify the SCO before increasing settings.

C. Set the taps on reduced-voltage autotransformer controllers at 65 percent.

D. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage solid-state controllers.

3.7 Protection

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.

B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

END OF SECTION 26 29 13

Exceptional service in the national interest

Sandia National Laboratories

Section 26 29 23 – Variable-Frequency Motor Controllers

February 2019

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 26 29 23 – Variable-Frequency Motor Controllers

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
1/31/19	Mike Smith	Subst	Removed Section 1.6, added content to Section 2.2 Manufactured Units, added content to 3.2 Installation; 3-year review performed

Section 26 29 23 – Variable-Frequency Motor Controllers

PART 1 - General

1.1 Summary

A. Furnish and install a complete Variable Frequency Controller (VFC) system as described in this Section and as detailed on Drawings. VFCs will be used to control speed of three-phase variable torque pump or fan alternating current (AC) induction motors.

B. Related sections: Refer to the following sections for related work:

1. Section 01 33 00, "Submittal Procedures"
2. Section 01 77 19, "Contract Closeout"
3. Section 23 09 93, "Facilities Control System"
4. Section 23 05 95, "Mechanical Systems Demonstrations"

1.2 References

A. Institute of Electrical and Electronics Engineers (IEEE)

519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

B. National Electrical Manufacturers Association (NEMA)

250	Enclosures for Electrical Equipment (1000 Volts Maximum)
ICS 2-222	Overload Relay Class Designation
MG 1	Motors and Generators

C. National Fire Protection Association (NFPA)

70	National Electrical Code (NEC)

D. International Electrotechnical Commission (IEC)

947-4-1	Low-voltage switchgear and Controlgear, Part 4-1: Contactors and Motor Starters

1.3 Definitions

A. FCS: Facilities Control System

B. FLN(P1): Floor Level Network (Protocol 1)

C. IGBT: Integrated gate bipolar transistor

D. PI: Proportional – Integral control action

E. PWM: Pulse-width modulated

F. SDR: Sandia Delegated Representative

G. VFC: Variable frequency controller

1.4 Submittals

A. Equipment Submittals: Submit in accordance with conditions of Contract and Section 01 33 00, “Submittal Procedures,” except as noted herein.

B. Product Data: For each type of VFC, provide dimensions; mounting arrangements; location for conduit entries; shipping and operating weights; and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

C. Shop Drawings: For each VFC:

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

   a. Each installed unit's type and details.
   b. Nameplate legends.
   c. Short-circuit current ratings of integrated unit.

2. Wiring Diagrams: Provide three (3) complete sets of VFC supplier’s standard drawings showing schematics and wiring for each type of VFC.

D. Operations and Maintenance Data: Provide three (3) copies of instruction books, operating manuals, comprehensive trouble shooting guide, spare parts list, and special bulletins covering on-site storage.

E. Leadership in Energy and Environmental Design (LEED) Submittals:

1. Product Data for Credit EA 5: For continuous metering equipment for energy consumption.

1.5 Informational Submittals

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

B. Manufacturer's field service report: Provide three (3) copies of the field test reports as specified in Part 3.

C. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arranged to demonstrate that heaters are sized for actual motor nameplate full-load currents.

D. If VFC is derated, submit derating calculations.

1.6 Quality Assurance

A. Source Limitations: Obtain VFCs of a single type through one source from a single manufacturer.

B. Electrical components, devices, and accessories shall be labeled and listed as defined in NFPA 70, Article 100, for intended use.

C. Exception – Magnetic Bearing Chillers – These chillers include a built-in special VFC manufactured to the chiller manufacturer’s specifications.

1.7 Storage

A. Store VFCs indoors in clean, dry space with uniform temperature to prevent condensation.

B. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.8 Warranty

A. Provide manufacturer’s warranty certificate upon acceptance of VFC system that shall include the following as a minimum:

1. If defect in supplied apparatus appears, or failure to comply with this Section is identified within period of five (5) years from date of manufacturer’s certified start-up, not to exceed 30 months from shipment, response to repair or replacement of VFC shall be within a forty-eight (48) hour period.
2. Contractor shall, without delay and at Contractor’s own expense, correct defects or failure of compliance by repairing defective parts, supplying non-defective replacement parts, or correcting defective or deficient design by any other means recommended by VFC manufacturer and accepted by SDR.

PART 2 - Products

2.1 Manufacturers

A. Subject to compliance with requirements, provide products by one of the following:

1. ABB Power Distribution
2. Danfoss Graham

2.2 Manufactured Units

A. Description: The VFC shall convert the input AC main power to an adjustable frequency and voltage as defined in the following sections. The VFC shall use insulated gate bipolar transistors (IGBT) in the inverter section with a Pulse Width Modulated (PWM) output and arranged to provide variable speed of a NEMA MG 1, Design B, 3-phase, high efficiency induction motor by adjusting output voltage, current, and frequency. The VFC shall be listed and labeled as a complete unit and shall include all accessories and requirements as described in this section.

B. The VFC shall be rated as shown on drawings. As a minimum the full load output current of the drive shall be equal to the equivalent motor horsepower as listed by NEC.

C. Unit Operating Requirements:

1. Input AC voltage tolerance of 208 volts AC ±10 percent or 480 volts AC ±10 percent, as specified in contract documents.
2. Input frequency tolerance of 60 Hz, ±2 Hz.
3. Capable of driving full load, under the following conditions, without derating:

    a. Ambient Temperature: 0 to 40 degrees C
    b. Humidity: Less than 95 percent (non-condensing)
    c. Altitude: 5500 feet (1680 m)

4. Minimum Efficiency: 96 percent at 60 Hz, full load
5. Minimum Displacement Primary-Side Power Factor: 96 percent
6. Overload Capability: 1.1 times the base load current for 60 seconds; 1.8 times the base load current for 3 seconds
7. Starting Torque: 100 percent of rated torque or as indicated
8. Speed Regulation: ±1 percent
9. Isolated control interface to allow controller to follow control signal over a 40:1 speed range
10. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
11. Vibration Withstand: Comply with NEMA ICS 61800-2.
12. Inverter Logic: Microprocessor-based, 32 bit, isolated from all power circuits.

D. Internal Adjustability Capabilities:

1. Minimum Speed: 0 to 100 percent of maximum rpm
2. Maximum Speed: 100 percent of maximum rpm
3. Acceleration: .1 to 1800 seconds
4. Deceleration: 1800 to .1 seconds
5. Current Limit: 30 to a minimum of 150 percent of maximum rating

E. Protection and Reliability Features: The VFC shall include the following:

1. The VFC including main breaker and bypass shall have an integrated withstand rating of no less than 100,000 amperes (symmetrical) and must be listed with UL or an equivalent test laboratory, unless noted otherwise in Contract documents.
2. Input transient protection by means of surge suppressors.

3. Upon power-up the VFC shall automatically test for valid operation of memory, loss of analog reference input, loss of communication, dynamic brake failure, DC to DC power supply, control power and the pre-charge circuit.
4. Under and over voltage trips, inverter over temperature, overload, and overcurrent trips.
5. Motor Overload Relay: Adjustable and capable of NEMA 250, Class 10 performance.
6. The VFC shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to set point without safety tripping or component damage (flying start).
7. The VFC shall be capable of DC injection braking at start to stop a reverse spinning motor prior to ramp.
8. The VFC shall be equipped with an automatic extended power ride-through circuit, which will utilize the inertia of the load to keep the drive powered. Typical control power ride-through for a fan load shall be a minimum of 200 milliseconds.
9. If the input reference power (4-20mA or 0-10V) is lost, this shall cause a warning to be issued and the user shall have the option of pre-selecting either (1) stopping and displaying the fault, (2) running at a programmable preset speed, or (3) hold the VFC speed based on the last good reference received. The VFC shall be programmable to signal this condition via a keypad warning, relay output, or over the serial communication link.
10. The VFC shall be capable of sensing a loss of load (broken belt or no water in pump) and signal the loss of load condition.
11. Critical frequency rejection, with three selectable, adjustable deadbands.
12. Instantaneous line-to-line and line-to-ground overcurrent trips.
13. Loss-of-phase protection.
14. Reverse-phase protection.
15. Short-circuit protection.
16. Motor over temperature fault.

F. Automatic Reset and Restart: To attempt three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts. Bi-directional auto-speed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

G. Status Lights: Door-mounted light indicators shall indicate: Power On, Run and Fault. The detailed information on the type of fault and other operating information on the VFC shall be annunciated on keypad display.

H. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

I. Panel Mounted VFC Controller: A panel mounted VFC controller or electromechanical hand-off-auto switch shall allow for selection between “Hand,” “Auto,” and “Off.” When “Hand” is selected motor speed shall be controlled via the panel mounted VFC controller. When “Auto” is selected motor speed shall be controlled via an external speed reference signal from either the FLN(P1) and/or a hardwired connection. The VFC shall incorporate “bumpless transfer” of speed reference when switching between “Hand” and “Auto” or between “Auto” and “Hand.” When “Off” is selected the VFC shall stop, regardless of prior control selection.

J. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

K. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz)
2. Motor speed (rpm)
3. Motor status (running, stop, fault)
4. Motor current (amperes)
5. Motor torque (percent)
6. Fault or alarming status (code)
7. PID feedback signal (percent)
8. DC-link voltage (VDC)
9. Set-point frequency (Hz)
10. Motor output voltage (V)

L. Control Signal Interface: Provide the VFC with the following unless otherwise specified on contract drawings:

1. Electrical Input Signal Interface: A minimum of two programmable analog inputs 4-20 mA and six programmable digital inputs.
2. Remote Speed Control Signal Inputs: Shall be able to accept one or more of the following types of speed control input signals from the FCS system, which shall be specified in the contract documents:

    a. 0 to 10 V dc
    b. 4-20 mA
    c. 0 to 15 psig
    d. Potentiometer using up/down digital inputs
    e. Fixed frequencies using digital inputs.

3. Additional Control Capabilities

    a. Remote start-stop capabilities utilizing one of the above digital inputs.
    b. PI control capabilities utilizing one of the analog inputs as the control variable, or the control variable monitored by the FLN(P1) connection.

4. Output Signal Interface: A minimum of one programmable analog output signal (4-20 mA), which can be configured to any of the following:

    a. Output frequency (Hz)
    b. Output current (load)
    c. DC-link voltage (V dc)
    d. Motor torque (percent)
    e. Motor speed (rpm)
    f. Set-point frequency (Hz)
    g. Control variable value

5. Remote Indication Interface: A minimum of three programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

   a. Motor running.
   b. Set point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

M. Communications: The VFC shall include an interface device that accepts control signals via SNL's Protocol 1 (P1) network communication connection to Siemens (Landis Division) Series 600 Modular Building Controller (MBC). Communication link shall meet the following requirements:

1. VFC shall have the ability to function on Siemens (Landis Division) system 600 P1 Network as a floor level network (FLN) device.
2. As a minimum, the VFC shall be able to perform the following tasks via the P1 network:

   a. Monitor drive frequency output
   b. Monitor drive speed
   c. Monitor drive current
   d. Monitor drive torque
   e. Monitor drive power
   f. Monitor drive temperature
   g. Monitor drive kWh
   h. Monitor drive run time
   i. Monitor control variable
   j. Control drive start/stop capabilities
   k. Control drive speed determined by System 600 control strategy

3. Gateway-type protocol translation shall not be accepted.

N. Input Power Disconnect: The VFC shall include a main power circuit breaker disconnecting device that opens all phases of incoming AC line. The disconnect shall provide positive shutdown of the input power to both VFC and bypass circuitry.

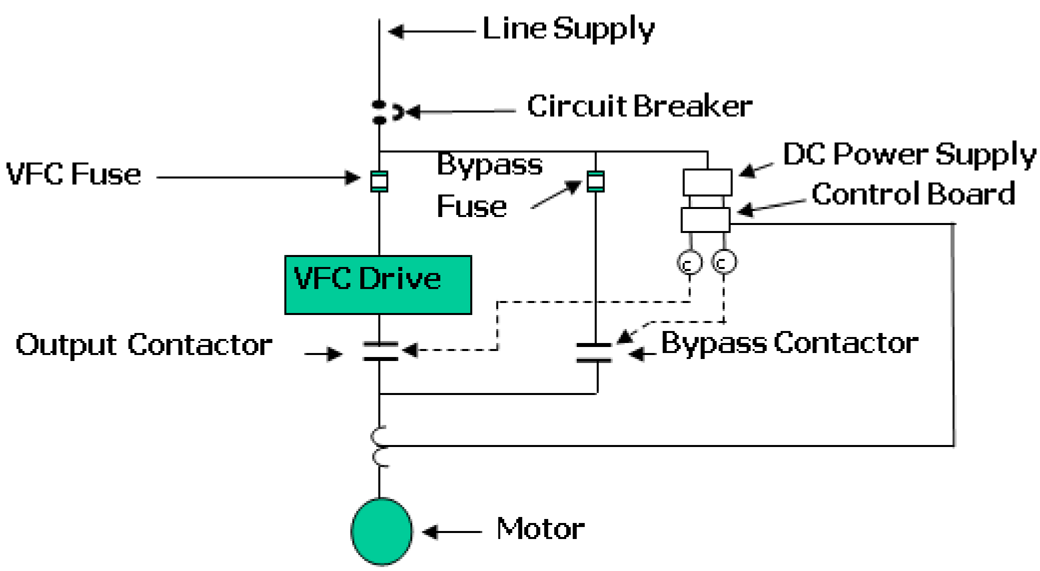
1. Disconnect shall be thermal magnetic, molded case circuit breaker.
2. Mount circuit breaker inside controller enclosure and include mounting bracket and through-the-door interlocking handle with provisions for padlocking.
3. A mechanical interlock shall prevent an operator from opening VFC drive door when the disconnect is in the "ON" position. Another mechanical interlock shall prevent operator from placing the disconnect in the "ON" position while the VFC drive door is open.

O. Electronic Bypass: When specified on Contract Drawings, the VFC shall include an electronic bypass that meets the following requirements:

1. Include circuitry necessary to safely transfer motor from VFC to power line, or from power line to VFC while motor is at zero speed.
2. Include a three-pole bypass contactor.
3. Provide motor overload protection in both "Controller" and "Bypass" mode.

4. A readily visible indicator shall be provided to indicate the tripped position of the overload.
5. Refer to the following schematic for typical VFC Bypass one-line diagram:

Typical VFC Bypass One-line Diagram



P. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2

2.3 Components

A. Enclose the VFC in a Type 12 enclosure per NEMA 250, unless noted otherwise on Drawings.

B. Louvers that are required for appropriate heat dissipation shall include air filters.

C. Do not mount VFC in motor control center (MCC).

D. Cooling fans shall be located and installed so that they are readily accessible and easily replaced.

E. Finish: Manufacturer's standard paint applied to factory assembled and tested VFCs before shipping.

2.4 Source Quality Control

A. Perform a harmonic analysis study in accordance with the latest version of IEEE 519 unless otherwise specified in contract documents.

B. The harmonic distortion at the PCC shall be predicted through computer modeling of the distribution system and connected AC drives. SNL personnel will provide power system data required to perform harmonic analysis study.

C. Do not exceed harmonic voltage and current distortion limits at point of common coupling (PCC) for general system applications, as recommended and defined by IEEE 519, unless specified otherwise in contract drawings.

D. If the calculations determine that the harmonic distortion levels are higher than the voltage and current specified, the drive manufacturer shall provide either line reactors, isolation transformers, multi-pulse drives, or trap filters to meet the intent of IEEE 519.

E. The harmonic analysis report shall be part of the submittal approval process.

2.5 Technical Support

A. Provide written certification from VFC manufacturer stating the availability of technical support for minimum of five (5) years from start-up.

B. Provide technical support on the following basis:

1. Respond within 24 hours for diagnosis and repair the problem

2.6 Test and Inspection Equipment

A. Manufacturer shall inform SNL through their bid submittal, if VFC or VFC system provided requires any special tools or equipment to test, analyze, or maintain system, and include additional price list for said equipment.

PART 3 - Execution

3.1 Examination

A. Examine areas and conditions under which VFCs are to be installed for compliance with requirements, installation tolerances, and other conditions affecting performance and provide SDR with written notification of conditions detrimental to proper completion of work.

B. Proceed with installation only after unsatisfactory conditions have been corrected in manner acceptable to SDR.

3.2 Installation

A. Anchor each VFC assembly arranged and sized according to manufacturer's written instructions. Attach by bolting.

B. Coordinate mounting and anchoring of VFCs with drawing details.

C. Install warning label on VFC indicating that load is subject to automatic restart upon power restoration.

D. Install warning label on any safety switch(es) installed between a VFC and its associated motor(s), indicating that VFC must be shut off prior to operation of the safety switch(es). Warning label shall also include location of the associated VFC.

E. Motors to be used with variable-frequency controllers must be rated for such service and must have shaft grounding provisions to avoid induced-voltage arc damage to bearings and races.

F. Conductors between VFC and its associated motor(s) shall be as follows:

1. For No. 12 AWG through No. 2 AWG, use 300% ground flexible VFD, 3+IG conductor cable manufactured by Belden Inc., part number as follows, or an approved equal:

a. For No. 12 AWG; Belden #29502.

b. For No. 10 AWG; Belden #29503.

c. For No. 8 AWG; Belden #29504.

d. For No. 6 AWG; Belden #29505.

e. For No. 4 AWG; Belden #29506.

f. For No. 2 AWG; Belden #29507.

2. For No. 1 AWG through No. 4/0 AWG, use 100% ground flexible VFD, 3+3G(segmented) conductor cable manufactured by Belden Inc., part number as follows, or an approved equal:

a. For No. 1 AWG; Belden #29528.

b. For No. 1/0 AWG; Belden #29529.

c. For No. 2/0 AWG; Belden #29530.

d. For No. 3/0 AWG; Belden #29531.

e. For No. 4/0 AWG; Belden #29532.

G. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

H. Comply with NECA 1.

3.3 Field Quality Control

A. Provide services: The Contractor shall engage a qualified VFC manufacturer’s service engineer to perform the following:

1. Test, checkout, and start up VFC system as required under "Field Quality Control" Article.
2. Select features of each VFC to coordinate with ratings characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, drive, and load.
3. Train SNL's personnel in proper operation and maintenance of VFC system.
4. Contractor shall coordinate testing, checkout, start-up, and training functions with SNL Maintenance organization.
5. Notify SDR a minimum of two weeks prior to scheduled test, checkout, and start-up.

B. Do not energize any portion of VFC system without authorization from VFC manufacturer's representative and SDR.

C. Demonstrate trouble-free, stable operation for the 0 to 100% speed range.

D. Correct malfunctioning units on-site where possible and retest to demonstrate compliance; otherwise, replace new units and retest.

E. SNL personnel will have the option to test VFC with a Dranetz power quality analyzer at point of common coupling, at no charge to Contractor, before and after installation.

1. If harmonic voltage and current distortion exceed limits specified in Part 2, Contractor shall furnish and install, at no cost to SNL, devices necessary to reduce distortion to acceptable limits.

F. VFC manufacturer's service engineer shall prepare final written documents of installation and inspection tests made in field, complete with meter readings and recordings, where applicable, and submit to SDR for approval. Data collected from these tests shall include:

1. Incoming voltages from each phase leg to neutral, and from phase to phase
2. External process signal and its source
3. Set-Up Parameters: Comply with SNL's written instructions
   a. Acceleration time to full motor speed in seconds
   b. Deceleration time from full motor speed in seconds
   c. Second acceleration/deceleration as applicable
   d. Maximum speed in hertz and RPM
   e. Minimum speed in hertz and RPM
4. Operational Parameters
   a. Line current for each phase at inverter at full load
   b. Line current for each phase at bypass in bypass mode
   c. Load current for each phase at full load
   d. Load current for each phase at bypass in bypass mode
5. Ambient temperature during test
6. DC bus voltage
7. Frequency output at 100% reference signal
8. Name of person completing test and start-up procedure
9. Date start-up completed

END OF SECTION 26 29 23

Special Specification Section 26 33 53S

Static Uninterruptible Power Supply

PART 1 GENERAL

1.01 SCOPE

A. The Contractor shall furnish and install a three-phase continuous duty, on-line, double conversion, solid-state uninterruptible power system, hereafter referred to as the UPS. The UPS shall operate in conjunction with the new tower's electrical system to provide power conditioning, back up and distribution for critical electrical loads. The UPS shall consist of, as required by the project, the UPS module, battery cabinet(s), and accessory or "option" cabinet(s) for transformers, maintenance bypass, parallel tie, and distribution applications, and other features as described in this specification.

1.02 SYSTEM DESCRIPTION

A. Standard UPS system will include a minimum of (1) rectifier, (1) inverter, (1) static bypass, (1) maintenance bypass, and (1) battery system.

B. Components:

1. Rectifier
2. Inverter
3. Sealed Lead Acid Batteries
4. Battery Charger
5. Automatic Bypass
6. User Interface Panel
7. Serial (RS-232) Communication Interface
8. Communication Card Slots (2)
9. Remote Emergency Power Off Contacts
10. Relay Output Contact (1)
11. Environmental Inputs (2)
12. Hardwired Input, Output
13. Bypass Transformer Cabinet

C. Modes of Operation: The UPS shall operate as an online, double-conversion UPS with the following modes:

1. Normal: During the Normal or Double-conversion Mode the rectifier shall derive power as needed from the commercial AC utility or generator source and supply filtered and regulated DC power to the online inverter. The inverter shall convert the DC power to highly regulated and filtered AC power for the critical loads.
2. Battery: Upon failure of the AC input source, the critical load must continue to be supplied by the inverter without switching. The inverter must obtain its power from the

battery. There must be no interruption in power to the critical load upon failure or restoration of the AC input source.

3. Recharge: Upon restoration of the AC input source, the rectifier/battery charger must recharge the battery. The inverter shall, without interruption of power, regulate the power to the critical load.
4. Bypass: A static bypass switch shall be used for transferring the critical load to the AC utility supply without interruption and shall be rated for continuous operation. Automatic re-transfer to normal operation must also be accomplished without interruption of power to the critical load. The static bypass switch must be capable of manual operation.
5. Maintenance bypass: An integral maintenance bypass shall be provided to supply the load directly from the AC utility supply, while the UPS is isolated for maintenance or repair.

1.03 REFERENCES

A. The UPS and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA and UL as follows. Where a conflict arises between these documents and statements made herein, the statements in this specification shall govern.

1. Safety
   a. IEC 62040-1-1 or EN 62040-1-1
   b. EN 60950
   c. UL 1778
   d. Cabinets are NEMA 1 and IP20 rated.
2. Emission and Immunity:
   a. EN 50091-2 (Emissions Class A and Harmonics)
   b. EN61000-4-2,-3,-4,-5 - Slow high energy surges in input/output lines: 1 kV. line/earth, 0.5 kV line/line (IEC 61000-4-5) - Fast low energy transients in power lines: 2 kV. line/earth (IEC 61000-4-4) - Fast low energy transients (burst) in control and signal lines: 1 kV line/earth (IEC 61000-4-4) - Electrostatic discharge (ESD): 8 kV air discharge, 6 kV contact discharge (IEC 61000-4-2) - Electromagnetic field: IEC 61000-4-3 level 3
   c. FCC Class A15J

B. Markings

1. UL, cUL

1.04 ACTION SUBMITTALS

A. Product Data: For each type of UPS.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for UPS.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For UPS.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
4. Include diagrams for power, signal, and control wiring.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Certificates: For UPS equipment, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate; describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Product Certificates: For each product, from manufacturer.

D. Factory Test Reports: Comply with specified requirements.

E. Product Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

F. Field quality-control reports.

G. Sample Warranties: For manufacturer's special warranties.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For UPS units to include in emergency, operation, and maintenance manuals.

1.07 QUALIFICATIONS

A. The manufacturer of the unit shall have a minimum of twenty years of experience in the design, manufacture and testing of Uninterruptible Power Supplies.

B. For the equipment specified herein, the manufacturer shall be ISO 9001.

C. Provide Seismic tested equipment as follows:

1. With optional bracing kit, the equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the California Building Code (CBC) through zone 4 application.

1.08 REGULATORY REQUIREMENTS

A. The UPS shall be UL labeled.

1.09 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.10 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Eaton – Model 9355

2.02 RATINGS

A. System Input

1. Input Voltage Operation Range
   Nominal 480 Vac with input transformer, 3-wire plus ground
2. +10% to –15% from nominal
3. Input Frequency
   a. 45 to 65 Hz
   b. auto-sensing
   c. capable of 50 to 60 Hz or 60 to 50 Hz frequency conversion
4. Input Power Factor: 0.99 typical
5. Input Current Distortion: 5% THD maximum at full rated linear load
6. Inrush Current:
   a. <2x branch rating without input transformer
   b. <5x branch rating with input transformer
7. Surge Protection:
   a. Line to Line 180 J
   b. Line to Ground 450 J

B. System Output, Normal Mode -Nominal Output Voltage

1. 208/120 Vac, Selectable through front panel or through serial port connection with power management software
2. Voltage regulation: +/-2% of selected output voltage in steady state
3. Transient Voltage Response: Meets Class 1 performance of IEC62040-3; +/-5% for 100% step load change; recovery in <1ms
4. Voltage THD:
   a. 2% Total Harmonic Distortion (THD) maximum phase to neutral into a maximum rated linear load (5% phase to phase)
   b. 5% THD maximum phase to neutral into a maximum rated non-linear load (7% phase to phase)
5. Nominal Frequency: 50 or 60 Hz selectable
6. Frequency Regulation:
   a. 50/60 Hz +/- 0.5 to +/- 3.0 Hz selectable, synchronized to mains, +/- 0.005 Hz free running single units
   b. +/- 0.15 Hz parallel units
   c. Slew rate: selectable to 1.0, 2.0, 3.0 Hz/s
7. Output Current: Maximum output current (at nominal output voltage) for the UPS shall be:
   a. 30 kVA system: 83 A @ 208 V, 79 A @ 220 V
8. Current Overload Capability without Bypass:
   a. 125% for 1 min
   b. 150% for 5 seconds
   c. >150% for 300 ms
9. Current Overload Capability with Bypass enabled”
   a. 1500A for ½ cycle
   b. 1000A for 0.1 sec
   c. 600A for 1 sec
10. Bypass:
    a. Automatic bypass shall provide an alternate path to power in the case of overload, inverter failure or other UPS failure
    b. External Maintenance Bypass can be utilized with the UPS to allow servicing of the UPS
    c. Transfer time to and from any internal bypass shall be no-break
11. Efficiency: Typical >91% while in normal mode, with nominal line conditions

C. System Output, Battery Mode

1. Nominal Output Voltage: 208Y/120 Vac
2. Voltage Regulation: +/-1% phase to neutral of nominal voltage (+/-2% phase to phase)
3. Transient Voltage Response
   a. Meets Class 1 performance of IEC62040-3
   b. +/-5% for 100% step load change; recovery in <1ms
4. Voltage THD:
   a. 2% Total Harmonic Distortion (THD) maximum into a maximum rated linear load
   b. 5% THD maximum phase to neutral into a maximum rated non-linear load (7% phase to phase)

5. Frequency Regulation: +/-0.005 Hz of selected nominal frequency

2.03 CONSTRUCTION

A. The UPS system shall initially be provided as a single-module, non-redundant system. The UPS shall be field-upgradeable for power rating (20 kVA to 30 kVA), additional parallel capacity or for redundant operation. The system shall be configurable as follows:

1. External Matching Battery Cabinets
2. Wall-mounted Maintenance Bypass Cabinet
3. Wall-mounted Hot-tie Cabinet with Bypass
4. Matching Cabinet with:
    a. Maintenance Bypass Switch
    b. Input Transformer
    c. Bypass Transformer
    d. Output Transformer

B. Converter (rectifier): Incoming power shall be filtered and converted to DC by a sine-wave rectifier. The rectifier corrects the input power factor to 0.99 and draws sinusoidal current (with less than 5% THD) from the utility. In the event of utility failure, the DC-DC converter shall be supplied power without interruption from the internal or external batteries.

1. Overload Capacity: The converter shall be capable of supplying up to 150% of rated load for at least five (5) seconds if no bypass is available.

C. Inverter: The inverter shall utilize IGBT technology and Digital Signal Processing to convert the DC power from the rectifier or converter to regulated AC power for output to critical loads.

1. Output Voltage: The inverter output voltage is specified in section 1.12.B.
2. Voltage Regulation: The inverter steady state voltage regulation is +/- 1% phase to neutral, 2% phase to phase. Dynamic regulation meets Class 1 performance of IEC62040-3.
3. Frequency Control: The inverter steady state frequency regulation is +/-0.005 Hz, free running in steady state. UPS is synchronized to Utility in normal operation.

D. Mechanical Construction

1. All materials and components of the UPS shall be new, of current manufacture, and shall not have been in prior service except as required during factory testing. The UPS shall be constructed of replaceable subassemblies. All active electronic devices shall be solid-state.

E. The UPS unit is comprised of an input rectifier, battery charger, inverter, bypass, and battery consisting of the appropriate number of sealed battery modules and shall be housed in a single freestanding enclosure. The UPS cabinet shall be cleaned, primed, and painted with the manufacturer's standard color. Casters and leveling feet shall be provided as standard.

1. Additional Cabinets shall match the UPS cabinet, and may contain, input, bypass, or output transformers, and may include a rotary Maintenance Bypass Switch
2. Matching external battery cabinets shall be available with different capacities and sizes.

2.04 SYSTEM INPUT & OUTPUT CONNECTIONS

A. AC Input:

1. All UPS units shall be capable of utilizing hardwired input. Input, Bypass, and/or output terminals may be placed in separate cabinets as determined by system configuration. Additional cabinets will contain sufficient power cabling to connect to the UPS power terminals when the cabinets are placed adjacent to the UPS.

B. AC Output:

1. UPS unit shall include fully-rated hardwired output
2. UPS unit shall include a fully-rated output circuit breaker

C. Extended Battery Connector: External battery cabinets include cable to connect each battery cabinet to the UPS or daisy chain external battery cabinets.

D. Emergency Power Off (EPO) Connection: The UPS shall provide a built-in landing for field connection of a remote Emergency Power Off circuit. Upon initiation of the EPO circuit, the UPS shall open its input relays, and disengage the battery converter, preventing power from being delivered to the attached loads.

E. Serial (RS-232) Communication Interface: A 9-pin sub-D connector shall provide capability for communicating with manufacture-supplied software package. The UPS shall also provide signals for indication of UPS alarm status.

F. (2) Communication Card Slots: The UPS shall provide (2) communication X-slots in the back of the UPS allowing for additional connectivity options, including SNMP/Web, AS/400 relays, Modbus/Jbus capabilities, etc.

G. (2) Programmable Input Connections: The UPS shall provide built-in inputs for field connection (environmental input). The inputs shall be parameter programmable to suit the needs of the application.

2.05 USER INTERFACE

A. Front Panel Display: The UPS shall include a front panel display consisting of a graphical LCD display with backlight, four (4) status LED’s, and a keypad.

1. Graphical LCD display: Includes basic language (English), display of unit function and operating parameters. It shall be used to signify the operating state of the UPS, for indicating alarms, for changing operations control parameters and set points.
2. Four status LED’s, which indicate:
   a. Alarms, with a red LED
   b. On Battery, with a yellow LED

c. On Bypass, with a yellow LED
d. Power On, with a green LED
3. Multifunction Keypad: UPS shall have keypad to allow user to adjust UPS parameters, view alarm and inverter logs, change UPS operational modes, and turn the UPS on and off.

B. Power Management Software Package: The UPS shall include serial communications interface that provides the following communication capabilities:

1. Monitor and graphically display input and output voltage and other operating characteristics
2. Notify end-users in the event of a power anomaly via network, E-mail, or page.
3. Communication Ports:
    a. Communication Card Slots: The UPS shall provide (2) communication X-slots in the back of the UPS allowing for additional connectivity options, including SNMP/Web, AS/400 relays, Modbus/Jbus capabilities, etc
    b. Serial communications (via RS-232) with manufacturer-supplied power management software package

2.06 BATTERIES

A. Battery Type: Valve Regulated Lead Acid (VRLA), minimum two-year warranted float service life at 25 degrees C

B. UPS Holdover Time (Runtime): Each UPS system, consisting of a minimum of six battery strings (108 battery blocks) for each power module shall have a minimum holdover time of 11 minutes at full rated load; 15 minutes at 70% load. See product manual for detailed information.

C. Extended Holdover Time (Runtime): Each UPS system shall have capability for addition of extra matching battery cabinets (in two cabinet configurations) to increase the total holdover time. Please refer to datasheet for a list of runtimes. The battery times listed are approximate and may vary depending on load configuration, temperature, battery age, and battery charge.

D. Battery Recharge Time:

1. Base UPS system consisting of six (6) battery strings will have a recharge time of max. 1.75 hours to 95% usable capacity @ nominal line after a full load discharge (30 kVA).

E. Bus Voltage: Nominal bus voltage is 216 VDC. Each string consists of 18 battery blocks in series with 9 Ah capacities.

F. Battery Protection:

1. Short Circuit Protection: Over-current protection shall protect the batteries from all short circuit fault conditions
2. Battery Module Protection: Internal battery circuit breaker shall be provided
3. Under-voltage Protection:

a. Inverter cutoff voltage: Battery operation shall be terminated when the battery voltage drops to the 1.67 VPC set point
b. Protective shutdown voltage: Inverter shall shutdown after 1 minute when the battery voltage drops below 1.7 VPC volts-per-cell typical

4. Over-voltage Protection: If the UPS system's battery bus voltage exceeds the predetermined set point then the UPS will disable the charger and alarm a high battery condition

G. Advanced Battery Management:

1. Battery recharge: After recharging batteries to full capacity, the charger will enter the rest mode to increase the battery lifetime according the ABM cycle. Hence, continuous float charging of the battery shall not be allowed. The active battery charger states are constant-current (charge mode), constant-voltage (float mode) and no-charge (rest mode).
2. Battery Runtime Monitoring: UPS shall monitor batteries and provide status to end user of battery runtime via front panel, serial communications, or both. Runtime calculations to be based on load demand and analysis of battery health.
3. Battery Health Monitoring: UPS shall periodically test and monitor battery health and provide warnings visually, audibly and/or serially when battery capacity falls below 80% of original capacity. Battery testing may also be user initiated via front panel or serial communications.

2.07 NAMEPLATES

A. Provide a printed nameplate for each UPS.

2.08 ENVIRONMENTAL CONDITIONS

A. The UPS shall be certified to the following safety standards:

1. EN 62040-1-1, IEC 62040-1-1, EN 60950

B. The UPS shall meet CISPR22 Class A (EN50091-2) for Emissions and EN50091-2 (IEC6100032 for 16 amps or less) for Harmonics

C. Audible Noise: Less than 57 dBA (A weighted) at one (1) meter from all sides in all system modes

D. Ambient Temperature

1. Operating: UPS +5 deg C to +40 deg C
2. Storage: UPS 0 deg C to +25 deg C

E. Relative Humidity

1. Operating: 5 to 95% non-condensing.
2. Storage: 5 to 95% non-condensing.

3. There shall be at least a 1.8°F (1.0°C) difference between the dry bulb temperature and the wet bulb temperature, at all times, to maintain a noncondensing environment
4. The maximum rate of temperature change shall be limited to 3°F over 5 minutes
5. (36°F/hour), based on the ASHRAE Standard 90.1-2013

F. Altitude

1. Operating: To 5500 feet (1700 meters). De-rating or reducing operating temperature range may be required for higher altitudes
2. Transit: To 33,000 FEET (10,000 meters)

G. Electrostatic Discharge: The UPS shall be able to withstand a minimum 8 kV without damage and without affecting the critical load

PART 3 EXECUTION

3.01 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of applicable NEMA and UL standards.

1. Standard Computer-automated UPS system test
2. Hipot test

3.02 INSTALLATION

A. The Contractors shall install all equipment per the manufacturer's recommendations.

3.03 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified under this section for a period of 2 working days. The manufacturer's representative shall provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. The Contractor shall provide three (3) copies of the manufacturer's field start-up report.

Section 26 36 00 – Transfer Switches

January 2019

Effective Date: 01/08/2019
Review Date: 01/08/2022

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 26 36 00 – Transfer Switches

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
12/20/18	Mike Smith	Subst	Information no longer applicable removed from Section 2.1-2.3, 2.5, and 3.3; Section 2.7 removed; removed “Remote Annunciation and Control Systems” from Section 1.2; 3-year review performed

Section 26 36 00 – Transfer Switches

PART 1 - General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.
2. Bypass/isolation switches.
3. Nonautomatic transfer switches.
4. Remote annunciation systems.

1.3 Action Submittals

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

1.4 Informational Submittals

A. Qualification Data: For manufacturer and testing agency.

B. Field quality-control reports.

1.5 Closeout Submittals

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 33 00 “Submittal Procedures.”

1. Features and operating sequences, both automatic and manual.

2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 Quality Assurance

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association (NETA) or is a nationally recognized testing laboratory (NRTL) as defined by Occupational Safety and Health Administration (OSHA) in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switches, bypass/isolation switches, nonautomatic transfer switches, and remote annunciator panels through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA ICS 1.

F. Comply with NFPA 70.

G. Comply with NFPA 110.

H. Comply with UL 1008 unless requirements of these specifications are stricter.

1.7 Field Conditions

A. Interruption of Existing Electrical Service: Follow Sandia National Laboratories (SNL) electrical outage procedures for any power interruption or outage.

1.8 Coordination

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 03 30 00 "Cast-in-Place Concrete."

PART 2 - Products

2.1 Manufactured Units

A. Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

1. Russelectric, Inc
2. Emerson/Asco
3. Onan/Cummins Power Generation

2.2 General Transfer-Switch Product Requirements

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 degrees C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

I. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.

J. Heater: Equip switches exposed to outdoor temperatures and humidity outside of manufacturer's recommended ranges (low temperature/high humidity) with an internal heater. Provide thermostat within enclosure to control heater.

K. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators shall have communication capability matched with remote device.

L. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations.

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

M. Enclosures: General-purpose NEMA 250, Type 12 and 3R/12, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.3 Automatic Transfer Switches

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Signal-Before-Transfer Contacts: When indicated, provide a set of normally open/normally closed dry contacts that operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

E. Digital Communication Interface: Matched to capability of remote annunciator panel.

F. Automatic Transfer-Switch Features:

1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

2.4 Bypass/Isolation Switches

A. Comply with requirements for Level 1 equipment according to NFPA 110.

B. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:

1. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
2. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.
3. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
4. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
5. Operability: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less.
6. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
7. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

C. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

2.5 Nonautomatic Transfer Switches

A. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." In addition, removable manual handle provides quick-make, quick-break manual-switching action. Switch shall be capable of electrically or manually transferring load in either direction with either or both sources energized. Control circuit disconnects from electrical operator during manual operation.

B. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.

C. Nonautomatic Transfer-Switch Accessories:

1. Pilot Lights: Indicate source to which load is connected.
2. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and alternate-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Alternate Source Available."

3. Unassigned Auxiliary Contacts: One set of normally closed contacts for each switch position, rated 10 A at 240-V ac.

2.6 Remote Annunciator System

A. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:

1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
2. Switch position.
3. Switch in test mode.
4. Failure of communication link.

B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

1. Indicating Lights: Grouped for each transfer switch monitored.
2. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
4. Lamp Test: Push-to-test or lamp-test switch on front panel.

2.7 Source Quality Control

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - Execution

3.1 Installation

A. Design each fastener and support to carry load indicated by seismic requirements.

B. Floor-Mounting Switch: Anchor to floor by bolting.

1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Section 26 05 29 "Hangers and Supports for Electrical Systems."

C. Annunciator Panel Mounting: Flush in wall, unless otherwise indicated.

D. Set field-adjustable intervals, delays and relays.

3.2 Connections

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.3 Field Quality Control

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

    a. Check for electrical continuity of circuits and for short circuits.
    b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    c. Verify that manual transfer warnings are properly placed.
    d. Perform manual transfer operation.

4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    c. Verify time-delay settings.
    d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
    f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
    g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

    a. Verify grounding connections and locations and ratings of sensors.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

E. Remove and replace malfunctioning units and retest as specified above.

F. Prepare test and inspection reports.

3.4 Demonstration

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Section 01810 "Facility Commissioning Requirements.”

B. Coordinate this training with that for generator equipment.

END OF SECTION 26 36 00

Exceptional service in the national interest

Sandia National Laboratories

Section 26 43 13 – Surge Protective Devices for Low-Voltage Power Circuits

December 2018

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 26 43 13 – Surge Protective Devices for Low-Voltage Electrical Power Circuits

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
12/10/18	Michael Smith	Subst	Added to related sections and Definitions, removed some sections, added to sections 2.1 and 2.2, three-year review performed

Section 26 43 13 – Surge Protective Devices for Low-Voltage Electrical Power Circuits

PART 1 - General

1.1 Summary

A. Section includes surge-protective devices (SPDs) for the protection of low-voltage (120 to 600 V) power distribution and control equipment.

B. Related Sections:

1. Section 01 33 00 “Submittal Procedures”
2. Section 26 24 12 “Switchboards Service Entrance”
3. Section 26 24 13 “Switchboards”
4. Section 26 24 16 “Panelboards”
5. Section 26 36 00 “Transfer Switches”
6. Section 26 41 13 “Lightning Protection for Structures”

1.2 Definitions

A. ATS: Acceptance Testing Specifications.

B. Inominal: Nominal discharge current.

C. MCOV: Maximum continuous operating voltage.

D. Mode(s), also Modes of Protection: The pair of electrical connections where the Voltage Protection Rating applies.

E. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

F. OCPD: Overcurrent protective device.

G. SCCR: Short-circuit current rating.

H. SPD: Surge Protective Device.

I. VPR: Voltage Protection Rating.

1.3 Action Submittals

A. Product Data: For each type of product indicated. Include the following:

1. Peak Surge Current ratings per mode and per phase

2. Operating Weights
3. Short Circuit Current Rating (SCCR)
4. Voltage Protection Ratings (VPRs) for all modes
5. Maximum Continuous Operating Voltage rating (MCOV)
6. I-nominal rating (I-n)
7. Physical Characteristics
8. Furnished Specialties and accessories.

1.4 Informational Submittals

A. Qualification Data: For qualified testing agency.

B. Product Certificates: For SPD devices, from manufacturer.

C. Field quality-control reports.

D. Warranties: Sample of special warranties.

1.5 Closeout Submittals

A. Operation and Maintenance Data: For SPD devices to include three (3) copies of instruction books, operation manuals, maintenance manuals, comprehensive troubleshooting guides, and spare parts lists.

1.6 Quality Assurance

A. Testing Agency Qualifications: Member company of International Electrical Testing Association (NETA) or a Nationally Recognized Testing Laboratory (NRTL).

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in National Fire Protection Association (NFPA) 70, by a testing agency, and marked for intended location and application.

C. Comply with Institute of Electrical and Electronics Engineers (IEEE) C62.41.2 and test devices according to IEEE C62.45.

D. Comply with Underwriters Laboratory (UL) 1283 and UL 1449.

E. Comply with NFPA 70.

F. The system must be tested to Military Standard (MIL-STD) 220A for electrical line noise attenuation per 50-ohm insertion loss measurement method of radio frequencies up to 100 MHz.

1.7 Delivery, Storage and Handling

A. Handle and store equipment in accordance with manufacturer's Installation and Maintenance Manuals. One (1) copy of this document to be provided with the equipment at time of shipment.

1.8 Project Conditions

A. Notify Sandia Designated Representative (SDR) in written request no fewer than 21 calendar days in advance of proposed electrical service interruptions. Include the approximate duration the utility will be off.

B. Do not proceed with interruption of electrical service without SDR's written permission.

C. Service Conditions: Rate SPDs for continuous operation under the following conditions unless otherwise indicated:

1. MCOV: Not less than 115 percent of nominal system line-line operating voltage.
2. Operating Temperature: 30 to 120 degrees F (0 to 50 degrees C).
3. Humidity: 0 to 85 percent, noncondensing.
4. Altitude: Less than 12,000 feet (3658 m) above sea level.

1.9 Coordination

A. Coordinate location of field-mounted SPDs to allow adequate clearances for maintenance.

1.10 Warranty

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - Products

2.1 Service Entrance and Transfer Switch Suppressors

A. Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

B. Surge Protection Devices:

1. Service entrance SPDs shall be in a separate enclosure from the service entrance switchboard/switchgear or service entrance panelboard, subject to compliance with requirements.
2. Unit must have a disconnect or circuit breaker allocated so that power can be removed for servicing and must be accessible for servicing without an outage to the switchboard/switchgear, panelboard, or transfer switch and labeled as so.
3. Comply with UL 1449, Type 2.
4. Modular design (with field-serviceable/replaceable modules)
5. Fabrication using bolted compression lugs for internal wiring.
6. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
7. SCCR: SPD rating complying with UL 1449, and matching or exceeding the service entrance equipment or transfer switch short-circuit rating and redundant suppression circuits; with individually fused metal-oxide varistors.
8. Light-Emitting Diode (LED) indicator lights for power and protection status of each phase of the unit. For exterior installations, the display shall be ultraviolet (UV) or all-weather rated so as not to deteriorate with extended exposure to direct sunlight.
9. Audible alarm, with silencing switch, to indicate when protection has failed.
10. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with and connect to the Sandia National Laboratories (SNL) Facilities Control System (FCS).
11. The SPD must have a Surge Counter that displays the combined total number of transient voltage surges detected from line-to-ground (L-G), line-to-line (L-L), line-to-neutral (L-N), and neutral-to-ground (N-G), with reset button.

C. Minimum Peak Surge Current Rating:

1. Per mode: 125,000 amps
2. Per phase: 250,000 amps

D. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2: 300,000 amps per phase.

E. Minimum Protection Modes (4): The SPD must provide L-N, L-L, L-G, and N-G protection. Protection modes and UL 1449 VPR for grounded wye circuits with 3-phase, 4-wire circuits shall be as follows:

VOLTAGE	L-N	L-L	L-G	N-G
208Y/120V	700	1000	700	700
480Y/277V	1200	1800	1200	1200

F. Inominal Rating: 20 kA.

G. SCCR: Equal or exceed 100 kA.

2.2 Non-Service Entrance Switchboard and Panelboard Suppressors

A. Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

B. Surge Protection Devices:

1. Switchboard/Panelboard SPDs shall be in a separate enclosure from the switchboard/ panelboard, subject to compliance with requirements
2. Unit must have a disconnect or circuit breaker allocated so that power can be removed for servicing; must be accessible for servicing without an outage to the switchboard/panelboard; and must be labeled as so.
3. Comply with UL 1449, Type 2.
4. Modular design (with field-serviceable/replaceable modules)
5. Short-circuit current rating complying with UL 1449, and matching or exceeding the switchboard/panelboard short-circuit rating and redundant suppression circuits; with individually fused metal-oxide varistors.
6. Fabrication using bolted compression lugs for internal wiring.
7. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
8. LED indicator lights for power and protection status of each phase of the unit. For exterior installations, the display shall be UV or all-weather rated so as not to deteriorate with extended exposure to direct sunlight.
9. Audible alarm, with silencing switch, to indicate when protection has failed.
10. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with and connect to SNL's FCS.
11. The SPD must have a Surge Counter that displays the combined total number of transient voltage surges detected from L-G, L-L, L-N, and N-G, with reset button.

C. Minimum Peak Surge Current Rating:

1. Per mode: 125,000 amps
2. Per phase: 250,000 amps

D. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2 shall be 300,000 amps per phase:

E. Minimum Protection Modes (4): The SPD must provide L-N, L-L, L-G, and N-G protection. Protection modes and UL 1449 VPR for grounded wye circuits with 3-phase, 4-wire circuits shall be as follows:

VOLTAGE	L-N	L-L	L-G	N-G
208Y/120V	700	1000	700	700
480Y/277V	1200	1800	1200	1200

F. Inominal Rating: 20 kA.

G. SCCR: Equal or exceed 100 kA.

2.3 Enclosures

A. Indoor Enclosures: National Electrical Manufacturers Association (NEMA) 250 Type 12.

B. Outdoor Enclosures: NEMA 250 Type3R/12

PART 3 - Execution

3.1 Installation

A. Install SPDs according to the manufacturer’s written instructions.

B. Install SPDs at power distribution or control equipment on load side, with ground lead bonded to power distribution or control equipment ground.

C. Install SPDs with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length or 36 ft. between bus and unit, whichever is less. Do not bond neutral and ground. Do not splice and extend SPD leads unless specifically permitted by manufacturer.

1. Cable connection between bus and SPD must be a minimum #8 American Wire Gauge (AWG).
2. Connecting wires must be twisted to reduce magnetic inductance.
3. Avoid short-radius bends in leads connecting the SPD and the bus of the protected equipment.

D. Provide a dedicated circuit breaker at the power distribution or control equipment, sized per construction drawings, as a dedicated disconnecting means for servicing the SPD. Comply with manufacturer’s written recommendation for circuit breaker size for connecting SPDs to distribution system. Match circuit breaker size to conductor size, unless otherwise noted.

E. Install plumb, level and rigid without distortion.

F. SPDs installed as an integral part of a lightning protection system must be installed on these services and equipment, as a minimum:

1. SPDs must be installed at the service entrance of each metallic power line, signal line, and communications line conductor entering the structure.
2. SPDs must be installed at all points where a conductor leaves the protected structure to supply an unprotected structure, if the length of the conductor is over 100 ft. If less than 100 ft, protection is assumed to be provided by the service entrance SPD.
3. SPDs must be installed at all points where a conductor leaves the protected structure to supply an unprotected exterior pole-mounted device (including but not limited to lighting fixtures, cameras, warning beacons, and antennae).
4. SPDs for data and telephone communication service entrances, and their installation, must comply with SNL Standard Construction Specifications.
5. SPDs for data system facility entrances, including cable television (CATV), alarm, and antenna systems, and their installation, must comply with NFPA 780

3.2 Field Quality Control

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
2. After installing SPDs but before electrical circuitry has been energized, verify compliance with installation requirements described in section 3.1 of this document.
3. Check all installed panels for proper grounding, fastening, and alignment.
4. During time of energization, complete startup checks according to manufacturer's written instructions.

C. Remove debris from SPD and wipe dust and dirt from all components.

D. Repaint marred and scratched surfaces with touch up paint to match original finish.

E. SPD will be considered defective if it does not pass tests and inspections.

1. Repair or replace malfunctioning units. Retest after repairs or replacements are made.

F. Prepare test and inspection reports and submit to SDR.

3.3 Startup Service

A. Do not energize or connect power distribution or control equipment, control terminals, or data terminals to their sources until SPDs are installed and connected.

B. Do not perform insulation resistance tests of the distribution wiring equipment with the SPDs installed. Disconnect before conducting insulation resistance tests and reconnect immediately after the testing is over.

3.4 Demonstration

A. Train maintenance personnel to operate and maintain SPDs.

END OF SECTION 26 43 13

Exceptional service in the national interest

Sandia National Laboratories

Section 26 56 00 – Exterior Lighting

November 2019

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 26 56 00 – Exterior Lighting

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Tim Peterson	Subst	Updated formatting.
7/26/19	Tarek Mamlook	Subst	*Updated section 1.8 A: updated the type of pole and the standards that covers the handling of such material. *Added section 2.6 to account for LED based lighting' *Updated section 3.4 A to account for steel materials too. *3-year review complete

11/20/19	Tarek Mam-look	Subst	Added to Section 2.0: Conventional LED and Solar Power LED Lights

Section 26 56 00 – Exterior Lighting

PART 1 - General

1.1 Summary

A. Section Includes:

1. Exterior luminaires with lamps and ballasts.
2. Luminaire-mounted photoelectric relays.
3. Poles and accessories.
4. Luminaire lowering devices.
5. This section is applicable to roadway, area, and security lighting. It is not applicable to high mast lighting 60 feet (18.3 m.) or greater in height, hazardous locations, or building-mounted lighting covered under Sandia National Laboratories' (SNL) Construction Standard Specification 26 51 00.

B. Related Sections:

1. Section 26 51 00, "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

2. Section 31 20 00, "Earthwork" for excavation and backfilling for poles and foundations.

3. Section 03 30 00, "Cast-In-Place Concrete" for pole foundations.

1.2 References

A. Standard drawing, WJ5010STD, Exterior Lighting Details.

B. Standard drawing, WJ6001STD, Exterior Lighting Equipment Schedule.

C. New Mexico Night Sky Protection Act (NMSA 74-12-1).

D. Federal Energy Management Program (FEMP), Energy Efficient Product Procurement for Exterior Lighting.

1.3 Definitions

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. Full Cutoff: No direct uplight emitted from the fixture (0% light output at 90° from vertical [nadir] and <10% at 80° from vertical [nadir]).

D. HID: High-intensity discharge.

E. LER: Luminaire efficacy rating.

F. Lighting Unit: A luminaire, or an assembly of luminaires, with a common support, including a pole or bracket, plus mounting and support accessories.

G. Lumen: Measured output of lamp and luminaire, or both.

H. Luminaire: Complete lighting fixture, including lamp(s); ballast housing if provided; and parts required to distribute the light, position and protect lamps, and connect lamps to the power supply. Also referred to as a light fixture.

I. NRTL: Nationally Recognized Testing Laboratory.

J. Pole: Luminaire support structure, including tower used for large area illumination.

K. Standard: Same definition as "Pole" above.

L. SDR: Sandia Delegated Representative.

1.4 Action Submittals

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. **Note: Where substitute lighting equipment and devices are proposed, the contractor shall be responsible for submitting a complete lighting level study to satisfy SNL that the substitute equipment is equivalent to what was specified.** Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area (EPA), and verification of indicated parameters.
2. Details of attaching luminaires and accessories.
3. Details of installation and construction.
4. Luminaire materials.
5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.

   a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

6. Photoelectric relays.
7. Ballasts, including energy-efficiency data.
8. Lamps, including life, output, CCT, CRI, lumens, and energy-efficiency data.
9. Materials, dimensions, and finishes of poles.
10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
11. Anchor bolts for poles.
12. Pole base.

13. Submit details of in-line fuseholder/fuse(s) if an equal but different type than specified in section 3.5 (D) is proposed

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
3. Wiring Diagrams: For power, signal, and control wiring.

C. Samples: Submit samples for verification purposes.

1. A sample of each individual fixture type shall be furnished when requested by the SDR.
2. Submit samples (a cut piece) of finished materials when requested by the SDR.

1.5 Informational Submittals

A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.

B. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

C. Certification of welder and certification of steel. Also provide weld procedure specification and procedure qualification record.

D. Product Certificates: Signed by manufacturers of lighting units certifying that their products comply with specified requirements.

E. Field quality-control reports.

F. Site test data reports.

G. Sustainability Data: Submit the LER for each fixture type, demonstrating compliance with FEMP LER requirements for exterior lighting.

H. Warranty: Sample of special warranty.

1.6 Closeout Submittals

A. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals.

1.7 Quality Assurance

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by the Occupational Safety and Health Administration (OSHA) in 29 CFR 1910.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. Comply with IEEE C2, "National Electrical Safety Code."

D. Comply with NFPA 70.

E. Manufacturer’s Qualifications: The manufacturer(s) shall be regularly engaged in the manufacture of exterior lighting units of the types and sizes required, whose products have been in satisfactory use in similar service for no less than ten years

F. Installer’s Qualifications: The installer shall have at least three years successful installation experience on projects with similar external lighting units. Submit proof when requested by the SDR.

1.8 Delivery, Storage, and Handling

A. Package steel poles for shipping according to ASTM A 500.

B. Inspect poles and luminaires for visual damage. All damaged poles and luminaires must be repaired or replaced by the contractor prior to installation.

C. Store luminaires in original containers and as directed by the manufacturer.

D. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

E. Retain factory-applied pole wrappings until right before pole installation. Handle poles with web fabric straps or special rope used for this purpose and approved by the SDR.

1.9 Warranty

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage. The warranty shall be mutually executed by the manufacturer and the installer, agreeing to replace light poles and luminaires exhibiting metallic damage such as cracks and failure of finish.

1. Warranty Period for Luminaires: **Five** years from date of Substantial Completion.
2. Warranty Period for Metal Corrosion: **Three** years from date of Substantial Completion.
3. Warranty Period for Color Retention: **Three** years from date of Substantial Completion.

4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than **three** years from date of Substantial Completion.

PART 2 - Products

2.1 Manufacturers

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include but are not limited to product(s) indicated on Drawings.

2.2 General Requirements for Luminaires

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

1. LER Tests Incandescent Fixtures: Where LER is specified, test according to NEMA LE 5A.
2. LER Tests Fluorescent Fixtures: Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
3. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.

B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Provide full cutoff luminaires in conformance with the New Mexico Night Sky Protection Act,.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.

F. Housings: One piece die cast aluminum with die cast door frame. Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires. A metallic barrier shall be provided between the optical chamber and electrical compartment.

G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect and remove ballast when door opens without need for tools.

H. Exposed Hardware Material: Stainless steel.

I. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet (UV) radiation.

J. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

K. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

L. Lenses and Refractors Gaskets: Materials are indicated on drawings. Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

M. EPA of luminaire including arm brackets, etc., shall not exceed 2 square feet (0.186 m^2).

N. All electrical components shall be mounted on ballast tray for easy removal. Mogul base socket to be mounted in optical chamber and be fully gasketed. Socket to be 4 kV pulse rated for high pressure sodium and metal halide lamps. Ballast tray shall support ballast and starter and shall be securely fastened to the housing for maximum thermal contact. Tray shall have connectors to allow removal of ballast assembly from housing without cutting wires.

O. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

P. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp and ballast characteristics:

   a. "USES ONLY" and include specific lamp type.
   b. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
   c. Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.
   d. American National Standards Institute (ANSI) ballast type (M98, M57, etc.) for HID luminaires.
   e. CCT and CRI for all luminaires.

Q. Lamps must contain 70p/LuHr or less of mercury.

2.3 Luminaire-Mounted Photoelectric Relays

A. Materials and controls will be indicated on the drawings.

2.4 Ballasts for HID Lamps

A. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features unless otherwise indicated:

1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
2. Shall be designed to accommodate +/- 10% variation in line voltage.
3. Power Factor: 0.9 or better.
4. Operating voltage shall match system voltage.
5. Minimum Starting Temperature: Minus 22 degrees F (Minus 30 degrees C).
6. Normal Ambient Operating Temperature: 104 degrees F (40 degrees C).
7. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

B. Auxiliary, Instant-On, Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent of light output. Components shall be mounted internal to the ballast and independent of the incoming line voltage.

C. High-Pressure Sodium Ballasts: Electromagnetic type with solid-state igniter/starter and capable of open-circuit operation without reduction of average lamp life. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 degrees C.

D. Energy Efficiency: Conform to the FEMP Energy Efficiency Product Procurement for Exterior Lighting requirements.

1. LER: Minimum of 65.

2.5 HID Lamps

A. Conform to ANSI Standards, C78 series, applicable to each type of lamp. Provide luminaires with lamps indicated on the drawings.

2.6 Conventional LED (Light Emitting Diode) Lights

A. Conform to ANSI Standards, C78.50 series, applicable to each type of LED light. Provide luminaires with lights indicated on the drawings. Refer to the SNL Exterior Lighting Subject Matter Expert (SME) for the types of approved LED lights.

2.7 Solar Powered LED (Light Emitting Diode) Lights

A. Conform to ANSI Standards, C136.40 series, applicable to solar powered LED lights. Provide luminaires with lights indicated on the drawings. Refer to the SNL Exterior Lighting SME for the types of approved solar powered LED lights and batteries. It is recommended to use Solar One’s SONXT 36 series with AGM batteries for solar lighting as it is ideal for roadways, street lighting, parking areas, and general outdoors areas. Solar powered lights are typically allowable in areas where conventional LED lights are not feasible or cost effective.

2.8 General Requirements for Poles and Support Components

A. Structural Characteristics: Comply with AASHTO LTS-4-M. Submit all combined stress ratio calculations.

1. Wind-Load Strength of Poles: 100 mph (160.9 km/h) and 1.3 gust factor for total support assembly, including pole, base, and anchorage, where used, to carry the fixtures, supports, and appurtenances at the indicated heights above grade without deflection or whipping.
2. Vibration dampers shall not be utilized.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.
2. Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
3. Anchor Bolts: Fabricated from hot rolled carbon steel bar with minimum yield strength of 55,000 psi (379,170 kPa). Bolts shall have "L" bend at one end and shall be galvanized for at least 12 inches (30.48 cm) on threaded end. Four bolts, eight galvanized nuts, and eight galvanized washers shall be provided per pole.
4. Anchor-Bolt Template: Plywood or steel.
5. Provide mountings that will correctly position the luminaire to provide the indicated light distribution.

D. Handhole: Reinforced, oval-shaped, with minimum clear opening of 4 inches (10.16cm) wide by 6 inches (15.24 m), with matching rain tight steel cover and attachment screws and centerline located approximately 18 inches (45.72 cm) above the base plate.

E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Section 03 30 00, "Cast-in-Place Concrete."

F. Pole Bases: Anchor slip-on flange type with galvanized steel hold-down or anchor bolts, leveling nuts, and base covers. Base covers shall be a two-piece carbon steel secured with at least two screws. Anchor base shall be fabricated from structural quality hot rolled carbon steel plate with yield strength of 36,000 psi (248,184 kPa). The base plate shall telescope the pole shaft and be circumferentially welded top and bottom. Provide slotted bolt holes to accommodate a ±0.5" (±1.27 cm) variation in nominal bolt circle.

2.9 Steel Poles

A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 55,000 psig (248 MPa); one-piece steel tube construction, 11-gauge minimum, with no circumferential splices, with access handhole in pole wall.

1. Shape: True round, tapered. Taper shall be uniform and approximately 0.14 inches per foot (1.17 cm per meter). Multi-sided poles are not acceptable.

2. Height: As specified on drawings.

B. Steel Mast Arms or Brackets: Provide as noted on drawings. Pole arms shall be fabricated from 2-inch (5.08 cm) pipe (except noted otherwise on drawings), continuously welded to pole attachment plate and having span and rise as indicated. Material and finish same as pole.

C. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with [**stainless**] [**galvanized**]-steel bolts.
2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
3. Match pole material and finish.

D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated on drawings, and securely fastened to pole top.

E. Removable overlapping pole caps shall be provided.

F. Grounding and Bonding Lugs: Two listed and labeled ground lugs shall be welded to the inside of the pole at the handhole location. The physical size of the ground lugs shall be kept to a minimum due to space limitations. One ground lug shall be suitable for connecting a minimum of two, #14 American Wire Gauge (AWG) (2.08 mm^2) through #10 AWG (5.26 mm^2) solid or stranded copper conductors and the other suitable for connecting a minimum of two, #8 AWG (8.37 mm^2) through #2 AWG (33.62 mm^2) stranded copper conductors

G. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.

H. Platform for Lamp and Ballast Servicing: Factory fabricated of steel with finish matching that of pole.

I. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.

J. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

K. Transformer Type Base: Same material and color as pole, 20" high.

2.10 Finishes

A. Metal Parts: All exterior surfaces shall be factory thermoset polyester powder-coated dark bronze, 2.5 mil (0.00635 cm) nominal thickness. (Interior of poles, arms, brackets, etc. shall have a factory-applied, rust-inhibiting coating.) Finish shall be applied over corrosion-resistant primer, free of streaks, runs, holidays, stains, blisters, and similar defects. Remove poles, luminaires, and accessories showing evidence of corrosion or finish failure during project warranty period and replace with new items.

B. Other Parts: Manufacturer's standard finish.

C. All paints and finishes shall be lead-free.

PART 3 - Execution

3.1 Installation

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports per manufacturer’s recommendations.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

D. Set units plumb, square, level, and secure according to manufacturer's written instructions and shop drawings. Install wiring and connections in accordance with the drawings.

E. Pole Installation:

1. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

2. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:

   a. Fire Hydrants and Storm Drainage Piping: [**60 inches (1520 mm)**]
   b. Water, Gas, Electric, Communication, and Sewer Lines: [**10 feet (3 m)**]
   c. Trees: [**15 feet (5 m)**] from tree trunk.

3. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 03 30 00, “Cast-in-Place Concrete.”

4. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.

   a. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
   b. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
   c. Install base covers unless otherwise indicated.
   d. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

5. Raise and set poles using web fabric slings (not chain or cable) or special rope approved for this purpose by the SDR.

6. All scratches in pole and fixture finish shall be touched up with manufacturer's furnished matching paint to the satisfaction of the SDR

3.2 Bollard Luminaire Installation

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top [**4 inches (100 mm)**] above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 03 30 00, “Cast-in-Place Concrete.”

3.3 Installation of Individual Ground-Mounting Luminaires

A. Install on concrete base with top [**4 inches (100 mm)**] above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 03 30 00, “Cast-in-Place Concrete.”

3.4 Corrosion Prevention

A. Aluminum & Steel: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum and steel by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 26 05 33, “Raceways and Boxes for Electrical Systems.” In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.5 Field Wiring

A. Wiring between luminaire and connections at transformer base (including grounding conductor) shall be Type Underground Feeder (UF) multiconductor cable, #14 AWG (2.08 mm^2) copper conductors (unless a larger ampacity cable is required), with number of conductors as shown on the drawings. The Type UF cable shall be supported at the top of the pole by means of a suitable "basket" type cable grip as manufactured by Kellems or equal approved by the SDR. The cable grip shall relieve the weight of the cable at the terminal block connections to the luminaire and prevent cable damage. A suitable hook or similar support shall be welded to the inside top of the pole for attaching the cable grip. The cable support shall be accessible from the top of the pole. Submit details of the cable supporting method for approval.

B. Wiring from transformer base to transformer base (including grounding conductor) shall be Type USE-2 or XHHW-2 cable, #6 AWG copper conductors (unless a larger cable is required for voltage drop or ampacity), with number of conductors as shown on the drawings.

C. Suitable insulated terminal blocks for connection of the above Type UF cable (including ground conductor) shall be provided in the luminaire. The design of the luminaire shall be such that high temperature fixture wire is not required between the luminaire and the Type UF cable conductors.

D. Install a listed in-line fuseholder and fuse in each light pole at the transformer base location for all ungrounded conductors. An insulating/waterproofing boot shall be installed on both the line and load sides with electrical tape installed at the interface of each conductor and end of boot per manufacturer's instructions. A type CC non-time-delay, rejection type fuse shall be installed in each fuseholder. Size of fuse and size/type of line and load side conductors are shown on the drawings. Provide adequate load and line side conductor slack in the form of U-bends at each in-line fuseholder. Breakaway type in-line fuseholders shall only be installed where indicated on the drawings.

E. Fuseholders and fuse shall be manufactured by Littelfuse®, type LEC or approved equal.

F. Install a Raychem GelCap Splice Kit (part number GelCap-SL-2/0-3Hole) at the transformer base from the #2 line conductor to the in-line fuse holder and on the #2 line conductors that splice through the transformer base. Install splices per the manufacturer's instructions.

3.6 Grounding

A. Ground metal poles and support structures according to the National Electric Code (NEC), Section 26 05 26, "Grounding and Bonding for Electrical Systems," and as shown on the drawings.

1. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
2. Install ¾-inch (1.91 cm) diameter (minimum) copper-clad ground rod at each pole, unless otherwise noted on the drawings. Ground rod shall be 10 feet (3.048 m) vertically in the concrete foundation and shall extend 3" above the concrete surface.
3. Connect ground rod to pole ground lug using #2 AWG (33.62 mm^2) copper conductor.
4. Bond ground rod to reinforcing bars in the concrete foundation.

3.7 Concrete Foundations

A. Construct concrete foundations conforming to Section 03 30 00, "Cast-In-Place Concrete." Comply with details shown on drawings and manufacturer's recommendations for reinforcing, anchor bolts, nuts, and washers. **Note: In parking lots, top of concrete foundation shall be at least 30 inches above finished grade except shown otherwise on the drawings.**

3.8 Ballast Installation

A. Connect ballast transformer taps, if provided, to maintain ballast voltage within manufacturer's recommended tolerance.

3.9 Field Quality Control

A. Inspect each installed unit for damage or malfunction. Replace or repair damaged fixtures and components as directed by the SDR.

B. Ensure all units are completely lamped, cleaned, and that finish is in excellent condition.

C. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.

1. Verify operation of photoelectric controls.

D. Measure power demand on the circuit after warm-up.

E. Illumination Tests:

1. Measure light intensity and uniformity at night at locations where specific illumination performance is indicated on the drawings and produce isolumen plots as directed by the SDR. Use photometers with calibration referenced to National Institute of Standards and Technology (NIST) standards.

2. Check for compliance with the New Mexico Night Sky Protection Act and correct mounting and component alignment as necessary.

3. Check for excessively noisy ballasts and correct as necessary.

F. Replace or repair damaged and malfunctioning units (including excessively noisy ballasts), correct as necessary, and retest as directed by the SDR.

G. Prepare and submit a written report of tests, inspections, observations, and verifications indicating and interpreting results. Report shall also include actual illumination levels compared to the drawings. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

H. Identification: Each pole shall have a 1-inch (2.54 cm) wide (nominal) identification tag identifying each pole per contract drawings and/or as directed by the SDR. Tags shall be black numbers and/or letters on yellow background, as applicable, 1 ½" inches (3.81 cm) high, reflective pressure sensitive, Almetek® brand or equal.

3.10 Adjusting and Cleaning

A. Clean components on completion of installation. Use methods and materials recommended by manufacturer. Where applicable, adjust aimable fixtures to provide required light intensities.

END OF SECTION 26 56 00

Section 31 20 00 – Earthwork

February 2018

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U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 31 20 00 – Earthwork

Table of Contents

Page

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Freeman Leaming	Subst	Formatted for 2004 CSI Formatting. Included information on excavation permit right at beginning of project conditions. Included information on traffic right at beginning of traffic conditions. Included mix information for flowable fill.
11/16/17	Freeman Leaming	Partial	Included in section 1.2.C DOE restrictions on the use of recycled crushed asphalt and recycled crushed concrete per DOE email date 7 April 2016. In section 2.2 changed requirements for flowable fill to match those provided by the NMDOT with the lower 150psi strength requirement due to lack of availability for the previously

			specified flowable fill. It was simply not available locally.
02/19/18	Tim Peterson	None	3-year review performed. No changes made.

Section 31 20 00 – Earthwork

Part 1 – General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Related Sections: Refer to the following sections for related work.

1. Section 01563, "Dust Control," for general dust control and air quality permitting requirements.
2. Section 03 30 00, "Cast-in-Place Concrete," for general excavation requirements.
3. Section 01 33 00, "Submittal Procedures."
4. Section 01065, "ES&H for Construction Contracts," for specific excavation permit requirements.
5. Section 01065S, "ES&H for Service Contracts," for specific excavation permit requirements.
6. Section 01701, "Subgrade Utilities As-Built Requirements."
7. Section 33 51 00, "Natural Gas Distribution."

C. References:

1. American Society for Testing and Materials (ASTM)

C131...............Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
C136...............Method for Sieve Analysis of Fine and Coarse Aggregates
D1557.............Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop
D4253.............Test Methods for Maximum Index Density of Soils Using a Vibratory Table
D4254.............Test Methods for Minimum Index Density of Soils and Calculation of Relative Density
D4318.............Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

2. Code of Federal Regulations (CFR)

Title 29 Part 1926.650............Safety and Health Regulations for Construction

1.2 Summary

A. Earthwork includes but is not limited to clearing, preparing, grading, excavating, filling, backfilling, and compacting of soils as necessary to accomplish finished construction as indicated on the drawings.

B. Excavation for Mechanical/Electrical Work: Excavation and backfill required in conjunction with underground mechanical and electrical utilities and buried mechanical and electrical appurtenances is included as work of this section.

C. Acceptable and Unacceptable Uses of Recycled Crushed Asphalt or Recycled Crushed Concrete: Based on a 7 April 2016 email, the Department of Energy (DOE) has placed environmental restrictions on the use of recycled crushed asphalt and recycled crushed concrete as construction aggregates. Those restrictions are provided here in their entirety, whether they fully apply to this section or not, to give a full understanding of the restrictions.

There are environmentally acceptable and unacceptable uses of recycled crushed asphalt and recycled crushed concrete as construction aggregates. This first item details acceptable uses, while the following item details unacceptable uses. Please read both items.

1. Acceptable uses of recycled crushed asphalt and recycled crushed concrete – Neither recycled crushed asphalt nor recycled crushed concrete may be used as a construction aggregate or as an ingredient in a construction aggregate at Sandia National Laboratories/New Mexico (SNL/NM), except in certain situations. Those acceptable situations are the following:

    a. As an aggregate base course under a concrete pavement, an asphaltic concrete pavement, or other relatively impermeable surface. The base course containing recycled crushed asphalt and/or recycled crushed concrete must not extend past the confines of the impermeable covering and, therefore, must not be used on the unpaved shoulders of a road, in the unpaved ditches of paved roads, or in any circumstance where it will be exposed to stormwater (where it would be susceptible to leaching or washing away).
    b. As an aggregate base course under a gravel road or parking lot where the base course containing the recycled crushed asphalt or recycled crushed concrete is below the gravel surface course sufficiently to ensure that it will not be directly exposed to traffic or stormwater throughout its expected service life.
    c. As a temporary ground cover of a recently disturbed area where construction is planned and vehicle traffic is prevented/prohibited. The purpose of this use is to stabilize the soil between construction projects while reserving the real estate for future planned construction. The recycled crushed asphalt or recycled crushed concrete containing material must be removed prior to the commencement of future

construction. An example of this acceptable use is around Building 730 in TA-I. An example of a project where application occurred in the past, but would not be approved for a similar project in the future is TA-II Corporate Storage Buildings because it was placed as permanent cover, not as temporary cover between construction projects.

2. Unacceptable uses of recycled crushed asphalt or recycled crushed concrete – There are additional situations where the use of recycled asphalt or recycled concrete as a construction aggregate or as an ingredient in a construction aggregate is unacceptable. Those unacceptable situations are the following:

   a. As any part of any construction aggregate in areas leased/permitted by DOE. There is no acceptable use of recycled asphalt or recycled concrete as a construction aggregate in areas leased/permitted by DOE.
   b. As a gravel surface course on unpaved parking lots because, as the surface course, it would be dispersed by vehicle traffic and exposed to stormwater, making it susceptible to leaching or washing away.
   c. As a gravel surface course on unpaved roads because, as the surface course, it would be dispersed by vehicle traffic and exposed to stormwater, making is susceptible to leaching or washing away.
   d. As a ground cover in areas intended for vegetative restoration because it has properties that can inhibit growth.
   e. As a ground cover in Environmental Restoration sites, environmentally sensitive areas, or highly erosive areas.
   f. Please note that regardless of the items listed in this section, parking lots might also be subject to the stormwater permitting and management requirements of the Clean Water Act.

1.3 Definitions

A. SNL/NM: Sandia National Laboratories New Mexico site

B. SDR: Sandia Delegated Representative

C. Borrow: Soil material obtained off-site when sufficient approved soil material is not available from excavations.

D. Drainage Fill: Course of washed granular materials supporting slab-on-grade, placed to cut off upward capillary flow of pore water.

E. Excavation: The removal of material encountered to subgrade elevations and the reuse or disposal of material removed.

F. Structures: Building, footing, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below ground surface.

G. Subgrade: The uppermost surface of an excavation or the top surface of a fill or backfill

H. Unauthorized Excavation: Removing materials beyond indicated subgrade elevations or dimensions without direction by the SDR.

I. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within building lines.

J. Flowable Concrete Backfill: Controlled low-strength flowable backfill with no less than 6-inch (152 mm) slump and no more than 10-inch (254 mm) slump.

K. Subbase Course: The layer placed between the subgrade and base course in a paving system or the layer placed between the subgrade and surface of a pavement or walk.

L. Base Course: The layer placed between the subbase and surface pavement in a paving.

M. Bedding Course: The Course placed over excavated sub-grade in a trench before laying pipe.

N. Backfill: Soil material or engineered lower strength material used to fill an excavation.

1.4 Action Submittals

A. General: Submit the following items in accordance with Conditions of Contract and Section 01 33 00, "Submittal Procedures."

B. Product Data: Submit product data for the following materials and items. Include laboratory test reports and other data to show compliance with specifications (including specified standards).

1. Each type of plastic warning tape.
2. Controlled low-strength material, including design mixture.

C. Test Reports: Submit test reports required under Quality Assurance as well as the following:

1. Laboratory analysis of each soil material proposed for fill and backfill from on-site and borrow sources.
2. One "Optimum Moisture – Maximum Density Curve" for each soil material.
3. Report of actual unconfined compressive strength and/or results of bearing tests of each stratum tested.

D. Traffic Plan: Contractor shall submit a proposed traffic plan prior to start of construction if required in the Contract documents. Traffic plan shall consist of the following:

1. How street(s) will be flagged and barricaded.
2. How street will be maintained.
3. Placement and size of steel plates to be used.
4. Duration of street closure.

E. Pre-excavation Site Survey: Document existing conditions of adjoining construction and site improvements, including finish surfaces, which might be misconstrued as damage by earthwork operations before earthwork operations begin. Arrange for photo and/or video documentation with SDR.

F. Pre-excavation site meeting: Meeting conducted at project site to clarify existing conditions and project specific hazards and tasks prior to excavation.

1.5 Quality Assurance

A. SNL will engage a soil testing and inspection service for quality control testing during earthwork operations. Should initial tests of Contractor's work indicate noncompliance with the specification, the Contractor shall make corrections as directed. Retesting required to determine compliance with this specification shall be performed by an approved testing laboratory at the Contractor's expense.

1.6 Project Conditions

A. Excavation Permit: SNL requires an Excavation Permit prior to most earthwork and excavation activities. Refer to Construction Standard Specification Section 01065, "ES&H for Construction and Service Contracts," for specific permitting requirements.

B. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the SDR.
2. Provide alternate routes around closed or obstructed traffic ways as approved by the SDR.

C. Spotted utilities: Contractor shall maintain all utility markings spotted by SNL personnel throughout the duration of the project.

D. Existing Utilities: Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, notify the SDR. Do not interrupt existing utilities without following the Standard Facilities Engineering procedures for utility outage.

Provide a minimum of two weeks' notice when practical, and await notice to proceed before interrupting any utilities.

E. Known Utilities: Type and location of known existing utilities and obstructions which are shown on the drawings are approximate, but are based on the best information available. Protect these and other utilities which are made known to General Contractor prior to excavation. Determine exact location of all known utilities by performing exploratory hand excavation to expose the utility. Hand excavate at least 5 feet (1.5 m) on each side of the indicated location unless the utility is located sooner. Remainder of excavation shall be completed only after the SDR has approved location of known utilities. When electrified utilities are to be removed, safety precautions specified under the procedure for unknown utilities shall be followed.

   1. If movement of traffic or public safety makes it necessary to backfill an exploratory excavation after the utility has been located, a suitable marker shall be installed to permanently mark the location.

F. Unknown Utilities: In the event that unidentified conduits, concrete encased ducts, or pipes are encountered that must be removed, all work on that part of the job will stop until the SDR is contacted, proper procedures are followed per Standard Specification 01065, and resumption of work is authorized.

G. Underground Telephone Cable: Where an underground telephone cable is shown on the Contract drawings, NO excavation is to be attempted in that vicinity until the line is properly located and staked by the Air Force Communications Service (AFCS). If an unknown cable is identified as a telephone cable during an excavation, all excavation is to cease until the AFCS identifies and properly stakes the cable locations in the vicinity of the excavation. (For assistance call 844-8411.)

H. Use of Explosives: The use of explosives is not permitted.

I. Protection of Persons and Property: Flag and barricade open excavations occurring as part of this work. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

   1. Contractor shall be responsible for protection of personnel and property in the work area for the duration of the Contract.

   2. Keep excavation free of water from any source at all times. Provide and operate pumps if necessary. Remove water from site in manner to avoid damage to adjoining property.

J. Pollution Control:

1. Comply with governing regulations pertaining to environmental protection prior to beginning any earthwork.

2. Comply with Construction Standard Specification 01563 "Dust Control."

3. Implement the project specific Storm Water Pollution Prevention Plan (SWPPP) if the project requires it prior to any disturbance.

4. Projects that do not require a fugitive dust permit or a SWPPP are still required to take the appropriate measures to limit dust, sediment, and other particulate matter from leaving the site. Use water sprinkling, temporary enclosures, and other suitable methods to limit amount of dust and dirt rising and scattering in the air to lowest practical level. Use appropriate sediment controls to prevent offsite sediment transportation and to protect storm drain inlets as required.

5. Clean adjacent structures and improvements of dust, dirt, and debris caused by earthworking operations, as directed by the SDR. Return adjacent areas to conditions existing prior to the start of the work.

K. Street Crossings: Excavations shall be conducted in a manner so as to cause the least interruption of traffic. Maintain half the width of the street open at all times unless prior approval from the SDR has been given to close the street. Request to close a street must be presented in writing to the SDR at least two weeks prior to the requested closing date.

Part 2 – Products

2.1 Soil Materials

A. General: Unless otherwise noted on the Contract documents, the existing site soils shall be used for fill and backfill materials. If the on-site soils are found by laboratory tests to be unsuitable for fill and backfill material, contact the SDR for direction.

1. Any additional fill material used must conform with the applicable requirements of this section.

B. Structural Fill: Structural fill shall consist of a controlled fill placed in areas indicated on the drawings.

1. Structural fill material shall consist of soils that conform to the following physical characteristics:

Sieve Size (Square Openings)	Percent Passing by Weight
6 inch (152 mm)	100

No. 4 (4.75 mm)	50 - 100
No. 200 (600 µm)	10 - 30

2. The plasticity index of material, as determined in accordance with ASTM D4318, shall not exceed 15.
3. The fill material shall be free from roots, grass, other vegetable matter, clay lumps, rocks larger than 6 inches (152 mm), or other deleterious materials. Stripped top soil shall not be used in structural fill.

C. Retaining Wall Backfill: Retaining wall backfill material shall be free-draining and conform to fill quality requirements as follows:

Sieve Size (Square Openings)	Percent Passing by Dry Weight
3/4 inch (19.1 mm)	100
No. 4 (4.75 mm)	30 - 80
No. 200 (600 µm)	0 - 5

The material should have a plasticity index of less than 5 when tested in accordance with ASTM D4318.

D. Granular Base

1. Granular base shall meet the following grading requirements as determined in accordance with ASTM C136.

Sieve Size (Square Openings)	Percent Passing by Dry Weight
1 inch (25 mm)	100
3/4 inch (19.1 mm)	80 - 100
No. 4 (4.75 mm)	30 - 60
No. 200 (600 µm)	3 - 10

2. The granular base shall have a plasticity index of no greater than 3 when tested in accordance with ASTM D4318. The coarse aggregate shall have a percent of wear, when subjected to the Los Angeles abrasion test (ASTM C131), of no greater than 50. Reconstituted asphalt base course is allowable when meeting these gradations.

E. Bedding: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch (25-mm) sieve and not more than eight percent passing a No. 200 (90.075-mm) sieve.

2.2 Controlled Low-Strength Material (Flowable Fill)

A. Controlled Low-Strength Material: Self-compacting, flowable concrete material meeting the requirements of Section 516: "Flowable Fill" of New Mexico State Department of Transportation Standard Specifications for Highway and Bridge Construction 2014 Edition.

B. Produce conventional-weight, controlled low-strength material with 150 psi maximum 28-day compressive strength when tested according to ASTM C 495.

2.3 Accessories

A. Warning Tape: Non-Detectable Warning Tape shall be installed above underground ducts or duct bank systems for electric and telecommunications systems only. All other underground utilities require Detectable Warning Tape.

B. Detectable Warning Tape: Provide an inert polyethylene film detectable warning tape manufactured for marking and identifying underground utilities. The warning tape shall be a minimum of 6 inches (152 mm) wide with a minimum metallic foil core of 0.35 mils (0.0089 mm) and shall be reinforced, consisting of 5.0 mil (0.13 mm) total thickness, and shall bear a continuous printed message designating the utility type repeated every 36 inches. The warning tape shall be "Terra Tape Sentry Line Detectable" as manufactured by Reef Industries, Inc., or an approved equal. The warning tape shall be colored in accordance with American Public Works Association (APWA) recommended color code for marking buried lines of all types.

C. Non-Detectable Warning Tape: Provide an inert polyethylene film non-detectable warning tape manufactured for marking and identifying underground utilities. The warning tape shall be a minimum of 6 inches (152 mm) wide and a minimum of 4.0 mil (0.1 mm) total thickness, and shall bear a continuous printed message designating the utility type repeated every 36 inches. The tape shall be "Terra Tape Standard" as manufactured by Reef Industries, Inc., or an approved equal. The tape shall be colored in accordance with APWA recommended color code for marking buried lines of all types.

D. Color Codes:

Electric - Red
Gas - Yellow
Water - Blue
Steam - Yellow
Sewer - Green
Communications - Orange

E. Text: The lettering shall be repeated continuously for the full length of the tape as follows:

CAUTION CAUTION CAUTION

BURIED (UTILITY TYPE) LINE BELOW

Part 3 – Execution

3.1 Preparation

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Protect subgrades and foundation soils against freezing temperatures or frost and excessive drying or wetting. Provide protective insulating materials as necessary. Remove temporary protection before placing subsequent materials.

C. Protection of Personnel: Flag and barricade open excavations occurring as part of this work.

D. Provide, protect, and maintain erosion and sedimentation controls during earthwork operations to prevent erosion or displacement of soils and discharge of soil-bearing water run-off or airborne dust to adjacent properties and walkways.

3.2 Clearing and Grubbing

A. General: Clearing and grubbing will be required for all areas indicated on the drawings to be excavated, improved on, or which fill is to be constructed. All cleared and grubbed materials, including trash, shall be deposited at the Kirtland Air Force Base Landfill or as directed by the SDR.

B. Clearing and Grubbing: Clearing shall consist of removal and disposal of trees, shrubbery, and other vegetation as well as brush and rubbish within the areas to be improved and constructed upon.

C. Grass and Topsoil: Grass, grass roots, and incidental topsoil shall not be left beneath fill area, nor shall this material be used as fill or backfill material.

3.3 Excavation

A. General: Excavate to contours, shapes, dimensions, and elevations required for the work indicated on the drawings; extend sufficiently to permit form placing, inspection, and removal. Undercutting is prohibited.

1. Earth excavation shall consist of excavation and removal of suitable soils for use as structural fill, as well as satisfactory disposal of all vegetation, debris, and deleterious materials encountered within area to be graded or in a borrow area, or any combination thereof.
2. Excavated areas shall be continuously maintained in a manner so that surfaces shall be smooth and have sufficient slope to allow water to drain from surface.
3. All existing man-made fill shall be removed in its entirety.
4. Width of excavations shall be to dimensions indicated on drawings, with additional space allowed as required for erection and stripping of forms, and inspection of related work.

B. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of the SDR. Unauthorized excavation, as well as remedial work directed by the SDR, shall be at Contractor's expense.

1. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top elevation. Flowable concrete fill (2000 psi minimum [14 MPa]) may be used to bring elevations to proper position, when acceptable to the SDR.
2. Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations of same classifications, unless otherwise directed by the SDR.

C. Additional Excavation: When excavation has reached required subgrade elevations, notify the SDR who will make an inspection of conditions.

1. If unsuitable bearing materials are encountered at required subgrade elevations, immediately notify the SDR for direction.

2. Removal of unsuitable material and its replacement shall be as directed by the SDR.

D. Stability of Excavations: Slope sides of excavations where possible in accordance with OSHA 1926.650. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfilling.

Shore all vertical cuts greater than 5 feet (1.5 m) in depth.

E. Dewatering: Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding project site and surrounding area. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations.

F. Storage of Soil Materials: Stockpile excavated materials acceptable for backfill and fill soil materials, including acceptable borrow materials, at a location on site as directed by the SDR. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent wind-blown dust.

G. Excavation for Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 feet (30.5 mm) and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of service, other construction, and for inspection.

H. Excavation for Pavements: Cut surface under pavements to comply with cross-sections, elevations, and grades as shown.

I. Excavation for Utility Trenches: Dig trenches to the uniform width required for particular item to be installed, sufficiently wide to provide ample working room. Provide minimum 6-inch (152 mm) clearance on both sides of pipe or conduit.

1. Follow the requirements in Construction Standard Specification Section 01701, “Subgrade Utilities As-Built Requirements.” As-built any changes found or made and return to SNL before job completion.
2. Excavate trenches to depth indicated or required. Carry depth of trenches for piping to establish indicated flow lines and invert elevations.
3. Where rock is encountered, carry excavation 6 inches (152 mm) below specified elevation and backfill with a 6-inch (152 mm) layer of crushed stone, gravel, or sand prior to pipe installation.
4. Grade bottoms of trenches as indicated, notching under pipe bells to provide solid bearing for entire body of pipe.
5. Do not backfill trenches until tests and inspections have been made and backfilling has been authorized by the SDR. Do not backfill until coordination of the required GPS “Utility Position Survey” for all new infrastructure and utility service installations per Construction Standard Specification Section 01701 has taken place. Use care in backfilling to avoid damage or displacement of pipe systems.
6. For grade dependent utilities, the entire length of trench between manholes or terminations shall be opened prior to placement of pipe. If existing utilities conflict with the new line, adjust the grade accordingly at the direction of the SDR.

J. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees F (1.66 degrees C).

3.4 Backfill and Fill

A. General: Place acceptable soil material in layers to required subgrade elevations, for each area classification listed below:

1. In excavations, use satisfactory excavated or borrow material.

2. Under building slabs, use granular base material, or as noted on drawing.
3. Behind retaining walls, use retaining wall backfill material.
4. Flowable concrete backfill may be used in lieu of soil when the ability to compact is affected by conditions such as safety or tight conditions.

B. Backfill excavation as promptly as work permits, but not until completion of the following:

1. Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.
2. Inspection, testing, approval, recording locations, and as-builting of underground utilities.
3. Coordination of GPS Utility Position Survey per Standard Specification 01701, "Subgrade Utilities As-Built Requirements."
4. Removal of concrete formwork.
5. Removal of temporary shoring and bracing, and backfilling of voids with satisfactory materials.
6. Removal of trash and debris from excavation.
7. Installing permanent or temporary horizontal bracing at horizontally supported walls.

C. Preparation: Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to placement of fills. Plow, strip, or break up sloped surfaces steeper than one vertical to four horizontal so that fill material will bond with existing surface.

1. Prior to placement of fill, notify the SDR, who will make an inspection of conditions to verify satisfactory removal of unsatisfactory materials.

D. Placement and Compaction: Place backfill and fill materials in layers not more than 8 inches (203 mm) in loose depth for material compacted by heavy compaction equipment, and not more than 6 inches (152 mm) loose depth for material compacted by hand-operated tampers.

1. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
2. Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations. Take care to prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.

E. Utility Trench Backfill: Place and compact bedding course on rock and other unyielding bearing surfaces and to fill unauthorized excavations. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

1. Backfill trenches with concrete where trench excavations pass under column or wall footings. Concrete shall fill from the bottom of the trench to the bottom of the footing and extend the full width of the trench to 18 inches (457 mm) beyond the edge(s) of the footing.
2. Provide 4-inch (102 mm) thick concrete base slab support for piping or conduit less than 30 inches (762 mm) below surface of roadways. After installation and testing, completely encase piping or conduit in a minimum of 4 inches (102 mm) of concrete before backfilling or placing roadway subbase.
3. Install continuous warning tape at all utility trenches as they are backfilled. Locate the tape approximately 36 inches (914 mm) above the utility line, but not less than 12 inches (305 mm) below grade. Install it directly above and parallel to the utility line with the printed side up. Take necessary precautions to avoid distorting or misplacing the tape as backfill continues.
4. When backfilling gas utility trenches, follow the backfill procedures listed in SNL Construction Standard Specification Section 33 51 00, "Natural Gas Distribution."
5. Do not backfill until coordination of the required GPS "Utility Position Survey" for all new infrastructure and utility service installations per Construction Standard Specification Section 01701.

3.5 Compaction

A. General: Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below.

B. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils that exhibit a well-defined moisture-density relationship (cohesive soils) determined in accordance with ASTM D1557 and not less than the following percentages of relative density, determined in accordance with ASTM D4253 and D4254, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).

1. Under Structures, Building Slabs, Steps, Pavement, and Curb and Gutter: Compact the top 12 inches (305 mm) below subgrade and each layer of backfill or fill material at 95 percent maximum dry density unless otherwise indicated on the drawings. (Exception: Utility trenches under pavements—compact the top 6 inches [152 mm] at 95 percent maximum dry density and each layer of backfill or fill material below subgrade at 90 percent maximum dry density unless otherwise indicated on the drawings.) Where the native soil is cohesionless, compact top 12 inches (305 mm) to a minimum relative density of 72 percent.
2. Under Lawn or Unpaved Areas: Compact the top 6 inches (152 mm) below subgrade and each layer of backfill or fill material at 85 percent maximum dry density for clayey soils (more than 35 percent passing No. 200 sieve) and 90 percent relative density for all other soils.

3. Under Walkways: Compact the top 6 inches (152 mm) below subgrade and each layer of backfill or fill material at 90 percent maximum dry density for clayey material or 90 percent relative density for all other material.

C. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade or layer of soil material, to prevent free water appearing on surface during or subsequent to compaction operations. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.

D. Frequency of Tests: The following testing frequencies are the minimum requirements. SNL reserves the right to conduct more frequent compaction testing as project conditions require.

1. Paved and Building Slab Areas: At sub-grade and at each compacted fill and backfill layer, at least one test for every 2000 sq. feet or less of paved area or building slab, but in no case fewer than three tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet of trench length for each lift.

3.6 Grading

A. General: Uniformly grade areas within limits of grading under this section, including adjacent transition areas. Smooth finished surfaces within specified tolerances, and compact with uniform levels or slopes between points where elevations are indicated, or between such points and existing grades.

B. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding. Finish surfaces free from irregular surface changes and as follows:

1. Lawn or Unpaved Areas: Finish areas to receive topsoil to within not more than 0.10 feet (30.5 mm) above or below required subgrade elevations.
2. Walks: Shape surface of areas under walks to line, grade, and cross-section, with finish surface not more than 1/2 inch (12.7 mm) above or below required subgrade elevation.
3. Pavements: Shape surface of areas under pavement to line, grade, and cross-section, with finish surface not more than 1/2 inch (12.7 mm) above or 1 inch (25 mm) below required subgrade elevation.

C. Grading Surface of Fill Under Building Slabs: Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grades within a tolerance of 1/2-inch (12.7 mm) when tested with a 10-foot (3 m) straightedge.

D. Compaction: After grading, compact subgrade surfaces to the depth and indicated percentage of maximum or relative density for each area classification.

3.7 Building Slab Drainage Course

A. Drainage course consists of an engineered granular base material over subgrade surface to support concrete building slabs. Material properties and placement shall be as indicated in the contract drawings or the geotechnical report. Minimum drainage course thickness is 6 inches.

3.8 Maintenance

A. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.

B. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, re-shape, and compact to required density prior to further construction.

C. Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn, or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.9 Disposal of Excess and Waste Material

A. Transport excess excavated material that is free of contaminates and debris to designated soil storage areas on Kirtland Air Force Base. Stockpile soil or spread as directed by the SDR.

3.10 Record Drawings

A. The Contractor shall supply one full size red-lined set of as-built drawings which identify the actual location of utility lines installed and the horizontal location and depth of all existing lines encountered during construction. The Contractor shall follow the requirements listed in Standard Specification 01701, "Subgrade Utilities As-Built Requirements."

END OF SECTION 31 20 00

Section 31 20 00 – Earthwork

February 2018

Effective Date: 02/19/2018
Review Date: 02/19/2021

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Section 31 20 00 – Earthwork

Table of Contents

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Freeman Leaming	Subst	Formatted for 2004 CSI Formatting. Included information on excavation permit right at beginning of project conditions. Included information on traffic right at beginning of traffic conditions. Included mix information for flowable fill.
11/16/17	Freeman Leaming	Partial	Included in section 1.2.C DOE restrictions on the use of recycled crushed asphalt and recycled crushed concrete per DOE email date 7 April 2016. In section 2.2 changed requirements for flowable fill to match those provided by the NMDOT with the lower 150psi strength requirement due to lack of availability for the previously

			specified flowable fill. It was simply not available locally.
02/19/18	Tim Peterson	None	3-year review performed. No changes made.

Section 31 20 00 – Earthwork

Part 1 – General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Related Sections: Refer to the following sections for related work.

1. Section 01563, "Dust Control," for general dust control and air quality permitting requirements.
2. Section 03 30 00, "Cast-in-Place Concrete," for general excavation requirements.
3. Section 01 33 00, "Submittal Procedures."
4. Section 01065, "ES&H for Construction Contracts," for specific excavation permit requirements.
5. Section 01065S, "ES&H for Service Contracts," for specific excavation permit requirements.
6. Section 01701, "Subgrade Utilities As-Built Requirements."
7. Section 33 51 00, "Natural Gas Distribution."

C. References:

1. American Society for Testing and Materials (ASTM)

C131...............Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
C136...............Method for Sieve Analysis of Fine and Coarse Aggregates
D1557.............Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop
D4253.............Test Methods for Maximum Index Density of Soils Using a Vibratory Table
D4254.............Test Methods for Minimum Index Density of Soils and Calculation of Relative Density
D4318.............Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

2. Code of Federal Regulations (CFR)

Title 29 Part 1926.650............Safety and Health Regulations for Construction

1.2 Summary

A. Earthwork includes but is not limited to clearing, preparing, grading, excavating, filling, backfilling, and compacting of soils as necessary to accomplish finished construction as indicated on the drawings.

B. Excavation for Mechanical/Electrical Work: Excavation and backfill required in conjunction with underground mechanical and electrical utilities and buried mechanical and electrical appurtenances is included as work of this section.

C. Acceptable and Unacceptable Uses of Recycled Crushed Asphalt or Recycled Crushed Concrete: Based on a 7 April 2016 email, the Department of Energy (DOE) has placed environmental restrictions on the use of recycled crushed asphalt and recycled crushed concrete as construction aggregates. Those restrictions are provided here in their entirety, whether they fully apply to this section or not, to give a full understanding of the restrictions.

There are environmentally acceptable and unacceptable uses of recycled crushed asphalt and recycled crushed concrete as construction aggregates. This first item details acceptable uses, while the following item details unacceptable uses. Please read both items.

1. <u>Acceptable</u> uses of recycled crushed asphalt and recycled crushed concrete – Neither recycled crushed asphalt nor recycled crushed concrete may be used as a construction aggregate or as an ingredient in a construction aggregate at Sandia National Laboratories/New Mexico (SNL/NM), except in certain situations. Those acceptable situations are the following:

   a. As an aggregate base course under a concrete pavement, an asphaltic concrete pavement, or other relatively impermeable surface. The base course containing recycled crushed asphalt and/or recycled crushed concrete must not extend past the confines of the impermeable covering and, therefore, must not be used on the unpaved shoulders of a road, in the unpaved ditches of paved roads, or in any circumstance where it will be exposed to stormwater (where it would be susceptible to leaching or washing away).
   b. As an aggregate base course under a gravel road or parking lot where the base course containing the recycled crushed asphalt or recycled crushed concrete is below the gravel surface course sufficiently to ensure that it will not be directly exposed to traffic or stormwater throughout its expected service life.
   c. As a temporary ground cover of a recently disturbed area where construction is planned and vehicle traffic is prevented/prohibited. The purpose of this use is to stabilize the soil between construction projects while reserving the real estate for future planned construction. The recycled crushed asphalt or recycled crushed concrete containing material must be removed prior to the commencement of future

construction. An example of this acceptable use is around Building 730 in TA-I. An example of a project where application occurred in the past, but would not be approved for a similar project in the future is TA-II Corporate Storage Buildings because it was placed as permanent cover, not as temporary cover between construction projects.

2. Unacceptable uses of recycled crushed asphalt or recycled crushed concrete – There are additional situations where the use of recycled asphalt or recycled concrete as a construction aggregate or as an ingredient in a construction aggregate is unacceptable. Those unacceptable situations are the following:

   a. As any part of any construction aggregate in areas leased/permitted by DOE. There is no acceptable use of recycled asphalt or recycled concrete as a construction aggregate in areas leased/permitted by DOE.
   b. As a gravel surface course on unpaved parking lots because, as the surface course, it would be dispersed by vehicle traffic and exposed to stormwater, making it susceptible to leaching or washing away.
   c. As a gravel surface course on unpaved roads because, as the surface course, it would be dispersed by vehicle traffic and exposed to stormwater, making is susceptible to leaching or washing away.
   d. As a ground cover in areas intended for vegetative restoration because it has properties that can inhibit growth.
   e. As a ground cover in Environmental Restoration sites, environmentally sensitive areas, or highly erosive areas.
   f. Please note that regardless of the items listed in this section, parking lots might also be subject to the stormwater permitting and management requirements of the Clean Water Act.

1.3 Definitions

A. SNL/NM: Sandia National Laboratories New Mexico site

B. SDR: Sandia Delegated Representative

C. Borrow: Soil material obtained off-site when sufficient approved soil material is not available from excavations.

D. Drainage Fill: Course of washed granular materials supporting slab-on-grade, placed to cut off upward capillary flow of pore water.

E. Excavation: The removal of material encountered to subgrade elevations and the reuse or disposal of material removed.

F. Structures: Building, footing, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below ground surface.

G. Subgrade: The uppermost surface of an excavation or the top surface of a fill or backfill

H. Unauthorized Excavation: Removing materials beyond indicated subgrade elevations or dimensions without direction by the SDR.

I. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within building lines.

J. Flowable Concrete Backfill: Controlled low-strength flowable backfill with no less than 6-inch (152 mm) slump and no more than 10-inch (254 mm) slump.

K. Subbase Course: The layer placed between the subgrade and base course in a paving system or the layer placed between the subgrade and surface of a pavement or walk.

L. Base Course: The layer placed between the subbase and surface pavement in a paving.

M. Bedding Course: The Course placed over excavated sub-grade in a trench before laying pipe.

N. Backfill: Soil material or engineered lower strength material used to fill an excavation.

1.4 Action Submittals

A. General: Submit the following items in accordance with Conditions of Contract and Section 01 33 00, "Submittal Procedures."

B. Product Data: Submit product data for the following materials and items. Include laboratory test reports and other data to show compliance with specifications (including specified standards).

1. Each type of plastic warning tape.
2. Controlled low-strength material, including design mixture.

C. Test Reports: Submit test reports required under Quality Assurance as well as the following:

1. Laboratory analysis of each soil material proposed for fill and backfill from on-site and borrow sources.
2. One "Optimum Moisture – Maximum Density Curve" for each soil material.
3. Report of actual unconfined compressive strength and/or results of bearing tests of each stratum tested.

D. Traffic Plan: Contractor shall submit a proposed traffic plan prior to start of construction if required in the Contract documents. Traffic plan shall consist of the following:

1. How street(s) will be flagged and barricaded.
2. How street will be maintained.
3. Placement and size of steel plates to be used.
4. Duration of street closure.

E. Pre-excavation Site Survey: Document existing conditions of adjoining construction and site improvements, including finish surfaces, which might be misconstrued as damage by earthwork operations before earthwork operations begin. Arrange for photo and/or video documentation with SDR.

F. Pre-excavation site meeting: Meeting conducted at project site to clarify existing conditions and project specific hazards and tasks prior to excavation.

1.5 Quality Assurance

A. SNL will engage a soil testing and inspection service for quality control testing during earthwork operations. Should initial tests of Contractor's work indicate noncompliance with the specification, the Contractor shall make corrections as directed. Retesting required to determine compliance with this specification shall be performed by an approved testing laboratory at the Contractor's expense.

1.6 Project Conditions

A. Excavation Permit: SNL requires an Excavation Permit prior to most earthwork and excavation activities. Refer to Construction Standard Specification Section 01065, "ES&H for Construction and Service Contracts," for specific permitting requirements.

B. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the SDR.
2. Provide alternate routes around closed or obstructed traffic ways as approved by the SDR.

C. Spotted utilities: Contractor shall maintain all utility markings spotted by SNL personnel throughout the duration of the project.

D. Existing Utilities: Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, notify the SDR. Do not interrupt existing utilities without following the Standard Facilities Engineering procedures for utility outage.

Provide a minimum of two weeks' notice when practical, and await notice to proceed before interrupting any utilities.

E. Known Utilities: Type and location of known existing utilities and obstructions which are shown on the drawings are approximate, but are based on the best information available. Protect these and other utilities which are made known to General Contractor prior to excavation. Determine exact location of all known utilities by performing exploratory hand excavation to expose the utility. Hand excavate at least 5 feet (1.5 m) on each side of the indicated location unless the utility is located sooner. Remainder of excavation shall be completed only after the SDR has approved location of known utilities. When electrified utilities are to be removed, safety precautions specified under the procedure for unknown utilities shall be followed.

1. If movement of traffic or public safety makes it necessary to backfill an exploratory excavation after the utility has been located, a suitable marker shall be installed to permanently mark the location.

F. Unknown Utilities: In the event that unidentified conduits, concrete encased ducts, or pipes are encountered that must be removed, all work on that part of the job will stop until the SDR is contacted, proper procedures are followed per Standard Specification 01065, and resumption of work is authorized.

G. Underground Telephone Cable: Where an underground telephone cable is shown on the Contract drawings, NO excavation is to be attempted in that vicinity until the line is properly located and staked by the Air Force Communications Service (AFCS). If an unknown cable is identified as a telephone cable during an excavation, all excavation is to cease until the AFCS identifies and properly stakes the cable locations in the vicinity of the excavation. (For assistance call 844-8411.)

H. Use of Explosives: The use of explosives is not permitted.

I. Protection of Persons and Property: Flag and barricade open excavations occurring as part of this work. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

1. Contractor shall be responsible for protection of personnel and property in the work area for the duration of the Contract.

2. Keep excavation free of water from any source at all times. Provide and operate pumps if necessary. Remove water from site in manner to avoid damage to adjoining property.

J. Pollution Control:

1. Comply with governing regulations pertaining to environmental protection prior to beginning any earthwork.

2. Comply with Construction Standard Specification 01563 "Dust Control."

3. Implement the project specific Storm Water Pollution Prevention Plan (SWPPP) if the project requires it prior to any disturbance.

4. Projects that do not require a fugitive dust permit or a SWPPP are still required to take the appropriate measures to limit dust, sediment, and other particulate matter from leaving the site. Use water sprinkling, temporary enclosures, and other suitable methods to limit amount of dust and dirt rising and scattering in the air to lowest practical level. Use appropriate sediment controls to prevent offsite sediment transportation and to protect storm drain inlets as required.

5. Clean adjacent structures and improvements of dust, dirt, and debris caused by earthworking operations, as directed by the SDR. Return adjacent areas to conditions existing prior to the start of the work.

K. Street Crossings: Excavations shall be conducted in a manner so as to cause the least interruption of traffic. Maintain half the width of the street open at all times unless prior approval from the SDR has been given to close the street. Request to close a street must be presented in writing to the SDR at least two weeks prior to the requested closing date.

Part 2 – Products

2.1 Soil Materials

A. General: Unless otherwise noted on the Contract documents, the existing site soils shall be used for fill and backfill materials. If the on-site soils are found by laboratory tests to be unsuitable for fill and backfill material, contact the SDR for direction.

1. Any additional fill material used must conform with the applicable requirements of this section.

B. Structural Fill: Structural fill shall consist of a controlled fill placed in areas indicated on the drawings.

1. Structural fill material shall consist of soils that conform to the following physical characteristics:

Sieve Size (Square Openings)	Percent Passing by Weight
6 inch (152 mm)	100

No. 4 (4.75 mm)	50 - 100
No. 200 (600 µm)	10 - 30

2. The plasticity index of material, as determined in accordance with ASTM D4318, shall not exceed 15.
3. The fill material shall be free from roots, grass, other vegetable matter, clay lumps, rocks larger than 6 inches (152 mm), or other deleterious materials. Stripped top soil shall not be used in structural fill.

C. Retaining Wall Backfill: Retaining wall backfill material shall be free-draining and conform to fill quality requirements as follows:

Sieve Size (Square Openings)	Percent Passing by Dry Weight
3/4 inch (19.1 mm)	100
No. 4 (4.75 mm)	30 - 80
No. 200 (600 µm)	0 - 5

The material should have a plasticity index of less than 5 when tested in accordance with ASTM D4318.

D. Granular Base

1. Granular base shall meet the following grading requirements as determined in accordance with ASTM C136.

Sieve Size (Square Openings)	Percent Passing by Dry Weight
1 inch (25 mm)	100
3/4 inch (19.1 mm)	80 - 100
No. 4 (4.75 mm)	30 - 60
No. 200 (600 µm)	3 - 10

2. The granular base shall have a plasticity index of no greater than 3 when tested in accordance with ASTM D4318. The coarse aggregate shall have a percent of wear, when subjected to the Los Angeles abrasion test (ASTM C131), of no greater than 50. Reconstituted asphalt base course is allowable when meeting these gradations.

E. Bedding: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch (25-mm) sieve and not more than eight percent passing a No. 200 (90.075-mm) sieve.

2.2 Controlled Low-Strength Material (Flowable Fill)

A. Controlled Low-Strength Material: Self-compacting, flowable concrete material meeting the requirements of Section 516: “Flowable Fill” of New Mexico State Department of Transportation Standard Specifications for Highway and Bridge Construction 2014 Edition.

B. Produce conventional-weight, controlled low-strength material with 150 psi maximum 28-day compressive strength when tested according to ASTM C 495.

2.3 Accessories

A. Warning Tape: Non-Detectable Warning Tape shall be installed above underground ducts or duct bank systems for electric and telecommunications systems only. All other underground utilities require Detectable Warning Tape.

B. Detectable Warning Tape: Provide an inert polyethylene film detectable warning tape manufactured for marking and identifying underground utilities. The warning tape shall be a minimum of 6 inches (152 mm) wide with a minimum metallic foil core of 0.35 mils (0.0089 mm) and shall be reinforced, consisting of 5.0 mil (0.13 mm) total thickness, and shall bear a continuous printed message designating the utility type repeated every 36 inches. The warning tape shall be “Terra Tape Sentry Line Detectable” as manufactured by Reef Industries, Inc., or an approved equal. The warning tape shall be colored in accordance with American Public Works Association (APWA) recommended color code for marking buried lines of all types.

C. Non-Detectable Warning Tape: Provide an inert polyethylene film non-detectable warning tape manufactured for marking and identifying underground utilities. The warning tape shall be a minimum of 6 inches (152 mm) wide and a minimum of 4.0 mil (0.1 mm) total thickness, and shall bear a continuous printed message designating the utility type repeated every 36 inches. The tape shall be “Terra Tape Standard” as manufactured by Reef Industries, Inc., or an approved equal. The tape shall be colored in accordance with APWA recommended color code for marking buried lines of all types.

D. Color Codes:

Electric - Red
Gas - Yellow
Water - Blue
Steam - Yellow
Sewer - Green
Communications - Orange

E. Text: The lettering shall be repeated continuously for the full length of the tape as follows:

CAUTION CAUTION CAUTION

BURIED (UTILITY TYPE) LINE BELOW

Part 3 – Execution

3.1 Preparation

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Protect subgrades and foundation soils against freezing temperatures or frost and excessive drying or wetting. Provide protective insulating materials as necessary. Remove temporary protection before placing subsequent materials.

C. Protection of Personnel: Flag and barricade open excavations occurring as part of this work.

D. Provide, protect, and maintain erosion and sedimentation controls during earthwork operations to prevent erosion or displacement of soils and discharge of soil-bearing water run-off or airborne dust to adjacent properties and walkways.

3.2 Clearing and Grubbing

A. General: Clearing and grubbing will be required for all areas indicated on the drawings to be excavated, improved on, or which fill is to be constructed. All cleared and grubbed materials, including trash, shall be deposited at the Kirtland Air Force Base Landfill or as directed by the SDR.

B. Clearing and Grubbing: Clearing shall consist of removal and disposal of trees, shrubbery, and other vegetation as well as brush and rubbish within the areas to be improved and constructed upon.

C. Grass and Topsoil: Grass, grass roots, and incidental topsoil shall not be left beneath fill area, nor shall this material be used as fill or backfill material.

3.3 Excavation

A. General: Excavate to contours, shapes, dimensions, and elevations required for the work indicated on the drawings; extend sufficiently to permit form placing, inspection, and removal. Undercutting is prohibited.

1. Earth excavation shall consist of excavation and removal of suitable soils for use as structural fill, as well as satisfactory disposal of all vegetation, debris, and deleterious materials encountered within area to be graded or in a borrow area, or any combination thereof.
2. Excavated areas shall be continuously maintained in a manner so that surfaces shall be smooth and have sufficient slope to allow water to drain from surface.
3. All existing man-made fill shall be removed in its entirety.
4. Width of excavations shall be to dimensions indicated on drawings, with additional space allowed as required for erection and stripping of forms, and inspection of related work.

B. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of the SDR. Unauthorized excavation, as well as remedial work directed by the SDR, shall be at Contractor's expense.

1. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top elevation. Flowable concrete fill (2000 psi minimum [14 MPa]) may be used to bring elevations to proper position, when acceptable to the SDR.
2. Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations of same classifications, unless otherwise directed by the SDR.

C. Additional Excavation: When excavation has reached required subgrade elevations, notify the SDR who will make an inspection of conditions.

1. If unsuitable bearing materials are encountered at required subgrade elevations, immediately notify the SDR for direction.

2. Removal of unsuitable material and its replacement shall be as directed by the SDR.

D. Stability of Excavations: Slope sides of excavations where possible in accordance with OSHA 1926.650. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfilling.

Shore all vertical cuts greater than 5 feet (1.5 m) in depth.

E. Dewatering: Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding project site and surrounding area. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations.

F. Storage of Soil Materials: Stockpile excavated materials acceptable for backfill and fill soil materials, including acceptable borrow materials, at a location on site as directed by the SDR. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent wind-blown dust.

G. Excavation for Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 feet (30.5 mm) and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of service, other construction, and for inspection.

H. Excavation for Pavements: Cut surface under pavements to comply with cross-sections, elevations, and grades as shown.

I. Excavation for Utility Trenches: Dig trenches to the uniform width required for particular item to be installed, sufficiently wide to provide ample working room. Provide minimum 6-inch (152 mm) clearance on both sides of pipe or conduit.

1. Follow the requirements in Construction Standard Specification Section 01701, "Subgrade Utilities As-Built Requirements." As-built any changes found or made and return to SNL before job completion.
2. Excavate trenches to depth indicated or required. Carry depth of trenches for piping to establish indicated flow lines and invert elevations.
3. Where rock is encountered, carry excavation 6 inches (152 mm) below specified elevation and backfill with a 6-inch (152 mm) layer of crushed stone, gravel, or sand prior to pipe installation.
4. Grade bottoms of trenches as indicated, notching under pipe bells to provide solid bearing for entire body of pipe.
5. Do not backfill trenches until tests and inspections have been made and backfilling has been authorized by the SDR. Do not backfill until coordination of the required GPS "Utility Position Survey" for all new infrastructure and utility service installations per Construction Standard Specification Section 01701 has taken place. Use care in backfilling to avoid damage or displacement of pipe systems.
6. For grade dependent utilities, the entire length of trench between manholes or terminations shall be opened prior to placement of pipe. If existing utilities conflict with the new line, adjust the grade accordingly at the direction of the SDR.

J. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees F (1.66 degrees C).

3.4 Backfill and Fill

A. General: Place acceptable soil material in layers to required subgrade elevations, for each area classification listed below:

1. In excavations, use satisfactory excavated or borrow material.

2. Under building slabs, use granular base material, or as noted on drawing.
3. Behind retaining walls, use retaining wall backfill material.
4. Flowable concrete backfill may be used in lieu of soil when the ability to compact is affected by conditions such as safety or tight conditions.

B. Backfill excavation as promptly as work permits, but not until completion of the following:

1. Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.
2. Inspection, testing, approval, recording locations, and as-builting of underground utilities.
3. Coordination of GPS Utility Position Survey per Standard Specification 01701, "Subgrade Utilities As-Built Requirements."
4. Removal of concrete formwork.
5. Removal of temporary shoring and bracing, and backfilling of voids with satisfactory materials.
6. Removal of trash and debris from excavation.
7. Installing permanent or temporary horizontal bracing at horizontally supported walls.

C. Preparation: Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to placement of fills. Plow, strip, or break up sloped surfaces steeper than one vertical to four horizontal so that fill material will bond with existing surface.

1. Prior to placement of fill, notify the SDR, who will make an inspection of conditions to verify satisfactory removal of unsatisfactory materials.

D. Placement and Compaction: Place backfill and fill materials in layers not more than 8 inches (203 mm) in loose depth for material compacted by heavy compaction equipment, and not more than 6 inches (152 mm) loose depth for material compacted by hand-operated tampers.

1. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
2. Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations. Take care to prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.

E. Utility Trench Backfill: Place and compact bedding course on rock and other unyielding bearing surfaces and to fill unauthorized excavations. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

1. Backfill trenches with concrete where trench excavations pass under column or wall footings. Concrete shall fill from the bottom of the trench to the bottom of the footing and extend the full width of the trench to 18 inches (457 mm) beyond the edge(s) of the footing.
2. Provide 4-inch (102 mm) thick concrete base slab support for piping or conduit less than 30 inches (762 mm) below surface of roadways. After installation and testing, completely encase piping or conduit in a minimum of 4 inches (102 mm) of concrete before backfilling or placing roadway subbase.
3. Install continuous warning tape at all utility trenches as they are backfilled. Locate the tape approximately 36 inches (914 mm) above the utility line, but not less than 12 inches (305 mm) below grade. Install it directly above and parallel to the utility line with the printed side up. Take necessary precautions to avoid distorting or misplacing the tape as backfill continues.
4. When backfilling gas utility trenches, follow the backfill procedures listed in SNL Construction Standard Specification Section 33 51 00, "Natural Gas Distribution."
5. Do not backfill until coordination of the required GPS "Utility Position Survey" for all new infrastructure and utility service installations per Construction Standard Specification Section 01701.

3.5 Compaction

A. General: Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below.

B. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils that exhibit a well-defined moisture-density relationship (cohesive soils) determined in accordance with ASTM D1557 and not less than the following percentages of relative density, determined in accordance with ASTM D4253 and D4254, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).

1. Under Structures, Building Slabs, Steps, Pavement, and Curb and Gutter: Compact the top 12 inches (305 mm) below subgrade and each layer of backfill or fill material at 95 percent maximum dry density unless otherwise indicated on the drawings. (Exception: Utility trenches under pavements—compact the top 6 inches [152 mm] at 95 percent maximum dry density and each layer of backfill or fill material below subgrade at 90 percent maximum dry density unless otherwise indicated on the drawings.) Where the native soil is cohesionless, compact top 12 inches (305 mm) to a minimum relative density of 72 percent.
2. Under Lawn or Unpaved Areas: Compact the top 6 inches (152 mm) below subgrade and each layer of backfill or fill material at 85 percent maximum dry density for clayey soils (more than 35 percent passing No. 200 sieve) and 90 percent relative density for all other soils.

3. Under Walkways: Compact the top 6 inches (152 mm) below subgrade and each layer of backfill or fill material at 90 percent maximum dry density for clayey material or 90 percent relative density for all other material.

C. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade or layer of soil material, to prevent free water appearing on surface during or subsequent to compaction operations. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.

D. Frequency of Tests: The following testing frequencies are the minimum requirements. SNL reserves the right to conduct more frequent compaction testing as project conditions require.

1. Paved and Building Slab Areas: At sub-grade and at each compacted fill and backfill layer, at least one test for every 2000 sq. feet or less of paved area or building slab, but in no case fewer than three tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet of trench length for each lift.

3.6 Grading

A. General: Uniformly grade areas within limits of grading under this section, including adjacent transition areas. Smooth finished surfaces within specified tolerances, and compact with uniform levels or slopes between points where elevations are indicated, or between such points and existing grades.

B. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding. Finish surfaces free from irregular surface changes and as follows:

1. Lawn or Unpaved Areas: Finish areas to receive topsoil to within not more than 0.10 feet (30.5 mm) above or below required subgrade elevations.
2. Walks: Shape surface of areas under walks to line, grade, and cross-section, with finish surface not more than 1/2 inch (12.7 mm) above or below required subgrade elevation.
3. Pavements: Shape surface of areas under pavement to line, grade, and cross-section, with finish surface not more than 1/2 inch (12.7 mm) above or 1 inch (25 mm) below required subgrade elevation.

C. Grading Surface of Fill Under Building Slabs: Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grades within a tolerance of 1/2-inch (12.7 mm) when tested with a 10-foot (3 m) straightedge.

D. Compaction: After grading, compact subgrade surfaces to the depth and indicated percentage of maximum or relative density for each area classification.

3.7 Building Slab Drainage Course

A. Drainage course consists of an engineered granular base material over subgrade surface to support concrete building slabs. Material properties and placement shall be as indicated in the contract drawings or the geotechnical report. Minimum drainage course thickness is 6 inches.

3.8 Maintenance

A. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.

B. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, re-shape, and compact to required density prior to further construction.

C. Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn, or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.9 Disposal of Excess and Waste Material

A. Transport excess excavated material that is free of contaminates and debris to designated soil storage areas on Kirtland Air Force Base. Stockpile soil or spread as directed by the SDR.

3.10 Record Drawings

A. The Contractor shall supply one full size red-lined set of as-built drawings which identify the actual location of utility lines installed and the horizontal location and depth of all existing lines encountered during construction. The Contractor shall follow the requirements listed in Standard Specification 01701, “Subgrade Utilities As-Built Requirements.”

END OF SECTION 31 20 00

SECTION 316329

DRILLED CONCRETE PIERS

PART 1. GENERAL

1.1 SCOPE

A. This section covers the requirements for the installation of drilled concrete piers.

B. Related Sections

a. Division 1 - General Specifications

b. Division 033000 – Cast In Place Concrete

1.2 DEFINITIONS

A. Drilled Pier: A foundation element, with or without an enlarged bearing area, extended downward by drilling through earth materials, water, or both, to an acceptable design depth and filled with structural concrete. The terms caisson and drilled shaft are synonymous with a drilled pier.

B. Bearing Stratum: The soil or rock stratum that carries the load transferred to it by an end bearing drilled pier.

C. Geotechnical Engineer: A professional engineer representing the Subcontractor to perform inspections associated with the drilled pier installation.

D. Geotechnical Engineering Services Report: A document that evaluated the engineering properties of the subsurface soils and/or rock underlying the site.

1.3 REFERENCES

A. References noted in these specifications form a part of these specifications to the extent applicable. The publications are referred to in the text by the basic designation only.

B. Codes and standards: The following tables provide the codes standards (including the edition) that shall be used and referenced for this project. NOTE: Codes and standards that are referenced within the required codes and standards shall be considered applicable to this project:

a. American Concrete Institute (ACI)

336.1	Specification for the Construction of Drilled Piers
301-10	Specifications for Structural Concrete

1.4 SUBMITTALS AND RECORD MANAGEMENT

A. Drilled Piers:

1. List of equipment.
2. Shop drawings for reinforcement to be submitted within specification (03300 Cast In Place Concrete).
3. Geotechnical Engineer's process for observation and inspection for acceptability of piers to include observation reports.
4. Records and test reports for concrete work as required to be submitted within specification (033000 Cast In Place Concrete).

1.5 QUALITY ASSURANCE

A. Construction Standards: Drilled shaft foundations shall be constructed in accordance with applicable requirements of ACI 336.1-01 "Specification for the Construction of Drilled Piers".

B. Design Criteria:

1. Drilled shaft foundations shall consist of monolithically cast-in-place concrete piles of sizes indicated.
2. Shaft foundations shall be straight cylindrical shaft type as indicated.
3. Shaft foundations shall extend from the indicated concrete cutoff elevation to the indicated tip elevation.

C. Inspections:

1. Geotechnical Engineer to perform all inspections and structural observations required.

PART 2. PIERS INSTALLATION

A. The following criteria shall be followed during the installation drilled shaft piers.

1. Careful observations should be made to verify that pier excavations are advanced to the design depth of penetration into the underlying substrate as indicated by the plans.

2. Excavations should be advanced using a single flight auger, or bucket type auger bits to the design depth. It should be verified by observation and measurement that the excavations are open to those depths. The auger should then be placed back into the excavations to two additional passes made to clean loose material present in the bottom of the excavations.

3. It is estimated that only minor caving and/or sloughing will occur during the drilling operations. As a result, concrete quantities should be near neat quantities as indicated by the plans.

4. Concrete should be placed through a hopper or other device so that it is channeled in such a manner to free fall and clear the walls of the excavation and reinforcing steel until it strikes the bottom. Adequate compaction will be achieved by free fall of the concrete up to 5 feet. The top 5 feet of concrete should be vibrated in order to achieve proper compaction.

5. Continuous observation of the construction of the drilled piers should be performed by the Geotechnical Engineer to ensure that they are installed to their design depths and meet the requirements outlined above.

Part 3 EXECUTION

A. Excavate drilled piers to dimensions and required elevations shown on the Design Documents. Clear all obstructions encountered during excavation.

B. The project Geotechnical Engineer will determine actual final bearing levels during excavation based on suitability of the bearing stratum.

3.1 REINFORCING STEEL

A. Reinforce drilled piers as shown on the project Design Documents and per specification (033000 Cast In Place Concrete).

B. Place reinforcement for drilled piers after acceptance of the drilled pier excavation.

C. Maintain proper dimension and location of reinforcing steel during concreting operations.

3.2 CONCRETE

A. Concrete work shall conform to Specification 033000.

B Place concrete within 24 hours of excavation, and after all inspections are complete and documented. If concrete placement cannot be made within 24 hours of drilling the pier, the SUBCONTRACTOR shall have their geotechnical representative reinspect and document the integrity of the excavation immediately prior to concrete placement.

C. Notify Contractor 24 hours in advance of concrete placement.

D. Mechanically vibrate at least the top 5 ft. of concrete at each pier following casing removal.

END OF SECTION

Exceptional service in the national interest

Sandia National Laboratories

Section 32 11 23.10 – Aggregate Base Course for Under Pavements

February 2018

Effective Date: 02/19/2018
Review Date: 02/19/2021

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Sandia National Laboratories

Section 32 11 23.10 – Aggregate Base Courses for Under Pavements

Table of Contents

Table of Figures

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02/19/18	Tim Peterson	None	3-year review performed. No changes made.

Section 32 11 23.10 – Aggregate Base Course for Under Pavements

Part 1 – General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General Conditions.

B. Related Sections: Refer to the following sections for related work.

1. Section 01 33 00, "Submittal Procedures"
2. Section 31 20 00, "Earthwork"
3. Section 32 12 16.02, "Asphalt Concrete Material"
4. Section 32 12 16.03, "Asphalt Concrete Installation"

C. References:

1. American Society for Testing and Materials (ASTM)

C88.........Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

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D3017.....Test Method for Water Content of Soil and Rock in-place by Nuclear Methods (Shallow Depth)

D4318.....Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

2. City of Albuquerque "Standard Specifications for Public Works Construction" Section 302, "Aggregate Base Course Construction."

1.2 Summary

A. Section Includes: Work provided under this specification shall include the furnishing, placement, and compaction of either aggregate base course (ABC), recycled asphalt base course (RABC), or crushed concrete base course (CCBC) when that base course is to be subsequently covered with a rigid or flexible pavement.

1. Job mix formulae and gradations shall meet the criteria as set forth in the most current City of Albuquerque approved base course mix designs.

B. This section does not include aggregate base courses that are intended to be exposed to the elements on a permanent basis without being subsequently covered with a rigid or flexible pavement.

C. Products Installed but not Furnished Under this Section:

1. Prime coat for surface sealing of compacted aggregate base course.

2. Prepared subgrade for a compacted soil foundation prior to placing an aggregate base course in preparation for an asphalt pavement.

D. Acceptable and Unacceptable Uses of Recycled Crushed Asphalt or Recycled Crushed Concrete: Based on a 7 April 2016 email, the Department of Energy (DOE) has placed environmental restrictions on the use of recycled crushed asphalt and recycled crushed concrete as construction aggregates. Those restrictions are provided here in their entirety, whether they fully apply to this section or not, in order to give a full understanding of the restrictions.

There are environmentally acceptable and unacceptable uses of recycled crushed asphalt and recycled crushed concrete as construction aggregates. This first item details acceptable uses while the following item details unacceptable uses. Please read both items.

1. Acceptable uses of recycled crushed asphalt and recycled crushed concrete – Neither recycled crushed asphalt nor recycled crushed concrete may be used as a construction aggregate or as an ingredient in a construction aggregate at SNL/NM except in certain situations. Those acceptable situations are:

a. As an aggregate base course under a concrete pavement, an asphaltic concrete pavement, or other relatively impermeable surface. The base course containing recycled crushed asphalt and/or recycled crushed concrete must not extend past the confines of the impermeable covering and, therefore, must not be used on the unpaved shoulders of a road, in the unpaved ditches of paved roads, or in any circumstance where it will be exposed to stormwater (where it would be susceptible to leaching or washing away).

b. As an aggregate base course under a gravel road or parking lot where the base course containing the recycled crushed asphalt or recycled crushed concrete is below the gravel surface course sufficiently to ensure that it will not be directly exposed to traffic or stormwater throughout its expected service life.

c. As a temporary ground cover of a recently disturbed area where construction is planned and vehicle traffic is prevented/prohibited. The purpose of this use is to stabilize the soil between construction projects while reserving the real estate for future planned construction. The recycled crushed asphalt or recycled crushed concrete containing material must be removed prior to the commencement of future construction. An example of this acceptable use is around Building 730 in Tech Area I (TA-I). An example of a project where application occurred in the past, but would not be approved for a similar project in the future, is TA-II Corporate Storage Buildings because it was placed as permanent cover, not as temporary cover between construction projects.

2. Unacceptable uses of recycled crushed asphalt or recycled crushed concrete – There are additional situations where the use of recycled asphalt or recycled concrete as a construction aggregate or as an ingredient in a construction aggregate is unacceptable. Those unacceptable situations are:

a. As any part of any construction aggregate in areas leased/permitted by DOE. There is no acceptable use of recycled asphalt or recycled concrete as a construction aggregate in areas leased/permitted by DOE.

b. As a gravel surface course on unpaved parking lots because, as the surface course, it would be dispersed by vehicle traffic and exposed to stormwater, making it susceptible to leaching or washing away.

c. As a gravel surface course on unpaved roads because, as the surface course, it would be dispersed by vehicle traffic and exposed to stormwater, making it susceptible to leaching or washing away.

d. As a ground cover in areas intended for vegetative restoration because it has properties that can inhibit growth.

e. As a ground cover in Environmental Restoration sites, environmentally sensitive areas, or highly erosive areas.

f. Please note that regardless of the items listed in this section, parking lots might also be subject to the stormwater permitting and management requirements of the Clean Water Act.

1.3 Definitions

A. SNL/NM: Sandia National Laboratories New Mexico Site

B. SDR: Sandia Delegated Representative

C. Emulsified Asphalt: A paving asphalt uniformly suspended with water. The emulsion permits the application of paving grade asphalts at normal atmospheric temperatures to obtain workable fluidity. In the emulsifying process, warm asphalt is mechanically milled into minute droplets or globules and dispersed in water, then treated with a small quantity of emulsifying agent, usually some type of soap. By proper selection of an emulsifying agent, emulsified asphalts are produced in several types and grades. By choice of emulsifying agent, the emulsified asphalt may be:

1. Anionic – asphalt globules are electro-negatively charged.

2. Cationic – asphalt globules are electro-positively charged.

D. Prime Coat: An application of emulsified asphalt to an untreated granular base in preparation for a subsequent asphalt course. The prime coat is designed to waterproof the base surface and provide adhesion between the base and the next course.

E. Base Course: Placed on prepared surfaces to distribute wheel loads, provide a non-frost susceptible material on which to support surface courses.

1.4 Action Submittals

A. General: Submit the following in accordance with Conditions of Contract and Section 01 33 00, "Submittal Procedures."

B. Product Data: Submit product data for each base course material and prime coat used, including supplier and design mix identification number.

C. Certification of Compliance: Provide certification that mix design complies with the requirements specified in 2.2 "Mixes" of this specification.

D. Test Reports: Provide laboratory test reports to show that materials comply with requirements specified in 2.1 "Materials" of this specification.

1.5 Project Conditions

Environmental Requirement: In the event of temporary suspension of the Work or inclement weather, or as directed by the SDR, all the Work, materials, and equipment incorporated therein shall be protected against damage, injury, or loss from the weather, whether in storage on or off the site.

1.6 Delivery, Storage, and Handling

A. Delivery: Contractor shall provide to the SDR with each load of batched material and/or material delivered to the job site, before unloading at the site, a copy of the delivery ticket on which is printed, stamped, or written the information defined in Table 1.

Table 1: Delivery Ticket Information

A.	Name of Supplier
B.	Date of Delivery
C.	Delivery Ticket Number

D.	Name of Contractor
E.	Project Name (optional)
F.	Job Mix Formula Identification Number
G.	Weight of Load
H.	Time Loaded

B. Protection: Base course shall be transported in suitable vehicles with a cover. A load shall be covered immediately after loading and remain covered until unloading.

Part 2 – Products

2.1 Materials

A. General: Provide base course material consisting of fine and coarse aggregate, the combination of materials conforming to the requirements of ASTM D2940.

Base course shall have a resistance value (R-value) not less than 76 as determined by ASTM D2844.

B. Coarse Aggregate: Durable crushed particles of either stone, gravel, asphalt concrete pavement, or portland cement concrete.

1. Aggregates retained on the No. 4 (4.75 mm) sieve shall be capable of withstanding the effects of handling, spreading, and compacting without degradation production or deleterious fines.

2. Coarse aggregates shall comply with the requirements shown in Table 2.

C. Fine Aggregate: Aggregates retained on the No. 4 (4.75 mm) sieve shall consist of fines from the operation of crushing course aggregate.

1. Natural sand, or finer mineral matter, or both, may be added where available and suitable.

2. Fine aggregate shall comply with the requirements shown in Table 2.

D. Prime Coat: Prime coat for surface sealing of compacted base course shall comply with the requirements of Section 32 12 16.02, "Asphalt Concrete Material."

Table 2: Engineering Requirements

Characteristic	Fine	Course
Los Angeles Abrasion Wear (ASTM C131)		40% max.
Soundness (5 cycles ASTM C88)	15% max.	15% max.
Crushed Aggregate (% Material Retained on 3/8-inch sieve (9.5 mm) by wt., having at least two (2) fractured faces)		50% max.
Maximum % passing No. 200 (75 μm)	60% of No. 30 (600 μm)	

Plasticity Index (Material finer than No. 40 sieve) (425 µm)	4.0 max.	
Sand Equivalent Value	35 min.	

2.2 Mixes

A. Job mix formula gradation shall comply with the requirements for gradation ranges and tolerances shown in Table 3.

B. Job mix formulas required in this specification are the same as those required by the City of Albuquerque's Public Works Department. Job mix formulas pre-approved by the City of Albuquerque Materials Engineer and shall comply with the latest edition of the City of Albuquerque Standard Specification for Public Works Construction, Section 302, "Aggregate Base Course Construction."

Table 3: Gradation Ranges and Tolerances

Sieve Size/Type	Production Range	Percent Passing	Production Tolerances (+/-%)
1-1/2 inch (38.1 mm)	100	100	
1 inch (25.4 mm)	95 - 100	100	
3/4 inch (19.1 mm)		90 - 100	8
1/2 inch (12.7 mm)	65 - 75		8
3/8 inch (9.5 mm)		65 - 80	8
No. 4 (4.75 mm)	34 - 46	48 - 55	8
No. 30 (600 µm)	12 - 18	18 - 25	5
No. 200 (600 µm)	5 - 12	6 - 15	3

2.3 Source Quality Control

A. Tests: A sample of material delivered to the project shall be taken for each 300 tons (270 metric tons) placed or each day's placement, whichever is greater, and tested for gradation and moisture density relationship.

1. Average value of individual gradation tests, for all sieve size determinations, shall comply with the job mix formula within the tolerances specified in Table 3.

2. Noncompliant material shall be resampled and retested for compliance. Material not in compliance after the initial and follow-up testing shall be removed and replaced by the Contractor at no cost to SNL.

Part 3 – Execution

3.1 Preparation

Immediately upon completion of compaction, Contractor shall seal the surface of the compacted base course with a prime coat according to the requirements of Section 32 12 16.03, "Asphalt Concrete Installation."

A. Prime coat shall be applied as required to provide a uniform coverage of the surface.

B. If final surfacing is to be placed within twenty-four (24) hours after completion of compaction, the prime coat may be waived as authorized by the SDR.

C. Traffic on compacted base course shall be limited to only final surfacing traffic and vehicles applying moisture control, as authorized by the SDR.

3.2 Installation

A. General: Each base course shall be placed in lifts which will provide not less than four (4) inches (102 mm) and not more than 6 inches (152 mm) compacted thickness. Work shall be to the lines, grades, dimensions, moisture, density, and typical sections as specified in contract documents.

B. Spreading: Aggregate bases shall be delivered to the roadbed as uniform mixtures and each layer shall be spread in one operation.

1. Aggregate bases shall be delivered to the roadbed at a uniform quantity without resorting to picking up, or otherwise shifting the aggregate base material.

2. Use of motor graders will be permitted during depositing, spreading, and compacting operations.

3. Segregation of aggregates shall be avoided and the material as spread shall be free from pockets of coarse or fine material.

C. Tolerances: Material shall be moisture conditioned within a range of optimum moisture plus or minus two percent (+/-2%), and compacted to a dry density greater than ninety-five (95) percent of maximum dry density as determined in accordance under the procedures specified in ASTM D1557. Such moisture shall be uniformly distributed throughout the material.

D. Finished Surface: Finished surface of the compacted aggregate base course shall not deviate from finished grade in excess of 1/2 inch (12.7 mm) in 10 feet (3 m) when tested with a 10-foot (3 m) straight edge in any direction. All deviations in excess of the specified shall be corrected by the Contractor prior to authorization for placement of the next lift of material.

3.3 Field Quality Control

A. Field testing of only locally processed or produced material directly incorporated into the Work, including but not limited to the establishment of density curves representative of materials to be used in the compliance test, will be paid by SNL.

In the event the initial testing shows defective work, materials, supplies, or equipment, all subsequent testing shall be at Contractor's sole expense. Contractor shall pay for such subsequent retesting directly to the testing agency.

B. Tests: Compaction tests will be taken at the rate of one test for each 500 square yards (420 m^2) per lift placed, or as directed by the SDR, in accordance with the requirements of ASTM D2922 and D3017. Areas represented by noncompliant tests shall be reworked and retested for compliance by SNL/NM.

Test reports will include but not be limited to the requirements of Table 4.

Table 4: Test Report Information

Field Data
Date of Sampling/Field Test
Project Number
Project Title
Location of sample/field test as defined by the project plans and specifications
Time of Sampling/Field Testing
Field test results with reference specification limits
Laboratory Data
Base Course Classification
Gradation
Plasticity Index
Liquid Limit
Optimum moisture/maximum dry density relationship and graph
Estimated Soil Resistance R-Value

3.4 Cleaning

Contractor shall keep the premises free from accumulations of waste materials, rubbish, and other debris resulting from the Work.

A. Remove all waste materials, rubbish, and debris from and about the premises.

B. Remove all tools, construction equipment and machinery, and surplus materials.

C. Contractor shall restore to their original condition those portions of the site not designated for alteration by the Contract documents.

END OF SECTION 32 11 23.10

Exceptional service in the national interest

Sandia National Laboratories

Section 32 11 23.10 – Aggregate Base Course for Under Pavements

February 2018

Effective Date: 02/19/2018
Review Date: 02/19/2021

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Section 32 11 23.10 – Aggregate Base Courses for Under Pavements

Table of Contents

Table of Figures

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Section 32 11 23.10 – Aggregate Base Course for Under Pavements

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b. As a gravel surface course on unpaved parking lots because, as the surface course, it would be dispersed by vehicle traffic and exposed to stormwater, making it susceptible to leaching or washing away.

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E. Base Course: Placed on prepared surfaces to distribute wheel loads, provide a non-frost susceptible material on which to support surface courses.

1.4 Action Submittals

A. General: Submit the following in accordance with Conditions of Contract and Section 01 33 00, "Submittal Procedures."

B. Product Data: Submit product data for each base course material and prime coat used, including supplier and design mix identification number.

C. Certification of Compliance: Provide certification that mix design complies with the requirements specified in 2.2 "Mixes" of this specification.

D. Test Reports: Provide laboratory test reports to show that materials comply with requirements specified in 2.1 "Materials" of this specification.

1.5 Project Conditions

Environmental Requirement: In the event of temporary suspension of the Work or inclement weather, or as directed by the SDR, all the Work, materials, and equipment incorporated therein shall be protected against damage, injury, or loss from the weather, whether in storage on or off the site.

1.6 Delivery, Storage, and Handling

A. Delivery: Contractor shall provide to the SDR with each load of batched material and/or material delivered to the job site, before unloading at the site, a copy of the delivery ticket on which is printed, stamped, or written the information defined in Table 1.

Table 1: Delivery Ticket Information

A.	Name of Supplier
B.	Date of Delivery
C.	Delivery Ticket Number

D.	Name of Contractor
E.	Project Name (optional)
F.	Job Mix Formula Identification Number
G.	Weight of Load
H.	Time Loaded

B. Protection: Base course shall be transported in suitable vehicles with a cover. A load shall be covered immediately after loading and remain covered until unloading.

Part 2 – Products

2.1 Materials

A. General: Provide base course material consisting of fine and coarse aggregate, the combination of materials conforming to the requirements of ASTM D2940.

Base course shall have a resistance value (R-value) not less than 76 as determined by ASTM D2844.

B. Coarse Aggregate: Durable crushed particles of either stone, gravel, asphalt concrete pavement, or portland cement concrete.

1. Aggregates retained on the No. 4 (4.75 mm) sieve shall be capable of withstanding the effects of handling, spreading, and compacting without degradation production or deleterious fines.

2. Coarse aggregates shall comply with the requirements shown in Table 2.

C. Fine Aggregate: Aggregates retained on the No. 4 (4.75 mm) sieve shall consist of fines from the operation of crushing course aggregate.

1. Natural sand, or finer mineral matter, or both, may be added where available and suitable.

2. Fine aggregate shall comply with the requirements shown in Table 2.

D. Prime Coat: Prime coat for surface sealing of compacted base course shall comply with the requirements of Section 32 12 16.02, “Asphalt Concrete Material.”

Table 2: Engineering Requirements

Characteristic	Fine	Course
Los Angeles Abrasion Wear (ASTM C131)		40% max.
Soundness (5 cycles ASTM C88)	15% max.	15% max.
Crushed Aggregate (% Material Retained on 3/8-inch sieve (9.5 mm) by wt., having at least two (2) fractured faces)		50% max.
Maximum % passing No. 200 (75 μm)	60% of No. 30 (600 μm)	

Plasticity Index (Material finer than No. 40 sieve) (425 µm)	4.0 max.	
Sand Equivalent Value	35 min.	

2.2 Mixes

A. Job mix formula gradation shall comply with the requirements for gradation ranges and tolerances shown in Table 3.

B. Job mix formulas required in this specification are the same as those required by the City of Albuquerque's Public Works Department. Job mix formulas pre-approved by the City of Albuquerque Materials Engineer and shall comply with the latest edition of the City of Albuquerque Standard Specification for Public Works Construction, Section 302, "Aggregate Base Course Construction."

Table 3: Gradation Ranges and Tolerances

Sieve Size/Type	Production Range	Percent Passing	Production Tolerances (+/-%)
1-1/2 inch (38.1 mm)	100	100	
1 inch (25.4 mm)	95 - 100	100	
3/4 inch (19.1 mm)		90 - 100	8
1/2 inch (12.7 mm)	65 - 75		8
3/8 inch (9.5 mm)		65 - 80	8
No. 4 (4.75 mm)	34 - 46	48 - 55	8
No. 30 (600 µm)	12 - 18	18 - 25	5
No. 200 (600 µm)	5 - 12	6 - 15	3

2.3 Source Quality Control

A. Tests: A sample of material delivered to the project shall be taken for each 300 tons (270 metric tons) placed or each day's placement, whichever is greater, and tested for gradation and moisture density relationship.

1. Average value of individual gradation tests, for all sieve size determinations, shall comply with the job mix formula within the tolerances specified in Table 3.

2. Noncompliant material shall be resampled and retested for compliance. Material not in compliance after the initial and follow-up testing shall be removed and replaced by the Contractor at no cost to SNL.

Part 3 – Execution

3.1 Preparation

Immediately upon completion of compaction, Contractor shall seal the surface of the compacted base course with a prime coat according to the requirements of Section 32 12 16.03, "Asphalt Concrete Installation."

A. Prime coat shall be applied as required to provide a uniform coverage of the surface.

B. If final surfacing is to be placed within twenty-four (24) hours after completion of compaction, the prime coat may be waived as authorized by the SDR.

C. Traffic on compacted base course shall be limited to only final surfacing traffic and vehicles applying moisture control, as authorized by the SDR.

3.2 Installation

A. General: Each base course shall be placed in lifts which will provide not less than four (4) inches (102 mm) and not more than 6 inches (152 mm) compacted thickness. Work shall be to the lines, grades, dimensions, moisture, density, and typical sections as specified in contract documents.

B. Spreading: Aggregate bases shall be delivered to the roadbed as uniform mixtures and each layer shall be spread in one operation.

1. Aggregate bases shall be delivered to the roadbed at a uniform quantity without resorting to picking up, or otherwise shifting the aggregate base material.

2. Use of motor graders will be permitted during depositing, spreading, and compacting operations.

3. Segregation of aggregates shall be avoided and the material as spread shall be free from pockets of coarse or fine material.

C. Tolerances: Material shall be moisture conditioned within a range of optimum moisture plus or minus two percent (+/-2%), and compacted to a dry density greater than ninety-five (95) percent of maximum dry density as determined in accordance under the procedures specified in ASTM D1557. Such moisture shall be uniformly distributed throughout the material.

D. Finished Surface: Finished surface of the compacted aggregate base course shall not deviate from finished grade in excess of 1/2 inch (12.7 mm) in 10 feet (3 m) when tested with a 10-foot (3 m) straight edge in any direction. All deviations in excess of the specified shall be corrected by the Contractor prior to authorization for placement of the next lift of material.

3.3 Field Quality Control

A. Field testing of only locally processed or produced material directly incorporated into the Work, including but not limited to the establishment of density curves representative of materials to be used in the compliance test, will be paid by SNL.

In the event the initial testing shows defective work, materials, supplies, or equipment, all subsequent testing shall be at Contractor's sole expense. Contractor shall pay for such subsequent retesting directly to the testing agency.

B. Tests: Compaction tests will be taken at the rate of one test for each 500 square yards (420 m^2) per lift placed, or as directed by the SDR, in accordance with the requirements of ASTM D2922 and D3017. Areas represented by noncompliant tests shall be reworked and retested for compliance by SNL/NM.

Test reports will include but not be limited to the requirements of Table 4.

Table 4: Test Report Information

Field Data
Date of Sampling/Field Test
Project Number
Project Title
Location of sample/field test as defined by the project plans and specifications
Time of Sampling/Field Testing
Field test results with reference specification limits
Laboratory Data
Base Course Classification
Gradation
Plasticity Index
Liquid Limit
Optimum moisture/maximum dry density relationship and graph
Estimated Soil Resistance R-Value

3.4 Cleaning

Contractor shall keep the premises free from accumulations of waste materials, rubbish, and other debris resulting from the Work.

A. Remove all waste materials, rubbish, and debris from and about the premises.

B. Remove all tools, construction equipment and machinery, and surplus materials.

C. Contractor shall restore to their original condition those portions of the site not designated for alteration by the Contract documents.

END OF SECTION 32 11 23.10

Exceptional service in the national interest

Sandia National Laboratories

Section 32 12 16.01 – Paving Asphalt Binder

February 2018

Effective Date: 02/19/2018
Review Date: 02/19/2021

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Sandia National Laboratories

Section 32 12 16.01 – Paving Asphalt Binder

Table of Contents

Page

Tables

Change Log

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2/19/18	Jennifer Sawayda	None	3-year review performed. No changes made.

Section 32 12 16.01 – Paving Asphalt Binder

Part 1 – General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General Conditions.

B. Related Sections: Refer to the following sections for related work.

1. Section 32 12 16.02, “Asphalt Concrete Material”
2. Section 32 12 16.03, “Asphalt Concrete Installation”

C. References:

1. American Society of Testing and Materials (ASTM):

D 5............Standard Test Method for Penetration of Bituminous Materials
D 8............Standard Definitions of Terms Relating to Materials for Roads and Pavements
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2. American Association of State Highway and Transportation Officials, AASHTO:

MP1..........Standard Specification for Performance Graded Asphalt Binder
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PP5...........Laboratory Evaluation of Modified Asphalt Systems
PP6...........Grading or Verifying the Performance Grade of an Asphalt Binder
PP-28........Superpave™ Volumetric Design for HMA

1.2 Summary

A. Section Includes: Paving asphalt binder for asphalt concrete (AC), bituminous treated base course construction (BTB), and plant mixed seal coat (PMSC), shall conform to the requirements of this specification.

1.3 Definitions

A. SNL/NM: Sandia National Laboratories New Mexico Site

B. SDR: Sandia Delegated Representative

1.4 Action Submittals

A. The CONTRACTOR shall submit qualifications in writing, and at least three references to whom the CONTRACTOR has supplied the same or similar binder, as directed by the SDR.

B. Submit certified test results in writing that a binder complies with this specification. That submittal is to occur as part of the job mix formula submittal under specification section 32 12 16.02, "Asphalt Concrete Material." This submittal must be made under the following conditions:

1. In association with the awarding of a SNL/NM service contract for paving services. Once the service contract is awarded and the associated job mix formula is accepted for use, no additional submittals are required for the duration of the service contract if the work is done by the contracted entity, there are no changes in the job mix formula, and the proper job mix formula is used in the appropriate circumstances.

2. For each project if not procured through the paving service contract process.

The certification shall include at a minimum:

1. Name of supplier

2. Source(s) of base asphalt cement(s)

3. Type and source(s) of admixture(s)

4. Proportions of materials

5. Laboratory test results of the binder

6. Certification statement that the binder complies with the requirements of this specification

1.5 Quality Assurance

A. The CONTRACTOR shall be solely responsible for the binder supplied under this specification, its proportions and manufacture.

B. The binder shall be supplied from a single source/supplier and be of a single formulation for the duration of either the authorized period of a job mix formula including the binder, or the project, as directed by the SDR.

Part 2 – Product

2.1 Asphalt Binder

A. An asphalt binder shall be either an asphalt cement, a blend of asphalt cement(s), or a blend of asphalt cement(s) and admixture(s), to be determined by the CONTRACTOR, complying with the requirements specified in either TABLE 321216.01-112.A 60-70 PENETRATION GRADE BINDER SPECIFICATION, or TABLE 321216.01-112.B AC-20 VISCOSITY GRADE BINDER SPECIFICATION, or TABLE 321216.01-112.C PERFORMANCE GRADE (PG) BINDER SPECIFICATIONS.

Part 3 – Execution

3.1 Sampling and Testing

A. Quality assurance sampling and testing of asphalt binders shall be performed by the CONTRACTOR, at no cost to SNL/NM, to verify compliance with the specification if required by the SDR. If required by the SDR, a sample shall be taken at random during paving operations from a load(s) of binder material shipped to the CONTRACTOR'S asphalt concrete supplier. If required by the SDR, the frequency of the sampling is at the discretion of the SDR. The sample shall be tested by the CONTRACTOR to verify compliance with the specification requirements specified in either TABLE 321216.01-112.A 60-70 PENETRATION GRADE BINDER SPECIFICATION, or TABLE 321216.01-112.B AC-20 VISCOSITY GRADE BINDER SPECIFICATION, or TABLE 321206.01-112.C PERFORMANCE GRADE (PG) BINDER SPECIFICATIONS. Test results shall be reported in writing to the SDR by the CONTRACTOR. Non-complying sample test results shall be reported in to the SDR within 24 hours of completion of the test(s). Complying sample test results shall be reported in writing to the SDR, no later than ten working days after the date of sampling.

B. A test report from binder sampling in item “A” above shall include, but not be limited to, (1) report date, (2) date of sampling, (3) bill of lading number of load sampled, (4) destination of load, (5) report of test results, (6) standard test identifications, (7) specification requirements, (8) statement of compliance, and certification signature. Failure to comply with quality assurance testing when required by the SDR may result in rejection of either the binder, and/or the job mix formula, and/or the associated job mix placed on a project, as directed by the SDR.

C. If non-complying material is identified, paving operations may be suspended, as directed by the SDR, during which time the CONTRACTOR and the SDR will meet to determine the impact of the non-compliance, and specify the necessary remedial action to be taken by the CONTRACTOR. Remedial action shall be either acceptance, acceptance at a pay adjustment, or removal and replacement at no cost to SNL/NM. Paving operations may continue upon written authorization by the SDR. The suspension of asphalt concrete operations due to the identification of non-complying binder shall be at no cost to the SNL/NM.

D. Production binder identified to be in non-compliance shall not be shipped to a project.

E. GRADE CORRELATION: TABLE 321216.01-112.D defines binder correlation(s). A binder grade to the right of a respective binder grade in the same row may be substituted except as noted in item “H” below.

F. A job mix formula using either penetration or viscosity grade binders shall be designed using the Marshall procedure and specifications.

G. A job mix formula using a performance grade, PG, binder shall be designed using the gyratory (SUPERPAVE) procedure and specification.

H. Binder substitution in an authorized job mix formula is not allowed.

3.2 Temperature

A. The CONTRACTOR shall specify the temperature ranges for mixing and compaction of a job mix formula for a binder, minimum and maximum, °F. Temperature ranges for mixing and compaction shall be specified in a job mix formula submittal.

B. The CONTRACTOR shall specify the “release to traffic” temperature, °F. Release to traffic temperature shall be the maximum temperature at which the viscosity of a binder is greater than 200,000 cps as determined by ASTM D4402. Release to traffic temperature shall be specified in a job mix formula submittal.

3.3 Measurement

A. Asphalt binder is an ingredient of asphalt concrete (AC), bituminous treated base course construction (BTB), and plant mixed seal coat (PMSC). The quantity of Binder required is determined by job the mix formula and is considered as incidental to the above materials, unless specified otherwise in the CONTRACT.

TABLE 321216.01-112.A – 60-70 PENETRATION GRADE BINDER SPECIFICATION (ASTM D 946) [1]

		CHARACTERISTIC	min	max	ASTM Procedure
I.		Original Binder			
	1	Penetration @ 25 °*C*, 100 g, 5 s, mm	60	70	D 5
	2	Flash Point (Cleveland open cup), °*C*	230		D 92
	3	Ductility @ 25 °*C*, 5 cm/min, cm	100		D 113
	4	Solubility in trichloroethylene, %	99.0		D 2042
II.		Asphalt after Thin Film Oven Test, TFOT			
	1	Retained penetration @ 25 °*C*, 100 g, 5 s, mm	52		D 5
	2	Ductility @ 25 °*C*, 5 cm/min, cm	50		D 113

[1] PG64-22 binders shall be used if 60-70 Penetration Grade and AC-20 Viscosity Grade binders are unavailable.

TABLE 321216.01-112.B - AC-20 VISCOSITY GRADE BINDER (ASTM D 3381, TABLE 2) [1]

		CHARACTERISTIC	min	max	Procedure
I.		Original Binder			
	1	Viscosity @ 60 °C, poises	1600	2400	ASTM D2171
	2	Viscosity @ 135 °C, cSt	300	-	ASTM D2170
	3	Penetration @ 25 °C, 100 g, 5 s	60	-	ASTM D5
	4	Flash Point, , °C (Cleveland open cup)	230	-	ASTM D92
	5	Solubility in trichloroethylene, %	99.0	-	ASTM D2042
II.		Tests on Residue from Thin-Film Oven Test			ASTM D1754
	1	Viscosity after TFOT @ 60 °C, poises	-	10,000	ASTM D2171
	2	Ductility after TFOT @ 25 °C, 5 cm/min, cm	50	-	ASTM D113

[1] PG64-22 binders shall be used if 60 – 70 Penetration Grade and AC-20 Viscosity Grade binders are unavailable.

TABLE 321216.01-112.C - PERFORMANCE GRADE (PG) BINDER SPECIFICATIONS

			Performance Grade Binder Characteristic	PG70-22	PG76-28	Standard Procedure
A.			Original Binder			
	1		Dynamic Shear, 1.0 kPa, min, G*/sin *d* @ rad/sec	70	76	AASHTO TP 5
	2		Flash Point, min	230	230	ASTM D48
	3		Viscosity, 3 Pa. s (3000 cP) max, @ temp	135	135	ASTM D4402 [1]
B.			Rolling Thin Film Oven Test Residue, RTFOT (T 240), 1 minute			
	1		Mass loss, 1% max	yes	yes	
	2		Dynamic Shear, 2.20 kPa, min, G*/sin *d* @ rad/sec	70	76	AASHTO TP 5
C.			Pressure Aging Vessel Residue, PAV (PP1), after RTFOT			
	1		PAV Temperature	110	110	
	2		Dynamic Shear: G*/sin *d*, max, 5,000 kPa, @10 rad/sec	28	28	AASHTO TP 5
	3		Physical Hardening (report) [2]			
		a.	Creep Stiffness: S, 300 Mpa, max, m-value, 0.300 minimum, @ 60 s	-12	-18	AASHTO TP 1 [3]
		b.	Direct Tension: Failure strain, 1.0% min @ 1.0 mm/min	-12	-18	AASHTO TP 3 [4]

Notes:

[1] This requirement may be waved if the binder supplier warrants that the supplied binder can be adequately pumped and mixed at temperatures that meet all safety standards.

[2] Physical Hardening – TP 1 is performed on a set of asphalt beams according to Section 13.1 of TP 1, except the conditioning is extended to 24 hrs ± 10 minutes at 10 °C above the minimum performance temperature. The 24 hour stiffness, S, and the m-value are reported for information purposes only.

[3] The physical hardening index “h” accounts for the physical hardening of the binder. It shall be determined and reported in the submittal for the proposed binder and each sample tested for compliance with TABLE 02512-112.PG76-28.A. “h” is calculated as follows:

$$h = (S_{24}/ S_{1})^{m1 / m24}$$

“1” and “24” indicate 1 and 24 hours of conditioning of the tank asphalt. Conditioning and testing is conducted at the designated test temperature. Values should be calculated and reported. “S” is the creep stiffness after 60 sec loading time and “m” is the slope of the log creep stiffness versus the log time curve after 60 sec loading time.

[4] If the creep stiffness “S”<300 MPa, the direct tension test is not required. If 300<S<600 MPa, the direct tension failure strain requirement can be used in lieu of the creep stiffness requirement. The m-value requirement must be satisfied in both cases.

TABLE 321216.01-112.D – ASPHALT BINDER CORRELATION(S)

Pen. Grade [1]	Visc. Grade [1]	Performance Grade [2]	
60-70	-	PG70-22	-
-	AC-20	PG70-22	-
-	-	PG70-22	PG76-28
-	-	-	PG76-28

[1] Marshall analysis/design
[2] Gyratory analysis/design

END OF SECTION 32 12 16.01

Exceptional service in the national interest

Sandia National Laboratories

Section 32 12 16.01 – Paving Asphalt Binder

February 2018

Effective Date: 02/19/2018
Review Date: 02/19/2021

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Sandia National Laboratories

Section 32 12 16.01 – Paving Asphalt Binder

Table of Contents

Page

Tables

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Part 1 – General

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The certification shall include at a minimum:

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6. Certification statement that the binder complies with the requirements of this specification

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B. The binder shall be supplied from a single source/supplier and be of a single formulation for the duration of either the authorized period of a job mix formula including the binder, or the project, as directed by the SDR.

Part 2 – Product

2.1 Asphalt Binder

A. An asphalt binder shall be either an asphalt cement, a blend of asphalt cement(s), or a blend of asphalt cement(s) and admixture(s), to be determined by the CONTRACTOR, complying with the requirements specified in either TABLE 321216.01-112.A 60-70 PENETRATION GRADE BINDER SPECIFICATION, or TABLE 321216.01-112.B AC-20 VISCOSITY GRADE BINDER SPECIFICATION, or TABLE 321216.01-112.C PERFORMANCE GRADE (PG) BINDER SPECIFICATIONS.

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3.1 Sampling and Testing

A. Quality assurance sampling and testing of asphalt binders shall be performed by the CONTRACTOR, at no cost to SNL/NM, to verify compliance with the specification if required by the SDR. If required by the SDR, a sample shall be taken at random during paving operations from a load(s) of binder material shipped to the CONTRACTOR'S asphalt concrete supplier. If required by the SDR, the frequency of the sampling is at the discretion of the SDR. The sample shall be tested by the CONTRACTOR to verify compliance with the specification requirements specified in either TABLE 321216.01-112.A 60-70 PENETRATION GRADE BINDER SPECIFICATION, or TABLE 321216.01-112.B AC-20 VISCOSITY GRADE BINDER SPECIFICATION, or TABLE 321206.01-112.C PERFORMANCE GRADE (PG) BINDER SPECIFICATIONS. Test results shall be reported in writing to the SDR by the CONTRACTOR. Non-complying sample test results shall be reported in to the SDR within 24 hours of completion of the test(s). Complying sample test results shall be reported in writing to the SDR, no later than ten working days after the date of sampling.

B. A test report from binder sampling in item “A” above shall include, but not be limited to, (1) report date, (2) date of sampling, (3) bill of lading number of load sampled, (4) destination of load, (5) report of test results, (6) standard test identifications, (7) specification requirements, (8) statement of compliance, and certification signature. Failure to comply with quality assurance testing when required by the SDR may result in rejection of either the binder, and/or the job mix formula, and/or the associated job mix placed on a project, as directed by the SDR.

C. If non-complying material is identified, paving operations may be suspended, as directed by the SDR, during which time the CONTRACTOR and the SDR will meet to determine the impact of the non-compliance, and specify the necessary remedial action to be taken by the CONTRACTOR. Remedial action shall be either acceptance, acceptance at a pay adjustment, or removal and replacement at no cost to SNL/NM. Paving operations may continue upon written authorization by the SDR. The suspension of asphalt concrete operations due to the identification of non-complying binder shall be at no cost to the SNL/NM.

D. Production binder identified to be in non-compliance shall not be shipped to a project.

E. GRADE CORRELATION: TABLE 321216.01-112.D defines binder correlation(s). A binder grade to the right of a respective binder grade in the same row may be substituted except as noted in item “H” below.

F. A job mix formula using either penetration or viscosity grade binders shall be designed using the Marshall procedure and specifications.

G. A job mix formula using a performance grade, PG, binder shall be designed using the gyratory (SUPERPAVE) procedure and specification.

H. Binder substitution in an authorized job mix formula is not allowed.

3.2 Temperature

A. The CONTRACTOR shall specify the temperature ranges for mixing and compaction of a job mix formula for a binder, minimum and maximum, °F. Temperature ranges for mixing and compaction shall be specified in a job mix formula submittal.

B. The CONTRACTOR shall specify the “release to traffic” temperature, °F. Release to traffic temperature shall be the maximum temperature at which the viscosity of a binder is greater than 200,000 cps as determined by ASTM D4402. Release to traffic temperature shall be specified in a job mix formula submittal.

3.3 Measurement

A. Asphalt binder is an ingredient of asphalt concrete (AC), bituminous treated base course construction (BTB), and plant mixed seal coat (PMSC). The quantity of Binder required is determined by job the mix formula and is considered as incidental to the above materials, unless specified otherwise in the CONTRACT.

TABLE 321216.01-112.A – 60-70 PENETRATION GRADE BINDER SPECIFICATION (ASTM D 946) [1]

		CHARACTERISTIC	min	max	ASTM Procedure
I.		Original Binder			
	1	Penetration @ 25 °*C*, 100 g, 5 s, mm	60	70	D 5
	2	Flash Point (Cleveland open cup), °*C*	230		D 92
	3	Ductility @ 25 °*C*, 5 cm/min, cm	100		D 113
	4	Solubility in trichloroethylene, %	99.0		D 2042
II.		Asphalt after Thin Film Oven Test, TFOT			
	1	Retained penetration @ 25 °*C*, 100 g, 5 s, mm	52		D 5
	2	Ductility @ 25 °*C*, 5 cm/min, cm	50		D 113

[1] PG64-22 binders shall be used if 60-70 Penetration Grade and AC-20 Viscosity Grade binders are unavailable.

TABLE 321216.01-112.B - AC-20 VISCOSITY GRADE BINDER (ASTM D 3381, TABLE 2) [1]

		CHARACTERISTIC	min	max	Procedure
I.		Original Binder			
	1	Viscosity @ 60 °C, poises	1600	2400	ASTM D2171
	2	Viscosity @ 135 °C, cSt	300	-	ASTM D2170
	3	Penetration @ 25 °C, 100 g, 5 s	60	-	ASTM D5
	4	Flash Point, , °C (Cleveland open cup)	230	-	ASTM D92
	5	Solubility in trichloroethylene, %	99.0	-	ASTM D2042
II.		Tests on Residue from Thin-Film Oven Test			ASTM D1754
	1	Viscosity after TFOT @ 60 °C, poises	-	10,000	ASTM D2171
	2	Ductility after TFOT @ 25 °C, 5 cm/min, cm	50	-	ASTM D113

[1] PG64-22 binders shall be used if 60 – 70 Penetration Grade and AC-20 Viscosity Grade binders are unavailable.

TABLE 321216.01-112.C - PERFORMANCE GRADE (PG) BINDER SPECIFICATIONS

			Performance Grade Binder Characteristic	PG70-22	PG76-28	Standard Procedure
A.			Original Binder			
	1		Dynamic Shear, 1.0 kPa, min, G*/sin *d* @ rad/sec	70	76	AASHTO TP 5
	2		Flash Point, min	230	230	ASTM D48
	3		Viscosity, 3 Pa. s (3000 cP) max, @ temp	135	135	ASTM D4402 [1]
B.			Rolling Thin Film Oven Test Residue, RTFOT (T 240), 1 minute			
	1		Mass loss, 1% max	yes	yes	
	2		Dynamic Shear, 2.20 kPa, min, G*/sin *d* @ rad/sec	70	76	AASHTO TP 5
C.			Pressure Aging Vessel Residue, PAV (PP1), after RTFOT			
	1		PAV Temperature	110	110	
	2		Dynamic Shear: G*/sin *d*, max, 5,000 kPa, @10 rad/sec	28	28	AASHTO TP 5
	3		Physical Hardening (report) [2]			
		a.	Creep Stiffness: S, 300 Mpa, max, m-value, 0.300 minimum, @ 60 s	-12	-18	AASHTO TP 1 [3]
		b.	Direct Tension: Failure strain, 1.0% min @ 1.0 mm/min	-12	-18	AASHTO TP 3 [4]

Notes:

[1] This requirement may be waved if the binder supplier warrants that the supplied binder can be adequately pumped and mixed at temperatures that meet all safety standards.

[2] Physical Hardening – TP 1 is performed on a set of asphalt beams according to Section 13.1 of TP 1, except the conditioning is extended to 24 hrs ± 10 minutes at 10 °C above the minimum performance temperature. The 24 hour stiffness, S, and the m-value are reported for information purposes only.

[3] The physical hardening index "h" accounts for the physical hardening of the binder. It shall be determined and reported in the submittal for the proposed binder and each sample tested for compliance with TABLE 02512-112.PG76-28.A. "h" is calculated as follows:

$$h = (S_{24} / S_{1})^{m1 / m24}$$

"1" and "24" indicate 1 and 24 hours of conditioning of the tank asphalt. Conditioning and testing is conducted at the designated test temperature. Values should be calculated and reported. "S" is the creep stiffness after 60 sec loading time and "m" is the slope of the log creep stiffness versus the log time curve after 60 sec loading time.

[4] If the creep stiffness "S"<300 MPa, the direct tension test is not required. If 300<S<600 MPa, the direct tension failure strain requirement can be used in lieu of the creep stiffness requirement. The m-value requirement must be satisfied in both cases.

TABLE 321216.01-112.D – ASPHALT BINDER CORRELATION(S)

Pen. Grade [1]	Visc. Grade [1]	Performance Grade [2]	
60-70	-	PG70-22	-
-	AC-20	PG70-22	-
-	-	PG70-22	PG76-28
-	-	-	PG76-28

[1] Marshall analysis/design
[2] Gyratory analysis/design

END OF SECTION 32 12 16.01

Exceptional service in the national interest

Sandia National Laboratories

Section 32 12 16.02 – Asphalt Concrete Material

February 2018

Effective Date: 02/19/2018
Review Date: 02/19/2021

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 32 12 16.02 – Asphalt Concrete Material

Table of Contents

Tables

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Freeman Leaming	Subst	Updated format to 2004 CSI. Differentiated better between this spec and the asphalt concrete installation spec including moving placement and compaction completely to other spec.
2/19/18	Tim Peterson	No changes	3-year review performed. No changes made.

Section 32 12 16.02 – Asphalt Concrete Material

Part 1 – General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections: Refer to the following sections for related work.

1. Section 32 12 16.03, "Asphalt Concrete Installation" for installation of the materials specified herein.

2. Section 32 12 16.01, "Paving Asphalt Binder" for asphalt binder used herein.

C. References:

1. American Society of Testing and Materials (ASTM):

C88 ....Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
C117 ....Method for Material Finer than 0.75µm (No. 200) Sieve in Mineral Aggregates by Washing
C131 ....Test Method for Resistance to Degradation of Small-size Coarse Aggregate by Abrasion and Impact in a Los Angeles Machine
C136 ....Method for Sieve Analysis of Fine and Coarse Aggregate
D242 ....Specifications for Mineral Filler for Bituminous Paving Mixtures
D692 ....Specification for Coarse Aggregate for Bituminous Paving Mixtures
D979 ....Methods of Sampling Bituminous Paving Mixtures
D995.............. Specification for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
D1073............ Specification for Fine Aggregate for Bituminous Paving Mixtures
D1074 ....Test Method for Compressive Strength of Bituminous Mixtures
D1559 ....Resistance to Plastic Flow of Bituminous Mixtures using Marshall Apparatus
D2041 ....Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures
D2493 ....Viscosity-Temperature Chart for Asphalts
D2726 ....Bulk Specific Gravity and Density of Compacted Bituminous Mixtures using Saturated Surface-Dry Specimens
D2851 ....Test for Determining the Percentage of Fractured Particles in Coarse Aggregate
D2950 ....Density of Bituminous Concrete in Place by Nuclear Methods
D3203 ....Percent Air Voids in Compacted Dense and Open Bituminous

Paving Mixtures
D3515 ....Standard Specification for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
D4791 ....Test for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

2. American Association of State Highway and Transportation Officials, AASHTO:

MP2 ....Specification for Superpave™ Volumetric Mix Design
PP-28 ....Superpave™ Volumetric Design for HMA
TP 4 ....Preparation of Compacted Specimens of Modified and Unmodified Hot Mix Asphalt by Means of SHRP Gyratory Compactor
PP 2 ....Short and Long-term Aging of Bituminous Mixes
T53 ....Quantitative Analysis of Bitumen from Bituminous Paving Mixtures, Ignition Oven Method A
T245 ....Resistance to Plastic Flow of Bituminous Mixture using Marshall Apparatus
T283 ....Resistance of Bituminous Mixture to Moisture Induced Damage
T304 ....Uncompacted Void Content of Fine Aggregate

3. Asphalt Institute:

MS-2 Mix Design Methods, Sixth Edition
MS-2 Mix Design Methods, Sixth Edition, Section 5.16, Modified Marshall Method for Large Aggregate

4. City of Albuquerque "Standard Specifications for Public Works Construction", latest edition.

Section 113 EMULSIFIED ASPHALTS
Section 117 ASPHALT REJUVENATING AGENTS
Section 118 HYDRATED LIME FILLER
Section 333 FOG SEAL COATS

1.2 Summary

A. Section Includes: The mix design, testing, furnishing, and delivery of asphalt concrete ready for placement. It does not include placement, compaction, or field testing relating to placement adequacy (installation). That is covered in Section 32 12 16.03, "Asphalt Concrete Installation".

B. Asphalt concrete shall consist of a mixture of asphalt binder, aggregates, mineral filler and admixtures, proportioned as required, batched and delivered as specified herein. All materials and job mix formulas used in asphalt concrete, either batched at or delivered to a project, shall be certified in accordance with the requirements of these specifications. The CONTRACTOR shall be solely responsible for asphalt concrete job mix formula supplied under this specification, its proportions and manufacture. Each job mix formula submitted and authorized for use under this specification shall be identified by a number unique to that job mix formula. If either a change in material(s) or material supplier(s) from that specified in the job mix formula occurs during a project, authorized use of the job mix formula on the project may be cancelled as directed by the SDR. A job mix formula shall not be used on a project without written approval of the SDR.

1.3 Definitions

A. SNL/NM: Sandia National Laboratories New Mexico Site

B. SDR: Sandia Delegated Representative

C. JMF: Job Mix Formula

1.4 Action Submittals

A. Job Mix Formula: A design job mix formula submitted shall be included but not be limited to the information specified in TABLE 321216.02-116.D-SUBMITTAL INFORMATION, as directed by the SDR.

B. A submittal shall be rejected if it does not include the specified information and samples. A job mix formula submittal shall be accepted or rejected within ten (10) working days of receipt by the SDR.

TABLE 321216.02-116.D – SUBMITTAL INFORMATION		
I.	Identification	
	A.	Asphalt concrete supplier
	B.	Laboratory that performed design/development tests
	C.	Date of Submittal
	D.	Unique mix code identification number
	E.	Aggregate sample date
II.	Job Mix Formula (jmf)	
	A.	Type/application of asphalt concrete
	B.	Component material target proportions to include combined aggregate gradation and asphalt content, specifications, and production tolerances
	C.	0.45 power gradation plot of combined aggregate gradation with specification and production limits
	D.	Temperature viscosity relationship of binder
	E.	Recommended mixing, compaction, and release to traffic maximum temperatures
	F.	Tabulation of job mix formula performance characteristics defined in either TABLE 321216.02-116.C.1 or TABLE 321216.02-116.C.2 as applicable, at the proposed design proportions, with reference specification limits and production limits (if specified), maximum theoretical specific gravity/density (as pcf), and bulk specific gravity/density (pcf).
	G.	Reference daily production gradation, see TABLE 321216.02-116.B
III.	Certifications of Compliance	
	A.	Compliance of job mix formula by NM Registered Professional Engineer in direct charge of design/development;
	B.	Design Laboratory Certification, projects bid after June 30, 2000.
		TABLE 321216.02-116.D – SUBMITTAL INFORMATION (Cont.)
	C.	Component materials testing and certification by supplier/manufacturer with supporting test data for materials used in design development

	D.	Certification and laboratory test results of asphalt binder used in job mix formula design development, see Section 321216.01 PAVING ASPHALT BINDER		
IV.	Design Development (tables and graphs, with specifications limits of the following):			
	A.	Marshall Design & Modified Marshall Designs (design development with a minimum of 4 asphalt binder contents required, and the recommended design characteristic bracketed by a minimum of two test points for the design binder content ± 0.5%)		
		1.	Design hammer blow counts, mold diameter, hammer mass and drop	
		2.	Stability (lbs.) vs. % asphalt content	
		3.	Flow (0.01 in.) vs. % asphalt content	
		4.	Briquette bulk Specific Gravity and Bulk Density (as pcf) vs. % asphalt content	
		5.	% Voids in Mineral Aggregate (% VMA) vs. % Asphalt content	
		6.	% Voids (Pa) in asphalt concrete vs. % asphalt content	
		7.	% Voids filled in asphalt concrete vs. % asphalt content	
		8.	Dust ratio vs. % asphalt content	
	B.	SUPERPAVE Design (Tables and graphs, with specifications limits of the following)		
		1.	Trial Designs: Aggregate gradations, 3 minimum required, and trial asphalt binder content (%)	
			a)	Table of Aggregate Gradations and 0.45 power plot, with specification limits
			b)	Trial design % asphalt content
			c)	Trial designs volumetric analysis for each gradation, VMA, Va, VFA, graph not required
			d)	Trial designs compaction analysis @ N_i, N_d, and N_m, for each gradation
			e)	Dust ratio for each trial design, graph not required
		2.	Job Mix Formula Design, (design development with a minimum of 4 asphalt binder contents required, and the recommended design characteristic bracketed by a minimum of two test points for the design binder content ± 0.5%)	
			a)	Table of design aggregate gradation and 0.45 power plat, with specification limits and production targets
			b)	Compaction analysis G_{mb} as % $G_{m,}$ at N_i, N_d, and N_m, for each gradation vs. asphalt content (separate graphs for N_i, N_d, and N_m)
			c)	Volumetric analysis of VMA, Va, VFA, and dust ratio at design gyration, @ N_d, vs. % asphalt content
			d)	Gyratory compaction tables as height of sample versus gyration, for each asphalt content, Gmb @ NM, and bulk specific gravity/density correction factor(s) (graphs not required)
			e)	Maximum theoretical specific gravity/density (as pcf), $G_{mm,}$ vs % asphalt content @ N_d
			f)	Corrected bulk specific gravity/density (as pcf), $G_{mb,}$ vs. % asphalt content
			g)	Dust ratio vs. % asphalt content
			h)	Recommended gyratory sample mass(g) for 115 mm sample height at Nm
	C.	Ignition Correction Factor: Correction for material losses during asphalt content ignition oven analysis		
			The correction factor shall be determined as the average value for three samples, design % asphalt content, design – 1.0%, and design + 1.0%, developed in an ignition oven complying with the requirements of AASHTO T53, Method A	

Part 2 – Products

2.1 Materials

A. Asphalt binder shall comply with the requirements of 32 12 16.01, “PAVING ASPHALT BINDER”.

B. Aggregates shall be crushed stone, crushed gravel, crushed asphalt concrete pavement, crushed Portland cement concrete, and natural or manufactured sand conforming to the quality and crushed particle requirements of this Specification. Coarse aggregates shall comply with the requirements of ASTM D692, Coarse Aggregate for Bituminous Paving Mixtures. Fine aggregates shall comply with the requirements of ASTM D1073, Fine Aggregate for Bituminous Paving Mixtures. The combined aggregates, proportioned as defined by the target gradation, shall comply with the requirements of TABLE 321216.02-116.A. Aggregates shall be certified to comply with the requirements of this Specification and authorized for use by the SDR before the materials may be incorporated in the construction. Prior to delivery of the aggregates or material containing the aggregates, the CONTRACTOR may be required to furnish samples of the aggregates to the SDR for testing. Daily production aggregates gradations shall be submitted to the SDR upon request.

C. Mineral filler shall comply with the requirements of ASTM D242, Mineral Filler for Bituminous Paving Mixtures and as specified herein. Mineral filler shall be certified to comply with the requirements of this Specification and approved for use by SDR before the materials may be incorporated in the construction. Prior to either delivery of the mineral filler or material containing the mineral filler, The CONTRACTOR may be required to furnish samples of the mineral filler to The SDR for testing.

D. Asphalt concrete shall comply with the minimum requirements of TABLE 321216.02.C.1.H, moisture susceptibility, percent retained strength at 7 % air voids, AASHTO T283 with freeze cycle. Admixtures to reduce moisture susceptibility in an asphalt concrete mix shall be either hydrated lime, Portland cement, liquid admixture, or a modified asphalt binder authorized by the SDR.

E. The materials specified in an authorized job mix formula shall be the same source and type for all asphalt concrete batched, delivered, placed and compacted, under the identification code defined for the authorized job mix formula.

2.2 Proportioning

A. The CONTRACTOR shall be solely responsible for the asphalt concrete JMF proportions and asphalt concrete either batched at and/or delivered to the site. Asphalt concrete shall be proportioned in accordance with the requirements of this Specification.

B. Asphalt concrete material proportioned with “performance grade binders” shall be proportioned to comply with the requirements of TABLE 321216.02-116.C.1 of this specification, AASHTO MP2, Specification for Superpave™ Volumetric Mix Design, and PP-28, Superpave™ Volumetric Design for HMA. The job mix formulas shall be designed under the direct supervision of a New Mexico Registered Professional Engineer who has completed a certified "SUPERPAVE Mixture Design & Analysis" Short Course.

C. Asphalt concrete for construction of classifications of Primary Streets, Secondary Streets, and Parking Lots shall be proportioned with performance grade (PG) binders.

D. Asphalt concrete for construction of street classification of Secondary Street with design equivalent single axle loads (Esals) less than 3.0 mil, may be proportioned with a PG70-22 performance grade (PG) binders.

E. Asphalt concrete proportioned with either penetration or viscosity grade binders shall be proportioned to comply with the requirements TABLE 321216.02-116.C.2. A JMF shall be prepared in a laboratory under the direct supervision of a New Mexico Registered Professional Engineer.

F. Asphalt concrete design and analysis shall be performed in a laboratory accredited in accordance with the requirements of the New Mexico State Highway and Transportation Department "Procedure for Approval of Testing Laboratories to Perform Inspection, Testing, and Mix Design Services", April 13, 1998 Edition.

G. An asphalt concrete job mix formula shall be proportioned to comply with the requirements of TABLE 321216.02-116.B AGGREGATE GRADATION PROPERTIES and either TABLE 321216.02-116.C.1 ASPHALT CONCRETE DESIGN SPECIFICATIONS PERFORMANCE GRADE BINDERS, or TABLE 321216.02-116.C.2 ASPHALT CONCRETE DESIGN SPECIFICATIONS PENETRATION AND VISCOSITY GRADED BINDERS.

H. Aggregates, mineral filler, and anti-strip admixture if required, shall be proportioned to provide a combined gradation that complies with the requirements specified in TABLE 321216.02-116.B, and have the same or similar shaped characteristic gradation curve as the specification limits specified therein when graphically plotted on a standard "0.45 POWER" gradation chart. The gradation shall be reported to the nearest whole percent for material passing sieves above the 0.075 mm (No. 200) sieve, and to the nearest 0.1 percent for material passing the 0.075 mm (No. 200) sieve. The theoretical maximum density gradation curve shall be the curve represented by a straight line drawn from the intersection of the ordinate and abscissa of the graph to the one hundred percent passing point for the nominal maximum size aggregate.

I. The design characteristic shape gradation curve for SP-II asphalt concrete shall be similar to an "S" shape curve, with a convex curve above the maximum density line for aggregate greater than 4.75 mm (No. 4) sieve and a concave curve below the maximum density line for aggregate finer than the 4.75 mm (No. 4) sieve.

J. The design characteristic shape gradation curve for Type SP-III and SP-IV asphalt concretes shall be similar to an "S" shape curve, with a convex curve above the maximum density line for aggregate greater than 2.36 mm (No. 8) sieve and a concave curve below the maximum density line for aggregate finer than the 2.36 mm (No. 8) sieve.

K. The design characteristic shape gradation curves for Types B, C, and D, asphalt concretes shall be similar to two convex curves above the maximum density line, one for aggregate greater than the 2.36 mm (No. 8) sieve, and one for the aggregate finer than the 2.36 (No. 8) sieve. The two curves shall intersect each other at the 2.36 mm (No. 8) sieve.

L. The design characteristic gradation curve shape for Type A asphalt concrete shall be similar to two convex curves above the maximum density line, one for aggregate greater than the 4.75 mm (N. 4) sieve, and one for aggregate finer than the 4.75 mm (No. 4) sieve. The two curves shall intersect each other at the 4.75 mm (No. 4) sieve.

M. The job mix formula asphalt binder content shall be proportioned to provide a job mix formula that complies with the requirements defined either in TABLE 321216.02-116.C.1 when proportioned with PG binders, or in TABLE 321216.02-116.C.2, when proportioned with either penetration or viscosity graded binders. The design asphalt binder content shall be selected, based on laboratory testing, aged binder/mix required. The binder content shall include a minimum of 75% virgin binder when a job mix formula is designed with recycled asphalt concrete pavement, RAP. The design percent binder content, ± 0.3%, shall not exceed the binder content at minimum VMA.

TABLE 321216.02-116.A – COMBINED AGGREGATE DESIGN PROPERTIES

CHARACTERISTIC	AGGREGATE TYPE Coarse		Fine	PROCEDURE
1. Coarse aggregate angularity, material > 4.75 mm	[1]	[2]	-	ASTM D 5821
ESALs < 3.0 mil	85	80		
3.0 ≤ ESALs < 30.0 mil	95	90		
30.0 mil ≤ ESALs	100	100		
2. Fine aggregate angularity as air voids, %, min	-		45	AASHTO TP 33
3. Flat and elongated particles, 3:1 or greater dimension, material > 4.75 mm, %	20 max			ASTM D 4791
4. Clay content, min %	-		45	ASTM D 2419
5. Deleterious material, max %	1		1	ASTM C 142
6. LA Abrasion, material > 2.36 mm, max loss, %	40		40	ASTM C 131
7. Soundness, max loss after 5 cycles, %	15		15	ASTM C 88

[1] coarse aggregate has one or more fractured faces
[2] coarse aggregate has two or more fractured faces

TABLE 321216.02-116.B - AGGREGATE GRADATION [3]													
	% PASSING TYPE, Nominal Maximum Size Aggregate [1]												PRODUCTION TOLERANCE
	SP-II/A,1		SP-III, 3/4		SP-IV, 1/2		SP-V/D, 3/8		B, 3/4		C, 1/2		
SIEVE SIZE, in	min	max	min	max	min	max	min	max	min	max	min	max	
1-1/2	100	100	-	-	-	-	-	-	-	-	-	-	
1.00	86	96	100	100	-	-	-	-	100	100-	-	-	8
¾	-	90-	89	96	100	100	-	-	88	96	100	100	8
½	62	83	-	90	88	96	100	-	-	90	88	96	8
3/8	-	-	64	85	-	90	91	97	70	85	73	90	8
No. 4	31	40	37	47	52	70	-	90	51	69	57	75	7 [2]
8	19	27	23	32	28	39	47	67	35	49	39	58	6
16	10	18	12	22	14	26	38	55	28	40	32	48	6
30	6	14	8	17	8	19	28	43	21	31	24	38	5
50	4	11	5	14	5	16	19	30	14	23	16	27	5
200	3.0	7.0	3.0	8.0	2.0	10.0	3.0	10.0	2.0	8.0	3.0	10.0	3.0
NOTES:	[1] SP-II and Type A gradation materials may not be used for the surface course [2] If recycled asphalt concrete aggregate (RAP) is used, ± 8% [3] A JMF aggregate gradation may pass through the restricted zone if all JMF volumetric design criteria is in compliance. The restricted zone is defined by the material passing the No. 8 to No. 30 sieves for SP-II and Type A asphalt concretes. The restricted zoned is defined by material passing the No. 4 to No. 30 sieves for all other asphalt concrete.												

TABLE 321216.02-116.C.1 – ASPHALT CONCRETE SUPERPAVE DESIGN SPECIFICATIONS							
DESCRIPTION		Local, Major Local, Residential, Intersection [1]		Collector, Minor and Major Arterial, Controlled Access Roadway, And Intersections [1]			
A.	Binder	PG70-22		PG76-28		PG76-28	
B.	Equiv. Single Axle Load, ESALs (millions)	<3		3 ≤ ESALs <30		30 ≤ ESALs [2]	
C.	Voids, %	3.5 – 4.5		3.5 – 4.5		3.5 – 4.5	
D.	Voids in Mineral Aggregate, VMA, %	min	max	min	max	min	max
	Type SP-II [3], (1 in.)	12	14	12	14	12	14
	Type SP-III, (3/4 in.)	-	-	13	15	13	15
	Type SP-IV, (1/2 in.)	-	-	14	16	14	16
	Type SP-V, (3/8 in.)	-	-	16	18	16	18
	Type A, (1 in.) [3]	12	14	-	-	-	-
	Type B, (3/4 in.)	13	15	-	-	-	-
	Type C, (1/2 in.)	14	16	-	-	-	-
	Type D, (3/8 in.)	16	18	-	-	-	-
E.	Voids filled with binder, %						
	Type SP-II [3], (1 in.)	-	-	65	75	65	75
	Type SP-III, (3/4 in.)	-	-	65	75	65	75
	Type SP-IV, (1/2 in.)	-	-	65	75	65	75
	Type SP-V, (3/8 in.)	-	-	65	75	65	75
	Type A, (1 in.) [3]	68	78	-	-	-	-
	Type B, (3/4 in.)	68	78	-	-	-	-
	Type C, (1/2 in.)	68	78	-	-	-	-
	Type D, (3/8 in.)	68	78	-	-	-	-
F.	Dust Ratio, -No. 200 (0.075 mm): $\%P_{be}$	0.6	1.6	0.6	1.6	0.6	1.6
G.	Gyratory compaction [4] At binder compaction temp, ± 5°F	N	% CMPTN	N	% CMPTN	N	% CMPTN
	Gyrations						
	N_i (initial)	7	91.0	8	89.0	9	89.0
	N_d (design)	75	96.0	100	96.0	125	96.0
	N_m (max)	115	98.0	160	98.0	205	98.0
H.	Moisture susceptibility, % retained strength @ 7% air voids, AASHTO T283, with freeze cycle	80 min		80 min		80 min	
NOTES:							
[1]	The intersection area shall be the core area common to all intersecting streets, and include the distance to the curb return of the approach and departure of the intersecting streets.						
[2]	Level II Design Complying with NMSHTD Procedures at Date of Bid, as directed by the SDR.						
[3]	SP-II and Type A gradations asphalt concrete shall not be used for surface course						
[4]	% of maximum theoretical specific gravity / density, G_{mm}						

TABLE 321216.02-116.C.2 – ASPHALT CONCRETE DESIGN SPECIFICATIONS PENETRATION & VISCOSITY GRADE BINDERS		
DESCRIPTION		Residential, Local, Major Local, And Intersection
A.	Binder Grade	60 – 70 Pen,
		AC-20 Viscosity
B.	Equiv. Single Axle Load, ESALs (million)	ESALs < 3.0
C.	Voids, %	3.5 – 4.5
D.	Voids in Mineral Aggregate, VMA, %	
	Type A, (1 in.)	12 – 14
	Type B, (3/4 in.)	13 – 15
	Type C, (1/2 in.)	14 – 16
	Type D, (3/8 in.)	15 – 17
E.	Voids filled with binder, %	68 – 78
F.	Dust Ratio, -No. 200 (0.075 mm): % P_{be}	0.6 – 1.6
G.	Marshall Stability Design, Blow counts/each face	50
	Stability, lbs, min	1500
	Flow, 0.01 in.	10 – 18
H.	Stability to Flow Ratio, minimum @target binder ± 0.5%	200
I.	Moisture Susceptibility, % retained strength,	80 min
	@ 7% air voids, AASHTO T283, with freeze cycle	
NOTES:		
[1]	The intersection area shall be the core area common to all intersecting streets and includes the distance to the curb return of the approach and departure of the intersecting street.	

Part 3 – Execution

3.1 Production

A. Asphalt concrete shall be produced in accordance with the requirements of ASTM D3515, the requirements of this Specification, or as authorized by the SDR. Production facilities shall comply with the requirements of ASTM D995, and this Specification. A plant shall be certified annually, by a New Mexico Registered Professional Engineer, to comply with the requirements of this Specification and Section 13. The production plant shall be calibrated annually with calibration standards traceable to the National Bureau of Standards. Certification shall be completed within 12 months prior to production of an authorized job mix formula at the plant. Certificates of calibration and production certifications shall be maintained at the plant for review by the SDR. A copy of the certifications shall be submitted to the SDR upon request.

B. Asphalt concrete shall be placed at the design proportions specified in the authorized job mix formula within the specified production tolerances for combined aggregate gradation and asphalt binder content. Asphalt concrete placed at a project, sampled and tested in accordance with this specification, shall have a gradation that complies with the authorized design gradation ± the production tolerance(s) specified in the authorized job mix formula. Asphalt concrete placed at a project, sampled and tested in accordance with this specification, shall have an asphalt content that complies with the design asphalt content ± 0.5% (laboratory analysis), T53-Quantitative Analysis of Bitumen From Bituminous Paving Mixtures, Ignition Oven Method, Method A (Modified: reference temperature for constant mass, 149 ± 3° C / 300 ± 7° F).

3.2 Delivery

A. Asphalt concrete shall be delivered in trucks free of fluid leaks. Trucks detected to have leaks shall not be allowed on the project. Subgrade, base course, and asphalt concrete surfaces contaminated by uncontrolled equipment fluids shall be removed and replaced with complying material. Contaminated material shall be disposed of as specified. When hauling time from the mixing plant to the job site exceeds two hours or when inclement weather prevails, bituminous mixtures shall be covered with tarpaulins while being hauled. The tarpaulins shall completely cover the load and be firmly tied down. Mixtures shall be delivered to site of the work and placed without segregation of the ingredients and within the temperature range specified in the authorized job mix formula. Diesel fuel or other petroleum based solvents shall not be used in the bed of transport vehicles as a release agent to prevent buildup of the asphalt material. Material contaminated with diesel fuel or other petroleum based solvents shall be removed and replaced with complying material by the CONTRACTOR, as directed by the SDR, at no cost to SNL/NM.

B. The CONTRACTOR shall provide with each load of asphalt concrete batched and/or delivered to the job site, before unloading at the site, a delivery ticket on which is printed, stamped or written, the information defined in TABLE 321216.02-116.E. One copy of the ticket shall be available for each of the SDR and the quality assurance testing program.

TABLE 321216.02-116.E – DELIVER TICKET INFORMATION
Name of Asphalt Concrete Supplier
Date of Delivery
Delivery Ticket Number Contractor
Project Name (optional)
Job Mix Formula Number
Weight of Load (tons)
Time Loaded

3.3 Placement and Compaction

A. See Related Section 32 12 16.03, "Asphalt Concrete Installation" for placement and compaction.

3.4 Material Sampling and Testing

A. MATERIAL QUALITY ASSURANCE:

1. Asphalt concrete quality assurance sampling and testing shall be performed in accordance with the requirements of this specification, the Supplemental Technical Specifications, or as directed by the SDR.

2. Quality assurance asphalt concrete analysis shall be (1) performed in a laboratory accredited in accordance with the requirements of the New Mexico State Highway and Transportation Department "Procedure for Approval of Testing Laboratories to Perform Inspection, Testing, and Mix Design Services", April 13, 1998 Edition, and (2) under the direct supervision of a New Mexico Registered Professional Engineer.

3. Testing equipment shall be calibrated annually with calibration standards traceable to the National Bureau of Standards. Calibration records and certifications shall be maintained at the laboratory for review by the SDR. A copy of the certifications shall be submitted to the SDR upon request.

4. Quality assurance sampling and testing shall be performed by a technician certified under the New Mexico State Highway and Transportation Department/Associated Contractors of New Mexico Technical Training and Certification Program for ASPHALT and SUPERPAVE™.

B. MATERIAL FIELD SAMPLING:

1. A quality assurance asphalt concrete material field sample shall be taken in accordance with the requirements of ASTM D979 for each job mix delivered. The materials shall be sampled at the greater rate of either one sample for each 250 tons, or one sample per day, for each type of material placed on a project, as directed by the SDR. The sample shall be of such size to provide material for all tests specified and a split sample to perform verification/referee tests for gradation and binder content, if required.

C. MATERIAL TESTING:

1. Asphalt concrete quality assurance sampling and testing shall be performed in accordance with the requirements of this Specification, the Supplemental Technical Specifications, or as directed by the SDR.

2. The asphalt concrete quality assurance sample shall be tested and the properties reported, with authorized job mix formula production limits, as specified in

TABLE 321216.02-116.F – FIELD SAMPLE LABORATORY TESTS.

TABLE 321216.02-116.F – FIELD SAMPLE LABORATORY TESTS	
I.	Marshall Design Analysis
	A. Energy Reference:
	1. Briquette mass / mold size; 2. Hammer size and drop; and 3. Number of blow counts per face;
	B. Volume characteristics of compacted briquettes, with production specifications, average of three:
	1. VMA, voids in mineral aggregate; 2. Va, voids in asphalt concrete; 3. VFA, voids filled with asphalt binder; and, 4. G_{mb}, bulk specific gravity and density, with authorized jmf target, average of three;
	C. G_{mm}, maximum theoretical specific gravity/density with authorized jmf target, one test;
	D. Strength Characteristics:
	1. Stability; 2. Flow; and, 3. Stability : flow ratio.
III.	SUPERPAVE analysis (sample aging is not required) Analysis at authorized jmf gyrations, N_i (initial), N_d (design), and N_m (max). (1) Two briquettes required. (2) Report average of test results of two briquette tests
	A. Compaction analysis with authorized design, and specifications (if applicable)
	1. Bulk specific gravity/density, G_{mb}, @ N_i, N_d, and N_m 2. Maximum theoretical specific gravity/density, G_{mm} 3. Compaction: G_{mb} as % G_{mm} at N_i, N_d, and N_m 4. Sample height, mm, at N_d
	B. Volume characteristics of compacted briquettes @ N_d, with design value and specifications
	1. VMA, voids in mineral aggregate 2. Va, voids in asphalt concrete 3. VFA, voids filled with asphalt binder
IV.	Asphalt binder content, with design value and authorized production range, T53 – Quantitative Analysis of Bitumen From Bituminous Paving Mixtures, Ignition Oven Method A (Modified: reference temperature for constant mass, 149 ± 3°C / 300 ± 7°F)
V.	Dust ratio, $\%P_{be}$
VI.	Extracted Combined Aggregate, with design value(s) and authorized production range
	A. Gradation
	B. Coarse aggregate angularity, material > 4.75 mm, coarse aggregate has two or more fractured faces
	C. Flat and elongated particles, 3:1 or greater dimension, material > 4.75 mm, %

3. A CONTRACTOR may challenge production material test results, binder content and aggregate gradation, and request that the retained split asphalt concrete

sample of record be released to his assigned laboratory and tested for compliance, as authorized by the SDR. Notification of challenge shall be made in writing to the SDR by the CONTRACTOR within 28 calendar days from date of sampling. Challenge test results shall be submitted to the SDR for evaluation no later than 42 calendar days from date of sampling. Challenge test results will be evaluated in accordance with "multi laboratory" precision tolerances specified, T53 for binder content, ASTM C117 and C136 for aggregate gradation. Challenge and record test results that comply with precision tolerances will be averaged with the companion test results of record and the material pay factor, PFM, recalculated, as directed by the SDR. Challenge and record test results that do not comply with the precision tolerances will direct the disqualification of the challenged sample, as directed by the SDR. Cut/core sample(s) will be taken from the area(s) represented by the disqualified challenge sample(s) and evaluated by the lab of record under the observation of the CONTRACTOR, in accordance with the requirements of this specification and replace the disqualified sample test results. Analysis of the replacement cut/core sample(s) may not be challenged. The CONTRACTOR will submit challenge test results in writing to the SDR for each split sample released to his assigned laboratory of record. Challenges filed after the time limitations will not be considered. SNL/NM shall pay for all complying tests.

D. MATERIAL FIELD TESTING:

1. Asphalt concrete material quality assurance sampling and testing shall be performed in accordance with the requirements of this Specification, the Supplemental Technical Specifications, or as directed by the SDR.

2. Quality assurance of in-place field compaction tests shall be conducted in accordance with the requirements of this specification, as directed by the SDR. A test shall determine the density of a constructed asphalt concrete roadway lift. Compaction shall be calculated as the measured in-place density, divided by the average maximum theoretical density (Gmm) of the samples taken for that day's placement, reported to one tenth of a percent, xxx.x%. Maximum theoretical density (Gmm) shall be determined in accordance with ASTM D2041.

   a. Field density for SP-II and Type A materials shall be measured from field core samples. A minimum of one core sample shall be taken for each lift of 250 tons of a material type, or fraction thereof, placed each day, but not less than 3 cores per day, as directed by the SDR. The bulk density (G_{mb}) of each core shall be measured in accordance with the requirements of D2726 and reported to the nearest one-tenth pound per cubic foot, (one kilogram per cubic meter). The compaction for the asphalt concrete shall be calculated as the average measured density of the cores for a lift of a type of material placed in a day, divided by the average of the maximum theoretical density (G_{mm}) of the samples of the same or similar materials taken for that day's placement, reported to the nearest one tenth of a percent, xxx.x%. The maximum theoretical density (G_{mm}) shall be determined in accordance with ASTM D2041, and reported to the nearest one-tenth pound per cubic foot, (one kilogram per cubic meter). The core barrel shall be 6 inches (150mm) outer diameter or greater, taken full depth. A lift sample shall be trimmed from the core at the lamination lines between lifts. The CONTRACTOR shall be responsible for material replacement at no cost to SNL/NM where samples are removed.

i. The field density for Types B, C, D, SP-III, SP-IV, and SP-V materials shall be measured in accordance with the requirements of ASTM D2950, at the minimum rate of three tests per lift, per 500 sy of each type of asphalt material placed in a day, as directed by the SDR.

ii. A reference density test of the support material, for the asphalt concrete roadway lift to be constructed, shall be taken prior to the placement of the fresh asphalt concrete lift, or defined from previous test results. The density of the support material shall be used as reference in performing the density test of a fresh asphalt concrete lift in accordance with the requirements ASTM D2950, placed over the support material. A density test of the support material shall be taken at the rate of one (1) test for each 500 sy of surface or less to be paved over in a day, as directed by the SDR. The density of the support material shall be reported as “reference support material density” in the compaction test report of the constructed asphalt concrete pavement over the area represented by the support material compaction test.

b. Compaction Tests

i. Compaction tests shall be taken at random locations on the asphalt being placed, as directed by the SDR. The three (3) general areas in which tests are to be taken are the free edge of the mat, mat interior, and the joints. The number of tests taken in each area will vary but the total number of tests taken on any project shall be in the following approximate proportions.

ii. Samples of the compacted Types S-III, S-IV, B, C, and D asphalt concretes may be taken and tested to determine compaction conformance of the finished pavement with the specified requirements either as requested by the CONTRACTOR, or as directed by the SDR. Cores shall be sampled and tested in accordance with 3.5.D, “Material Field Testing”.

TABLE 321216.02-116.G FIELD IN PLACE DENSITY PROPORTIONS	
Location	% of Total Tests
Free Edge of Mat[1]	20 to 33
Mat Interior	33 to 60
Joints[2]	20 to 33
Notes:	
1	The free Edge of Mat test shall be taken in the area between one (1) foot and two (2) feet in from a free edge of a lift.
2	Joints shall include the longitudinal and transverse butt joints between adjacent lifts of asphalt having the same finish elevation. Tests may be taken on material placed against a cold joint edge of formed surface.

E. TEST REPORTS

1. Test reports shall include but not be limited to the information specified in TABLE 321216.02-116.H – TEST REPORT.

2. Test results shall be reported to the SDR, CONTRACTOR, and the Supplier in writing, within 7 working days of completion of the sampling of the asphalt and/or the field testing. Non-complying tests shall be reported to the SDR, CONTRACTOR, and the Supplier within 1 working day of completion of the test.

TABLE 321216.02-116.H – TEST REPORT		
A.		Field Data and Test Results:
	1.	Date of Sampling/Test
	2.	SNL Project Number or Permit Number
	3.	Project Title
	4.	Asphalt Concrete Supplier
	5.	Delivery Ticket Number (asphalt concrete sample – only)
	6.	Job Mix Formula Number
	7.	Location of Sample/Test as defined by Contract Documents
	8.	Time of Sampling/Testing
	9.	Material temperature at time of sampling, °F
	10.	Ambient temperature at time of sampling, °F
	11.	Field test results with reference specification limits (compaction test)
B.		Laboratory Test Results
	1.	Laboratory results as defined in TABLE 321216.02-116.F
	2.	Field Test Data, per 3.5.D, “Material Field Testing”.
C.		Recommended Pay Adjustment Factor for a LOT
	1.	C_{LM}, material factor, see TABLE 321216.02-116.J
	2.	C_{LC}, placement/compaction factor, see TABLE 0321216.02-116.K

3. The New Mexico Registered Professional Engineer in direct charge of the laboratory shall certify on a quality assurance test report that the test procedures used to generate the report complied with the specifications.

3.5 Performance and Acceptance

A. If there are failing tests on the asphalt concrete for material properties, placement, compaction or thickness, the SDR may, at his discretion, direct the LOT to be removed and replaced with materials complying with the specifications at no cost to SNL/NM, or may make reductions in the amount paid to the CONTRACTOR for asphalt concrete paving as defined in 3.5.B. below. A LOT shall be defined as the total tonnage placed in a day, for each type of material placed.

B. Each LOT of asphalt concrete material shall be paid at an adjusted price, as determined by the schedule of values, for asphalt concrete calculated in accordance with the equation below and adjusted by a material factor, PFm, specified in TABLE 321216.02-116.J, as authorized by the SDR. Acceptance samples shall be sampled and tested in accordance with the requirements of 3.5.D. “Material Field Testing”, and tested for compliance with the specifications. A material pay factor, PFm, shall be determined in accordance with TABLE 321216.02-116.J, as defined for test results for combined aggregate gradation and asphalt content, as compared to the authorized job mix formula’s production specifications. All complying acceptance samples taken in a day for a material type shall represent a LOT in the computation specified in TABLE 321216.02-116.J. Non complying acceptance samples shall be evaluated in accordance with these specifications as directed by the SDR. The material factor, PFM, for a LOT shall be determined based on the deviation of the average value, arithmetic mean, M, of the acceptance samples’ test results from the job mix formula targets, T, adjusted for the range of the test results, maximum value minus the minimum value. If the absolute value of the deviation of the daily mean from the target is greater than the maximum allowable deviation, the LOT will be removed and replaced with materials complying with the specifications at no cost to the SNL/NM as directed by the SDR. If it is determined by the SDR to be more practical to accept the material under a specific project condition, the LOT may be accepted under written agreement between the SNL/NM and the CONTRACTOR at an assigned pay factor PFM=0.70, for a LOT having a compaction pay factor PFc, equal or greater than 0.85, as authorized by the SDR.

$$UP' = PF_M \times UP$$

UP’, Adjusted Unit Price/Ton

UP, Unit Price/Ton

PF_M, Material Adjustment Factor

<table>
<tr><td colspan="5">TABLE 321216.02-116.J – MATERIAL FACTOR, PF_M, FOR GRADATION & BINDER CONTENT</td></tr>
<tr><td colspan="2">NUMBER OF DAILY SAMPLES</td><td colspan="3">For [T-M] equal or greater than D’, [1, 2]
D’, MAXIMUM ALLOWABLE DEVIATION [3]</td></tr>
<tr><td colspan="2">1</td><td>1.40D</td><td>1.20D</td><td>D</td></tr>
<tr><td colspan="2">2</td><td>D + R</td><td>D + 0.37R</td><td>D – 0.10R</td></tr>
<tr><td colspan="2">3</td><td>D + 0.30R</td><td>D + 0.07R</td><td>D – 0.14R</td></tr>
<tr><td colspan="2">4</td><td>D + 0.16R</td><td>D – 0.01R</td><td>D – 0.17R</td></tr>
<tr><td colspan="2">5</td><td>D +0.11R</td><td>D – 0.03R</td><td>D – 0.20R</td></tr>
<tr><td colspan="2">6</td><td>D + 0.09R</td><td>D – 0.05R</td><td>D – 0.22R</td></tr>
<tr><td colspan="2">7</td><td>D + 0.07R</td><td>D – 0.07R</td><td>D – 0.24R</td></tr>
<tr><td colspan="2">8</td><td>D + 0.06R</td><td>D – 0.08R</td><td>D – 0.25R</td></tr>
<tr><td colspan="2">9</td><td>D + 0.05R</td><td>D – 0.09R</td><td>D – 0.26R</td></tr>
<tr><td colspan="2">10 OR MORE</td><td>D + 0.04R</td><td>D – 0.10R</td><td>D – 0.27R</td></tr>
<tr><td colspan="2">MATERIAL FACTOR PF_M [3]</td><td>0.85</td><td>0.95</td><td>1.00</td></tr>
<tr><td>[1]</td><td colspan="4">D, production tolerance +/- %, see TABLE 321216.02-116.B and Section 2.02 PROPORTIONING, and authorized job mix formula, R, range of test values, maximum – minimum values, M, average test value of a LOT’s samples test results, T, target value specified in the authorized job mix formula.</td></tr>
<tr><td>[2]</td><td colspan="4">If the deviation of the daily mean from the target exceeds the maximum allowable deviation for a LOT, [T-M]>D’, the LOT will be removed and replaced with material complying with this specification, at no cost to SNL/NM, as directed by the SDR. If determined by the SDR to be more practical to accept the material, the LOT may be accepted under written agreement between SNL/NM and the CONTRACTOR at an assigned pay factor PF_M = 0.70, for compaction LOT(s) having a compaction factor, PF_C, equal or greater than 0.85, as directed by the SDR.</td></tr>
<tr><td>[3]</td><td colspan="4">The material factor PF_m, shall be the lowest of the factors calculated for either the combined aggregate gradation of material passing the nominal maximum size aggregate screen, 3/8 inch, and smaller screens, or, the binder content.</td></tr>
</table>

C. The placement and compaction factor, PF_c, for a LOT shall be determined based on the average value of the compaction tests for the LOT, with any single test neither less than 90.0% nor greater than 98%, and TABLE 321216.02-116.K. If a test for a LOT is either less than 90.0% or greater than 98%, the LOT will be evaluated as directed by the SDR.

$$UP' = PF_c \times UP$$

UP’, Adjusted Unit Price

PF_c, see TABLE 321216.02-116.K

UP, Unit Price

TABLE 321216.02-116.K – PAY FACTOR (PF_C) FOR COMPACTION	
Average of Acceptance Test Results	Pay Factor, PF_c
98.0% and greater	[1]
97.1 to 97.9	0.85
93.0 to 97.0	1.00
92.0 to 92.9	0.95
91.0 to 91.9	0.90 [2]
90.0 to 90.9	0.85 [2]
Less than 90%	[1], [2]
[1]	The material defined for the LOT shall be removed and replaced with asphalt concrete material complying with this Specification at no cost to SNL/NM, as directed by the SDR. Upon written agreement, the CONTRACTOR and SDR may determine that for practical purposes the LOT shall not be removed. If determined by the SDR to be more practical to accept a LOT, a LOT may be accepted under written agreement between SNL/NM and the CONTRACTOR at an assigned compaction pay factor PF c = 0.50 [2], for a LOT having a material pay factor equal or greater than 0.85, as directed by the SDR.
[2]	When the lift is the surface course, and is accepted at this pay factor, the CONTRACTOR shall apply a sanded fog seal to the LOT complying with the applicable requirements of City of Albuquerque “Standard Specifications for Public Works Construction” SECTION 333 FOG SEAL, latest edition as directed by the SDR, at no cost to SNL/NM.

END OF SECTION 32 12 16.02

Exceptional service in the national interest

Section 32 12 16.02 – Asphalt Concrete Material

February 2018

Effective Date: 02/19/2018
Review Date: 02/19/2021

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Section 32 12 16.02 – Asphalt Concrete Material

Table of Contents

Page

Tables

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Freeman Leaming	Subst	Updated format to 2004 CSI. Differentiated better between this spec and the asphalt concrete installation spec including moving placement and compaction completely to other spec.
2/19/18	Tim Peterson	No changes	3-year review performed. No changes made.

Section 32 12 16.02 – Asphalt Concrete Material

Part 1 – General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections: Refer to the following sections for related work.

1. Section 32 12 16.03, "Asphalt Concrete Installation" for installation of the materials specified herein.

2. Section 32 12 16.01, "Paving Asphalt Binder" for asphalt binder used herein.

C. References:

1. American Society of Testing and Materials (ASTM):

C88 ....Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
C117 ....Method for Material Finer than 0.75µm (No. 200) Sieve in Mineral Aggregates by Washing
C131 ....Test Method for Resistance to Degradation of Small-size Coarse Aggregate by Abrasion and Impact in a Los Angeles Machine
C136 ....Method for Sieve Analysis of Fine and Coarse Aggregate
D242 ....Specifications for Mineral Filler for Bituminous Paving Mixtures
D692 ....Specification for Coarse Aggregate for Bituminous Paving Mixtures
D979 ....Methods of Sampling Bituminous Paving Mixtures
D995.............. Specification for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
D1073............ Specification for Fine Aggregate for Bituminous Paving Mixtures
D1074 ....Test Method for Compressive Strength of Bituminous Mixtures
D1559 ....Resistance to Plastic Flow of Bituminous Mixtures using Marshall Apparatus
D2041 ....Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures
D2493 ....Viscosity-Temperature Chart for Asphalts
D2726 ....Bulk Specific Gravity and Density of Compacted Bituminous Mixtures using Saturated Surface-Dry Specimens
D2851 ....Test for Determining the Percentage of Fractured Particles in Coarse Aggregate
D2950 ....Density of Bituminous Concrete in Place by Nuclear Methods
D3203 ....Percent Air Voids in Compacted Dense and Open Bituminous

Paving Mixtures
D3515 ....Standard Specification for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
D4791 ....Test for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

2. American Association of State Highway and Transportation Officials, AASHTO:

MP2 ....Specification for Superpave™ Volumetric Mix Design
PP-28 ....Superpave™ Volumetric Design for HMA
TP 4 ....Preparation of Compacted Specimens of Modified and Unmodified Hot Mix Asphalt by Means of SHRP Gyratory Compactor
PP 2 ....Short and Long-term Aging of Bituminous Mixes
T53 ....Quantitative Analysis of Bitumen from Bituminous Paving Mixtures, Ignition Oven Method A
T245 ....Resistance to Plastic Flow of Bituminous Mixture using Marshall Apparatus
T283 ....Resistance of Bituminous Mixture to Moisture Induced Damage
T304 ....Uncompacted Void Content of Fine Aggregate

3. Asphalt Institute:

MS-2 Mix Design Methods, Sixth Edition
MS-2 Mix Design Methods, Sixth Edition, Section 5.16, Modified Marshall Method for Large Aggregate

4. City of Albuquerque "Standard Specifications for Public Works Construction", latest edition.

Section 113 EMULSIFIED ASPHALTS
Section 117 ASPHALT REJUVENATING AGENTS
Section 118 HYDRATED LIME FILLER
Section 333 FOG SEAL COATS

1.2 Summary

A. Section Includes: The mix design, testing, furnishing, and delivery of asphalt concrete ready for placement. It does not include placement, compaction, or field testing relating to placement adequacy (installation). That is covered in Section 32 12 16.03, "Asphalt Concrete Installation".

B. Asphalt concrete shall consist of a mixture of asphalt binder, aggregates, mineral filler and admixtures, proportioned as required, batched and delivered as specified herein. All materials and job mix formulas used in asphalt concrete, either batched at or delivered to a project, shall be certified in accordance with the requirements of these specifications. The CONTRACTOR shall be solely responsible for asphalt concrete job mix formula supplied under this specification, its proportions and manufacture. Each job mix formula submitted and authorized for use under this specification shall be identified by a number unique to that job mix formula. If either a change in material(s) or material supplier(s) from that specified in the job mix formula occurs during a project, authorized use of the job mix formula on the project may be cancelled as directed by the SDR. A job mix formula shall not be used on a project without written approval of the SDR.

1.3 Definitions

A. SNL/NM: Sandia National Laboratories New Mexico Site

B. SDR: Sandia Delegated Representative

C. JMF: Job Mix Formula

1.4 Action Submittals

A. Job Mix Formula: A design job mix formula submitted shall be included but not be limited to the information specified in TABLE 321216.02-116.D-SUBMITTAL INFORMATION, as directed by the SDR.

B. A submittal shall be rejected if it does not include the specified information and samples. A job mix formula submittal shall be accepted or rejected within ten (10) working days of receipt by the SDR.

TABLE 321216.02-116.D – SUBMITTAL INFORMATION		
I.	Identification	
	A.	Asphalt concrete supplier
	B.	Laboratory that performed design/development tests
	C.	Date of Submittal
	D.	Unique mix code identification number
	E.	Aggregate sample date
II.	Job Mix Formula (jmf)	
	A.	Type/application of asphalt concrete
	B.	Component material target proportions to include combined aggregate gradation and asphalt content, specifications, and production tolerances
	C.	0.45 power gradation plot of combined aggregate gradation with specification and production limits
	D.	Temperature viscosity relationship of binder
	E.	Recommended mixing, compaction, and release to traffic maximum temperatures
	F.	Tabulation of job mix formula performance characteristics defined in either TABLE 321216.02-116.C.1 or TABLE 321216.02-116.C.2 as applicable, at the proposed design proportions, with reference specification limits and production limits (if specified), maximum theoretical specific gravity/density (as pcf), and bulk specific gravity/density (pcf).
	G.	Reference daily production gradation, see TABLE 321216.02-116.B
III.	Certifications of Compliance	
	A.	Compliance of job mix formula by NM Registered Professional Engineer in direct charge of design/development;
	B.	Design Laboratory Certification, projects bid after June 30, 2000.
		TABLE 321216.02-116.D – SUBMITTAL INFORMATION (Cont.)
	C.	Component materials testing and certification by supplier/manufacturer with supporting test data for materials used in design development

	D.			Certification and laboratory test results of asphalt binder used in job mix formula design development, see Section 321216.01 PAVING ASPHALT BINDER
IV.				Design Development (tables and graphs, with specifications limits of the following):
	A.			Marshall Design & Modified Marshall Designs (design development with a minimum of 4 asphalt binder contents required, and the recommended design characteristic bracketed by a minimum of two test points for the design binder content ± 0.5%)
		1.		Design hammer blow counts, mold diameter, hammer mass and drop
		2.		Stability (lbs.) vs. % asphalt content
		3.		Flow (0.01 in.) vs. % asphalt content
		4.		Briquette bulk Specific Gravity and Bulk Density (as pcf) vs. % asphalt content
		5.		% Voids in Mineral Aggregate (% VMA) vs. % Asphalt content
		6.		% Voids (Pa) in asphalt concrete vs. % asphalt content
		7.		% Voids filled in asphalt concrete vs. % asphalt content
		8.		Dust ratio vs. % asphalt content
	B.			SUPERPAVE Design (Tables and graphs, with specifications limits of the following)
		1.		Trial Designs: Aggregate gradations, 3 minimum required, and trial asphalt binder content (%)
			a)	Table of Aggregate Gradations and 0.45 power plot, with specification limits
			b)	Trial design % asphalt content
			c)	Trial designs volumetric analysis for each gradation, VMA, Va, VFA, graph not required
			d)	Trial designs compaction analysis @ N_i, N_d, and N_m, for each gradation
			e)	Dust ratio for each trial design, graph not required
		2.		Job Mix Formula Design, (design development with a minimum of 4 asphalt binder contents required, and the recommended design characteristic bracketed by a minimum of two test points for the design binder content ± 0.5%)
			a)	Table of design aggregate gradation and 0.45 power plat, with specification limits and production targets
			b)	Compaction analysis G_{mb} as % $G_{m,}$ at N_i, N_d, and N_m, for each gradation vs. asphalt content (separate graphs for N_i, N_d, and N_m)
			c)	Volumetric analysis of VMA, Va, VFA, and dust ratio at design gyration, @ N_d, vs. % asphalt content
			d)	Gyratory compaction tables as height of sample versus gyration, for each asphalt content, Gmb @ NM, and bulk specific gravity/density correction factor(s) (graphs not required)
			e)	Maximum theoretical specific gravity/density (as pcf), $G_{mm,}$ vs % asphalt content @ N_d
			f)	Corrected bulk specific gravity/density (as pcf), $G_{mb,}$ vs. % asphalt content
			g)	Dust ratio vs. % asphalt content
			h)	Recommended gyratory sample mass(g) for 115 mm sample height at Nm
	C.			Ignition Correction Factor: Correction for material losses during asphalt content ignition oven analysis
				The correction factor shall be determined as the average value for three samples, design % asphalt content, design – 1.0%, and design + 1.0%, developed in an ignition oven complying with the requirements of AASHTO T53, Method A

Part 2 – Products

2.1 Materials

A. Asphalt binder shall comply with the requirements of 32 12 16.01, "PAVING ASPHALT BINDER".

B. Aggregates shall be crushed stone, crushed gravel, crushed asphalt concrete pavement, crushed Portland cement concrete, and natural or manufactured sand conforming to the quality and crushed particle requirements of this Specification. Coarse aggregates shall comply with the requirements of ASTM D692, Coarse Aggregate for Bituminous Paving Mixtures. Fine aggregates shall comply with the requirements of ASTM D1073, Fine Aggregate for Bituminous Paving Mixtures. The combined aggregates, proportioned as defined by the target gradation, shall comply with the requirements of TABLE 321216.02-116.A. Aggregates shall be certified to comply with the requirements of this Specification and authorized for use by the SDR before the materials may be incorporated in the construction. Prior to delivery of the aggregates or material containing the aggregates, the CONTRACTOR may be required to furnish samples of the aggregates to the SDR for testing. Daily production aggregates gradations shall be submitted to the SDR upon request.

C. Mineral filler shall comply with the requirements of ASTM D242, Mineral Filler for Bituminous Paving Mixtures and as specified herein. Mineral filler shall be certified to comply with the requirements of this Specification and approved for use by SDR before the materials may be incorporated in the construction. Prior to either delivery of the mineral filler or material containing the mineral filler, The CONTRACTOR may be required to furnish samples of the mineral filler to The SDR for testing.

D. Asphalt concrete shall comply with the minimum requirements of TABLE 321216.02.C.1.H, moisture susceptibility, percent retained strength at 7 % air voids, AASHTO T283 with freeze cycle. Admixtures to reduce moisture susceptibility in an asphalt concrete mix shall be either hydrated lime, Portland cement, liquid admixture, or a modified asphalt binder authorized by the SDR.

E. The materials specified in an authorized job mix formula shall be the same source and type for all asphalt concrete batched, delivered, placed and compacted, under the identification code defined for the authorized job mix formula.

2.2 Proportioning

A. The CONTRACTOR shall be solely responsible for the asphalt concrete JMF proportions and asphalt concrete either batched at and/or delivered to the site. Asphalt concrete shall be proportioned in accordance with the requirements of this Specification.

B. Asphalt concrete material proportioned with "performance grade binders" shall be proportioned to comply with the requirements of TABLE 321216.02-116.C.1 of this specification, AASHTO MP2, Specification for Superpave™ Volumetric Mix Design, and PP-28, Superpave™ Volumetric Design for HMA. The job mix formulas shall be designed under the direct supervision of a New Mexico Registered Professional Engineer who has completed a certified "SUPERPAVE Mixture Design & Analysis" Short Course.

C. Asphalt concrete for construction of classifications of Primary Streets, Secondary Streets, and Parking Lots shall be proportioned with performance grade (PG) binders.

D. Asphalt concrete for construction of street classification of Secondary Street with design equivalent single axle loads (Esals) less than 3.0 mil, may be proportioned with a PG70-22 performance grade (PG) binders.

E. Asphalt concrete proportioned with either penetration or viscosity grade binders shall be proportioned to comply with the requirements TABLE 321216.02-116.C.2. A JMF shall be prepared in a laboratory under the direct supervision of a New Mexico Registered Professional Engineer.

F. Asphalt concrete design and analysis shall be performed in a laboratory accredited in accordance with the requirements of the New Mexico State Highway and Transportation Department "Procedure for Approval of Testing Laboratories to Perform Inspection, Testing, and Mix Design Services", April 13, 1998 Edition.

G. An asphalt concrete job mix formula shall be proportioned to comply with the requirements of TABLE 321216.02-116.B AGGREGATE GRADATION PROPERTIES and either TABLE 321216.02-116.C.1 ASPHALT CONCRETE DESIGN SPECIFICATIONS PERFORMANCE GRADE BINDERS, or TABLE 321216.02-116.C.2 ASPHALT CONCRETE DESIGN SPECIFICATIONS PENETRATION AND VISCOSITY GRADED BINDERS.

H. Aggregates, mineral filler, and anti-strip admixture if required, shall be proportioned to provide a combined gradation that complies with the requirements specified in TABLE 321216.02-116.B, and have the same or similar shaped characteristic gradation curve as the specification limits specified therein when graphically plotted on a standard "0.45 POWER" gradation chart. The gradation shall be reported to the nearest whole percent for material passing sieves above the 0.075 mm (No. 200) sieve, and to the nearest 0.1 percent for material passing the 0.075 mm (No. 200) sieve. The theoretical maximum density gradation curve shall be the curve represented by a straight line drawn from the intersection of the ordinate and abscissa of the graph to the one hundred percent passing point for the nominal maximum size aggregate.

I. The design characteristic shape gradation curve for SP-II asphalt concrete shall be similar to an "S" shape curve, with a convex curve above the maximum density line for aggregate greater than 4.75 mm (No. 4) sieve and a concave curve below the maximum density line for aggregate finer than the 4.75 mm (No. 4) sieve.

J. The design characteristic shape gradation curve for Type SP-III and SP-IV asphalt concretes shall be similar to an "S" shape curve, with a convex curve above the maximum density line for aggregate greater than 2.36 mm (No. 8) sieve and a concave curve below the maximum density line for aggregate finer than the 2.36 mm (No. 8) sieve.

K. The design characteristic shape gradation curves for Types B, C, and D, asphalt concretes shall be similar to two convex curves above the maximum density line, one for aggregate greater than the 2.36 mm (No. 8) sieve, and one for the aggregate finer than the 2.36 (No. 8) sieve. The two curves shall intersect each other at the 2.36 mm (No. 8) sieve.

L. The design characteristic gradation curve shape for Type A asphalt concrete shall be similar to two convex curves above the maximum density line, one for aggregate greater than the 4.75 mm (N. 4) sieve, and one for aggregate finer than the 4.75 mm (No. 4) sieve. The two curves shall intersect each other at the 4.75 mm (No. 4) sieve.

M. The job mix formula asphalt binder content shall be proportioned to provide a job mix formula that complies with the requirements defined either in TABLE 321216.02-116.C.1 when proportioned with PG binders, or in TABLE 321216.02-116.C.2, when proportioned with either penetration or viscosity graded binders. The design asphalt binder content shall be selected, based on laboratory testing, aged binder/mix required. The binder content shall include a minimum of 75% virgin binder when a job mix formula is designed with recycled asphalt concrete pavement, RAP. The design percent binder content, ± 0.3%, shall not exceed the binder content at minimum VMA.

TABLE 321216.02-116.A – COMBINED AGGREGATE DESIGN PROPERTIES

CHARACTERISTIC	AGGREGATE TYPE Coarse		Fine	PROCEDURE
1. Coarse aggregate angularity, material > 4.75 mm	[1]	[2]	-	ASTM D 5821
ESALs < 3.0 mil	85	80		
3.0 ≤ ESALs < 30.0 mil	95	90		
30.0 mil ≤ ESALs	100	100		
2. Fine aggregate angularity as air voids, %, min	-		45	AASHTO TP 33
3. Flat and elongated particles, 3:1 or greater dimension, material > 4.75 mm, %	20 max			ASTM D 4791
4. Clay content, min %	-		45	ASTM D 2419
5. Deleterious material, max %	1		1	ASTM C 142
6. LA Abrasion, material > 2.36 mm, max loss, %	40		40	ASTM C 131
7. Soundness, max loss after 5 cycles, %	15		15	ASTM C 88

[1] coarse aggregate has one or more fractured faces
[2] coarse aggregate has two or more fractured faces

TABLE 321216.02-116.B - AGGREGATE GRADATION [3]

SIEVE SIZE, in	% PASSING TYPE, Nominal Maximum Size Aggregate [1]												PRODUCTION TOLERANCE
	SP-II/A,1		SP-III, 3/4		SP-IV, 1/2		SP-V/D, 3/8		B, 3/4		C, 1/2		
	min	max	min	max	min	max	min	max	min	max	min	max	
1-1/2	100	100	-	-	-	-	-	-	-	-	-	-	
1.00	86	96	100	100	-	-	-	-	100	100-	-	-	8
¾	-	90-	89	96	100	100	-	-	88	96	100	100	8
½	62	83	-	90	88	96	100	-	-	90	88	96	8
3/8	-	-	64	85	-	90	91	97	70	85	73	90	8
No. 4	31	40	37	47	52	70	-	90	51	69	57	75	7 [2]
8	19	27	23	32	28	39	47	67	35	49	39	58	6
16	10	18	12	22	14	26	38	55	28	40	32	48	6
30	6	14	8	17	8	19	28	43	21	31	24	38	5
50	4	11	5	14	5	16	19	30	14	23	16	27	5
200	3.0	7.0	3.0	8.0	2.0	10.0	3.0	10.0	2.0	8.0	3.0	10.0	3.0

NOTES:

[1] SP-II and Type A gradation materials may not be used for the surface course

[2] If recycled asphalt concrete aggregate (RAP) is used, ± 8%

[3] A JMF aggregate gradation may pass through the restricted zone if all JMF volumetric design criteria is in compliance. The restricted zone is defined by the material passing the No. 8 to No. 30 sieves for SP-II and Type A asphalt concretes. The restricted zoned is defined by material passing the No. 4 to No. 30 sieves for all other asphalt concrete.

TABLE 321216.02-116.C.1 – ASPHALT CONCRETE SUPERPAVE DESIGN SPECIFICATIONS

DESCRIPTION		Local, Major Local, Residential, Intersection [1]		Collector, Minor and Major Arterial, Controlled Access Roadway, And Intersections [1]			
A.	Binder	PG70-22		PG76-28		PG76-28	
B.	Equiv. Single Axle Load, ESALs (millions)	<3		3 ≤ ESALs <30		30 ≤ ESALs [2]	
C.	Voids, %	3.5 – 4.5		3.5 – 4.5		3.5 – 4.5	
D.	Voids in Mineral Aggregate, VMA, %	min	max	min	max	min	max
	Type SP-II [3], (1 in.)	12	14	12	14	12	14
	Type SP-III, (3/4 in.)	-	-	13	15	13	15
	Type SP-IV, (1/2 in.)	-	-	14	16	14	16
	Type SP-V, (3/8 in.)	-	-	16	18	16	18
	Type A, (1 in.) [3]	12	14	-	-	-	-
	Type B, (3/4 in.)	13	15	-	-	-	-
	Type C, (1/2 in.)	14	16	-	-	-	-
	Type D, (3/8 in.)	16	18	-	-	-	-
E.	Voids filled with binder, %						
	Type SP-II [3], (1 in.)	-	-	65	75	65	75
	Type SP-III, (3/4 in.)	-	-	65	75	65	75
	Type SP-IV, (1/2 in.)	-	-	65	75	65	75
	Type SP-V, (3/8 in.)	-	-	65	75	65	75
	Type A, (1 in.) [3]	68	78	-	-	-	-
	Type B, (3/4 in.)	68	78	-	-	-	-
	Type C, (1/2 in.)	68	78	-	-	-	-
	Type D, (3/8 in.)	68	78	-	-	-	-
F.	Dust Ratio, -No. 200 (0.075 mm): $\%P_{be}$	0.6	1.6	0.6	1.6	0.6	1.6
G.	Gyratory compaction [4] At binder compaction temp, ± 5°F	N	% CMPTN	N	% CMPTN	N	% CMPTN
	Gyrations						
	N_i (initial)	7	91.0	8	89.0	9	89.0
	N_d (design)	75	96.0	100	96.0	125	96.0
	N_m (max)	115	98.0	160	98.0	205	98.0
H.	Moisture susceptibility, % retained strength @ 7% air voids, AASHTO T283, with freeze cycle	80 min		80 min		80 min	
NOTES:							
[1]	The intersection area shall be the core area common to all intersecting streets, and include the distance to the curb return of the approach and departure of the intersecting streets.						
[2]	Level II Design Complying with NMSHTD Procedures at Date of Bid, as directed by the SDR.						
[3]	SP-II and Type A gradations asphalt concrete shall not be used for surface course						
[4]	% of maximum theoretical specific gravity / density, G_{mm}						

TABLE 321216.02-116.C.2 – ASPHALT CONCRETE DESIGN SPECIFICATIONS PENETRATION & VISCOSITY GRADE BINDERS		
DESCRIPTION		Residential, Local, Major Local, And Intersection
A.	Binder Grade	60 – 70 Pen,
		AC-20 Viscosity
B.	Equiv. Single Axle Load, ESALs (million)	ESALs < 3.0
C.	Voids, %	3.5 – 4.5
D.	Voids in Mineral Aggregate, VMA, %	
	Type A, (1 in.)	12 – 14
	Type B, (3/4 in.)	13 – 15
	Type C, (1/2 in.)	14 – 16
	Type D, (3/8 in.)	15 – 17
E.	Voids filled with binder, %	68 – 78
F.	Dust Ratio, -No. 200 (0.075 mm): % P_{be}	0.6 – 1.6
G.	Marshall Stability Design, Blow counts/each face	50
	Stability, lbs, min	1500
	Flow, 0.01 in.	10 – 18
H.	Stability to Flow Ratio, minimum @target binder ± 0.5%	200
I.	Moisture Susceptibility, % retained strength,	80 min
	@ 7% air voids, AASHTO T283, with freeze cycle	
NOTES:		
[1]	The intersection area shall be the core area common to all intersecting streets and includes the distance to the curb return of the approach and departure of the intersecting street.	

Part 3 – Execution

3.1 Production

A. Asphalt concrete shall be produced in accordance with the requirements of ASTM D3515, the requirements of this Specification, or as authorized by the SDR. Production facilities shall comply with the requirements of ASTM D995, and this Specification. A plant shall be certified annually, by a New Mexico Registered Professional Engineer, to comply with the requirements of this Specification and Section 13. The production plant shall be calibrated annually with calibration standards traceable to the National Bureau of Standards. Certification shall be completed within 12 months prior to production of an authorized job mix formula at the plant. Certificates of calibration and production certifications shall be maintained at the plant for review by the SDR. A copy of the certifications shall be submitted to the SDR upon request.

B. Asphalt concrete shall be placed at the design proportions specified in the authorized job mix formula within the specified production tolerances for combined aggregate gradation and asphalt binder content. Asphalt concrete placed at a project, sampled and tested in accordance with this specification, shall have a gradation that complies with the authorized design gradation ± the production tolerance(s) specified in the authorized job mix formula. Asphalt concrete placed at a project, sampled and tested in accordance with this specification, shall have an asphalt content that complies with the design asphalt content ± 0.5% (laboratory analysis), T53-Quantitative Analysis of Bitumen From Bituminous Paving Mixtures, Ignition Oven Method, Method A (Modified: reference temperature for constant mass, 149 ± 3° C / 300 ± 7° F).

3.2 Delivery

A. Asphalt concrete shall be delivered in trucks free of fluid leaks. Trucks detected to have leaks shall not be allowed on the project. Subgrade, base course, and asphalt concrete surfaces contaminated by uncontrolled equipment fluids shall be removed and replaced with complying material. Contaminated material shall be disposed of as specified. When hauling time from the mixing plant to the job site exceeds two hours or when inclement weather prevails, bituminous mixtures shall be covered with tarpaulins while being hauled. The tarpaulins shall completely cover the load and be firmly tied down. Mixtures shall be delivered to site of the work and placed without segregation of the ingredients and within the temperature range specified in the authorized job mix formula. Diesel fuel or other petroleum based solvents shall not be used in the bed of transport vehicles as a release agent to prevent buildup of the asphalt material. Material contaminated with diesel fuel or other petroleum based solvents shall be removed and replaced with complying material by the CONTRACTOR, as directed by the SDR, at no cost to SNL/NM.

B. The CONTRACTOR shall provide with each load of asphalt concrete batched and/or delivered to the job site, before unloading at the site, a delivery ticket on which is printed, stamped or written, the information defined in TABLE 321216.02-116.E. One copy of the ticket shall be available for each of the SDR and the quality assurance testing program.

TABLE 321216.02-116.E – DELIVER TICKET INFORMATION
Name of Asphalt Concrete Supplier
Date of Delivery
Delivery Ticket Number Contractor
Project Name (optional)
Job Mix Formula Number
Weight of Load (tons)
Time Loaded

3.3 Placement and Compaction

A. See Related Section 32 12 16.03, "Asphalt Concrete Installation" for placement and compaction.

3.4 Material Sampling and Testing

A. MATERIAL QUALITY ASSURANCE:

1. Asphalt concrete quality assurance sampling and testing shall be performed in accordance with the requirements of this specification, the Supplemental Technical Specifications, or as directed by the SDR.

2. Quality assurance asphalt concrete analysis shall be (1) performed in a laboratory accredited in accordance with the requirements of the New Mexico State Highway and Transportation Department "Procedure for Approval of Testing Laboratories to Perform Inspection, Testing, and Mix Design Services", April 13, 1998 Edition, and (2) under the direct supervision of a New Mexico Registered Professional Engineer.

3. Testing equipment shall be calibrated annually with calibration standards traceable to the National Bureau of Standards. Calibration records and certifications shall be maintained at the laboratory for review by the SDR. A copy of the certifications shall be submitted to the SDR upon request.

4. Quality assurance sampling and testing shall be performed by a technician certified under the New Mexico State Highway and Transportation Department/Associated Contractors of New Mexico Technical Training and Certification Program for ASPHALT and SUPERPAVE™.

B. MATERIAL FIELD SAMPLING:

1. A quality assurance asphalt concrete material field sample shall be taken in accordance with the requirements of ASTM D979 for each job mix delivered. The materials shall be sampled at the greater rate of either one sample for each 250 tons, or one sample per day, for each type of material placed on a project, as directed by the SDR. The sample shall be of such size to provide material for all tests specified and a split sample to perform verification/referee tests for gradation and binder content, if required.

C. MATERIAL TESTING:

1. Asphalt concrete quality assurance sampling and testing shall be performed in accordance with the requirements of this Specification, the Supplemental Technical Specifications, or as directed by the SDR.

2. The asphalt concrete quality assurance sample shall be tested and the properties reported, with authorized job mix formula production limits, as specified in

TABLE 321216.02-116.F – FIELD SAMPLE LABORATORY TESTS.

TABLE 321216.02-116.F – FIELD SAMPLE LABORATORY TESTS		
I.	Marshall Design Analysis	
	A.	Energy Reference:
	1.	Briquette mass / mold size;
	2.	Hammer size and drop; and
	3.	Number of blow counts per face;
	B.	Volume characteristics of compacted briquettes, with production specifications, average of three:
	1.	VMA, voids in mineral aggregate;
	2.	Va, voids in asphalt concrete;
	3.	VFA, voids filled with asphalt binder; and,
	4.	G_{mb}, bulk specific gravity and density, with authorized jmf target, average of three;
	C.	G_{mm}, maximum theoretical specific gravity/density with authorized jmf target, one test;
	D.	Strength Characteristics:
	1.	Stability;
	2.	Flow; and,
	3.	Stability : flow ratio.
III.	SUPERPAVE analysis (sample aging is not required) Analysis at authorized jmf gyrations, N_i (initial), N_d (design), and N_m (max). (1) Two briquettes required. (2) Report average of test results of two briquette tests	
	A.	Compaction analysis with authorized design, and specifications (if applicable)
	1.	Bulk specific gravity/density, G_{mb}, @ N_i, N_d, and N_m
	2.	Maximum theoretical specific gravity/density, G_{mm}
	3.	Compaction: G_{mb} as % G_{mm} at N_i, N_d, and N_m
	4.	Sample height, mm, at N_d
	B.	Volume characteristics of compacted briquettes @ N_d, with design value and specifications
	1.	VMA, voids in mineral aggregate
	2.	Va, voids in asphalt concrete
	3.	VFA, voids filled with asphalt binder
IV.	Asphalt binder content, with design value and authorized production range, T53 – Quantitative Analysis of Bitumen From Bituminous Paving Mixtures, Ignition Oven Method A (Modified: reference temperature for constant mass, 149 ± 3°C / 300 ± 7°F)	
V.	Dust ratio, $\%P_{be}$	
VI.	Extracted Combined Aggregate, with design value(s) and authorized production range	
	A.	Gradation
	B.	Coarse aggregate angularity, material > 4.75 mm, coarse aggregate has two or more fractured faces
	C.	Flat and elongated particles, 3:1 or greater dimension, material > 4.75 mm, %

3. A CONTRACTOR may challenge production material test results, binder content and aggregate gradation, and request that the retained split asphalt concrete

sample of record be released to his assigned laboratory and tested for compliance, as authorized by the SDR. Notification of challenge shall be made in writing to the SDR by the CONTRACTOR within 28 calendar days from date of sampling. Challenge test results shall be submitted to the SDR for evaluation no later than 42 calendar days from date of sampling. Challenge test results will be evaluated in accordance with “multi laboratory” precision tolerances specified, T53 for binder content, ASTM C117 and C136 for aggregate gradation. Challenge and record test results that comply with precision tolerances will be averaged with the companion test results of record and the material pay factor, PFM, recalculated, as directed by the SDR. Challenge and record test results that do not comply with the precision tolerances will direct the disqualification of the challenged sample, as directed by the SDR. Cut/core sample(s) will be taken from the area(s) represented by the disqualified challenge sample(s) and evaluated by the lab of record under the observation of the CONTRACTOR, in accordance with the requirements of this specification and replace the disqualified sample test results. Analysis of the replacement cut/core sample(s) may not be challenged. The CONTRACTOR will submit challenge test results in writing to the SDR for each split sample released to his assigned laboratory of record. Challenges filed after the time limitations will not be considered. SNL/NM shall pay for all complying tests.

D. MATERIAL FIELD TESTING:

1. Asphalt concrete material quality assurance sampling and testing shall be performed in accordance with the requirements of this Specification, the Supplemental Technical Specifications, or as directed by the SDR.

2. Quality assurance of in-place field compaction tests shall be conducted in accordance with the requirements of this specification, as directed by the SDR. A test shall determine the density of a constructed asphalt concrete roadway lift. Compaction shall be calculated as the measured in-place density, divided by the average maximum theoretical density (Gmm) of the samples taken for that day’s placement, reported to one tenth of a percent, xxx.x%. Maximum theoretical density (Gmm) shall be determined in accordance with ASTM D2041.

   a. Field density for SP-II and Type A materials shall be measured from field core samples. A minimum of one core sample shall be taken for each lift of 250 tons of a material type, or fraction thereof, placed each day, but not less than 3 cores per day, as directed by the SDR. The bulk density (G_{mb}) of each core shall be measured in accordance with the requirements of D2726 and reported to the nearest one-tenth pound per cubic foot, (one kilogram per cubic meter). The compaction for the asphalt concrete shall be calculated as the average measured density of the cores for a lift of a type of material placed in a day, divided by the average of the maximum theoretical density (G_{mm}) of the samples of the same or similar materials taken for that day’s placement, reported to the nearest one tenth of a percent, xxx.x%. The maximum theoretical density (G_{mm}) shall be determined in accordance with ASTM D2041, and reported to the nearest one-tenth pound per cubic foot, (one kilogram per cubic meter). The core barrel shall be 6 inches (150mm) outer diameter or greater, taken full depth. A lift sample shall be trimmed from the core at the lamination lines between lifts. The CONTRACTOR shall be responsible for material replacement at no cost to SNL/NM where samples are removed.

i. The field density for Types B, C, D, SP-III, SP-IV, and SP-V materials shall be measured in accordance with the requirements of ASTM D2950, at the minimum rate of three tests per lift, per 500 sy of each type of asphalt material placed in a day, as directed by the SDR.

ii. A reference density test of the support material, for the asphalt concrete roadway lift to be constructed, shall be taken prior to the placement of the fresh asphalt concrete lift, or defined from previous test results. The density of the support material shall be used as reference in performing the density test of a fresh asphalt concrete lift in accordance with the requirements ASTM D2950, placed over the support material. A density test of the support material shall be taken at the rate of one (1) test for each 500 sy of surface or less to be paved over in a day, as directed by the SDR. The density of the support material shall be reported as “reference support material density” in the compaction test report of the constructed asphalt concrete pavement over the area represented by the support material compaction test.

b. Compaction Tests

i. Compaction tests shall be taken at random locations on the asphalt being placed, as directed by the SDR. The three (3) general areas in which tests are to be taken are the free edge of the mat, mat interior, and the joints. The number of tests taken in each area will vary but the total number of tests taken on any project shall be in the following approximate proportions.

ii. Samples of the compacted Types S-III, S-IV, B, C, and D asphalt concretes may be taken and tested to determine compaction conformance of the finished pavement with the specified requirements either as requested by the CONTRACTOR, or as directed by the SDR. Cores shall be sampled and tested in accordance with 3.5.D, “Material Field Testing”.

TABLE 321216.02-116.G FIELD IN PLACE DENSITY PROPORTIONS	
Location	% of Total Tests
Free Edge of Mat[1] Mat Interior Joints[2]	20 to 33 33 to 60 20 to 33
Notes:	
1	The free Edge of Mat test shall be taken in the area between one (1) foot and two (2) feet in from a free edge of a lift.
2	Joints shall include the longitudinal and transverse butt joints between adjacent lifts of asphalt having the same finish elevation. Tests may be taken on material placed against a cold joint edge of formed surface.

E. TEST REPORTS

1. Test reports shall include but not be limited to the information specified in TABLE 321216.02-116.H – TEST REPORT.

2. Test results shall be reported to the SDR, CONTRACTOR, and the Supplier in writing, within 7 working days of completion of the sampling of the asphalt and/or the field testing. Non-complying tests shall be reported to the SDR, CONTRACTOR, and the Supplier within 1 working day of completion of the test.

TABLE 321216.02-116.H – TEST REPORT	
A.	Field Data and Test Results:
1.	Date of Sampling/Test
2.	SNL Project Number or Permit Number
3.	Project Title
4.	Asphalt Concrete Supplier
5.	Delivery Ticket Number (asphalt concrete sample – only)
6.	Job Mix Formula Number
7.	Location of Sample/Test as defined by Contract Documents
8.	Time of Sampling/Testing
9.	Material temperature at time of sampling, °F
10.	Ambient temperature at time of sampling, °F
11.	Field test results with reference specification limits (compaction test)
B.	Laboratory Test Results
1.	Laboratory results as defined in TABLE 321216.02-116.F
2.	Field Test Data, per 3.5.D, "Material Field Testing".
C.	Recommended Pay Adjustment Factor for a LOT
1.	C_{LM}, material factor, see TABLE 321216.02-116.J
2.	C_{LC}, placement/compaction factor, see TABLE 0321216.02-116.K

3. The New Mexico Registered Professional Engineer in direct charge of the laboratory shall certify on a quality assurance test report that the test procedures used to generate the report complied with the specifications.

3.5 Performance and Acceptance

A. If there are failing tests on the asphalt concrete for material properties, placement, compaction or thickness, the SDR may, at his discretion, direct the LOT to be removed and replaced with materials complying with the specifications at no cost to SNL/NM, or may make reductions in the amount paid to the CONTRACTOR for asphalt concrete paving as defined in 3.5.B. below. A LOT shall be defined as the total tonnage placed in a day, for each type of material placed.

B. Each LOT of asphalt concrete material shall be paid at an adjusted price, as determined by the schedule of values, for asphalt concrete calculated in accordance with the equation below and adjusted by a material factor, PFm, specified in TABLE 321216.02-116.J, as authorized by the SDR. Acceptance samples shall be sampled and tested in accordance with the requirements of 3.5.D. “Material Field Testing”, and tested for compliance with the specifications. A material pay factor, PFm, shall be determined in accordance with TABLE 321216.02-116.J, as defined for test results for combined aggregate gradation and asphalt content, as compared to the authorized job mix formula’s production specifications. All complying acceptance samples taken in a day for a material type shall represent a LOT in the computation specified in TABLE 321216.02-116.J. Non complying acceptance samples shall be evaluated in accordance with these specifications as directed by the SDR. The material factor, PFM, for a LOT shall be determined based on the deviation of the average value, arithmetic mean, M, of the acceptance samples’ test results from the job mix formula targets, T, adjusted for the range of the test results, maximum value minus the minimum value. If the absolute value of the deviation of the daily mean from the target is greater than the maximum allowable deviation, the LOT will be removed and replaced with materials complying with the specifications at no cost to the SNL/NM as directed by the SDR. If it is determined by the SDR to be more practical to accept the material under a specific project condition, the LOT may be accepted under written agreement between the SNL/NM and the CONTRACTOR at an assigned pay factor PFM=0.70, for a LOT having a compaction pay factor PFc, equal or greater than 0.85, as authorized by the SDR.

$$UP' = PF_M \times UP$$

UP’, Adjusted Unit Price/Ton

UP, Unit Price/Ton

PF_M, Material Adjustment Factor

<table>
<tr><td colspan="4">TABLE 321216.02-116.J – MATERIAL FACTOR, PF_M, FOR GRADATION & BINDER CONTENT</td></tr>
<tr><td>NUMBER OF DAILY SAMPLES</td><td colspan="3">For [T-M] equal or greater than D’, [1, 2]
D’, MAXIMUM ALLOWABLE DEVIATION [3]</td></tr>
<tr><td>1</td><td>1.40D</td><td>1.20D</td><td>D</td></tr>
<tr><td>2</td><td>D + R</td><td>D + 0.37R</td><td>D – 0.10R</td></tr>
<tr><td>3</td><td>D + 0.30R</td><td>D + 0.07R</td><td>D – 0.14R</td></tr>
<tr><td>4</td><td>D + 0.16R</td><td>D – 0.01R</td><td>D – 0.17R</td></tr>
<tr><td>5</td><td>D +0.11R</td><td>D – 0.03R</td><td>D – 0.20R</td></tr>
<tr><td>6</td><td>D + 0.09R</td><td>D – 0.05R</td><td>D – 0.22R</td></tr>
<tr><td>7</td><td>D + 0.07R</td><td>D – 0.07R</td><td>D – 0.24R</td></tr>
<tr><td>8</td><td>D + 0.06R</td><td>D – 0.08R</td><td>D – 0.25R</td></tr>
<tr><td>9</td><td>D + 0.05R</td><td>D – 0.09R</td><td>D – 0.26R</td></tr>
<tr><td>10 OR MORE</td><td>D + 0.04R</td><td>D – 0.10R</td><td>D – 0.27R</td></tr>
<tr><td>MATERIAL FACTOR PF_M [3]</td><td>0.85</td><td>0.95</td><td>1.00</td></tr>
<tr><td>[1]</td><td colspan="3">D, production tolerance +/- %, see TABLE 321216.02-116.B and Section 2.02 PROPORTIONING, and authorized job mix formula, R, range of test values, maximum – minimum values, M, average test value of a LOT’s samples test results, T, target value specified in the authorized job mix formula.</td></tr>
<tr><td>[2]</td><td colspan="3">If the deviation of the daily mean from the target exceeds the maximum allowable deviation for a LOT, [T-M]>D’, the LOT will be removed and replaced with material complying with this specification, at no cost to SNL/NM, as directed by the SDR. If determined by the SDR to be more practical to accept the material, the LOT may be accepted under written agreement between SNL/NM and the CONTRACTOR at an assigned pay factor PF_M = 0.70, for compaction LOT(s) having a compaction factor, PF_C, equal or greater than 0.85, as directed by the SDR.</td></tr>
<tr><td>[3]</td><td colspan="3">The material factor PF_m, shall be the lowest of the factors calculated for either the combined aggregate gradation of material passing the nominal maximum size aggregate screen, 3/8 inch, and smaller screens, or, the binder content.</td></tr>
</table>

C. The placement and compaction factor, PF_c, for a LOT shall be determined based on the average value of the compaction tests for the LOT, with any single test neither less than 90.0% nor greater than 98%, and TABLE 321216.02-116.K. If a test for a LOT is either less than 90.0% or greater than 98%, the LOT will be evaluated as directed by the SDR.

$$UP' = PF_c \times UP$$

UP’, Adjusted Unit Price

PF_c, see TABLE 321216.02-116.K

UP, Unit Price

<table>
<tr><th colspan="3">TABLE 321216.02-116.K – PAY FACTOR (PF $_C$) FOR COMPACTION</th></tr>
<tr><td colspan="2">Average of Acceptance Test Results</td><td>Pay Factor, PF $_c$</td></tr>
<tr><td colspan="2">98.0% and greater</td><td>[1]</td></tr>
<tr><td colspan="2">97.1 to 97.9</td><td>0.85</td></tr>
<tr><td colspan="2">93.0 to 97.0</td><td>1.00</td></tr>
<tr><td colspan="2">92.0 to 92.9</td><td>0.95</td></tr>
<tr><td colspan="2">91.0 to 91.9</td><td>0.90 [2]</td></tr>
<tr><td colspan="2">90.0 to 90.9</td><td>0.85 [2]</td></tr>
<tr><td colspan="2">Less than 90%</td><td>[1], [2]</td></tr>
<tr><td>[1]</td><td colspan="2">The material defined for the LOT shall be removed and replaced with asphalt concrete material complying with this Specification at no cost to SNL/NM, as directed by the SDR. Upon written agreement, the CONTRACTOR and SDR may determine that for practical purposes the LOT shall not be removed. If determined by the SDR to be more practical to accept a LOT, a LOT may be accepted under written agreement between SNL/NM and the CONTRACTOR at an assigned compaction pay factor PF c = 0.50 [2], for a LOT having a material pay factor equal or greater than 0.85, as directed by the SDR.</td></tr>
<tr><td>[2]</td><td colspan="2">When the lift is the surface course, and is accepted at this pay factor, the CONTRACTOR shall apply a sanded fog seal to the LOT complying with the applicable requirements of City of Albuquerque “Standard Specifications for Public Works Construction” SECTION 333 FOG SEAL, latest edition as directed by the SDR, at no cost to SNL/NM.</td></tr>
</table>

END OF SECTION 32 12 16.02

Exceptional service in the national interest

Sandia National Laboratories

Section 32 12 16.03 – Asphalt Concrete Installation

February 2018

Effective Date: 02/19/2018
Review Date: 02/19/2021

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 32 12 16.03 – Asphalt Concrete Installation

Table of Contents

Page

Tables

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Freeman Leaming	General	Updated format to 2004 CSI. Differentiated better between this spec and the asphalt concrete material spec including moving placement and compaction completely to this spec.
2/19/18	Tim Peterson	None	3-year review performed. No changes made.

Section 32 12 16.03 – Asphalt Concrete Installation

Part 1 – General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections: Refer to the following sections for related work.

1. Section 32 12 16.02, "Asphalt Concrete Material" for asphalt concrete material to be placed.

2. Section 32 12 16.01, "Paving Asphalt Binder" for asphalt binder used herein.

C. References:

1. City of Albuquerque "Standard Specifications for Public Works Construction", latest edition.

Section 113 Emulsified Asphalts
Section 117 Asphalt Rejuvenating Agents
Section 118 Hydrated Lime Filler
Section 336 Asphalt Concrete Pavement

1.2 Summary

A. Section Includes: Installation (placement, compaction, etc.) and field testing relating to installation of a delivered asphalt concrete material. It does not include the mix design, material testing, furnishing, and delivery of asphalt concrete ready for placement. That is covered in Section 32 12 16.02, "Asphalt Concrete Material".

B. Asphalt concrete pavement shall consist of a mixture of mineral aggregate and asphalt binder, placed and compacted on either a prepared subgrade, or base, or asphalt concrete pavement, in conformity with the lines, grades, and dimensions shown on the plans or as specified in the supplementary Specifications, and this specification. The asphalt concrete including materials, mixing, and hauling shall comply with the requirements of SNL/NM Standard Specification Sections 32 12 16.01, "Paving Asphalt Binder" and 32 12 16.02, "Asphalt Concrete Material" and the supplementary technical specifications. The CONTRACTOR shall be solely responsible for the asphalt concrete pavement supplied under section 32 12 16.02, placement, and compaction.

C. For construction and reconstruction street projects requiring asphalt concrete pavement placement equal or greater than either 500 tons of asphalt concrete per day, the CONTRACTOR shall have a full time asphalt pavement construction supervisor on site to direct the asphalt concrete pavement construction during test sections and pavement construction operations. The supervisor shall be certified under the New Mexico State Highway and Transportation Department/Associated Contractors of New Mexico Technical Training and Certification Program for ASPHALT and SUPERPAVE™. The supervisor shall be identified by the CONTRACTOR at the preconstruction meeting and shall be the contact person for the SDR during asphalt concrete pavement construction. Supervisor certification shall be made available to the SDR upon request.

D. At the direction of the SDR, a Pre-Paving Conference shall be held no later than seven calendar days prior to the start of asphalt concrete pavement construction. The meeting agenda/assigned responsibilities shall be accomplished at the conference.

I. ENGINEER/OWNER (SNL/NM)
   A. Scope of the project.
   B. Identify construction management team and contact telephone numbers.
   C. Review CONTRACT requirements for asphalt pavement construction.
   D. Review Quality Assurance Program.

II. CONTRACTOR
   A. Review pavement construction schedules.
      1. Test strip location and placement schedules if required by the contract.
      2. Proposed pavement construction schedule for duration of the project.
   B. Identify Construction personnel and contact telephone numbers.
      1. Contractor Staff
      2. Sub-Contractor(s)
      3. Supplier(s)
      4. Safety Manager
   C. Present construction placement procedure plans.
      1. Equipment Schedule
      2. Asphalt Concrete Job Mix Formula
      3. Paving Methodology
      4. Traffic Control Plan
      5. Quality Control Plan

III. DISCUSSION AND COMMENT

1.3 Definitions

C. SNL/NM: Sandia National Laboratories New Mexico Site

D. SDR: Sandia Delegated Representative

Part 2 – Products

2.1 Materials

A. ASPHALT CONCRETE

Asphalt concrete shall be placed at the design proportions specified in the authorized job mix formula, within the specified production tolerances for combined aggregate gradation and asphalt binder content. Asphalt concrete placed at a project, sampled and tested in accordance with this specification, shall have a gradation that complies with the authorized design gradation ± the production tolerance(s) specified in the authorized job mix formula. Asphalt concrete placed at a project, sampled and tested in accordance with this specification, shall have an asphalt content that complies with the design asphalt content ± 0.5% (laboratory analysis).

B. PRIME AND TACK COAT

1. Prime coat shall comply with the requirements of COA Section 113 except that if the prime contract between SNL and the CONTRACTOR is Firm Fixed price or Variant of a Firm Fixed Price 113.6 MEASUREMENT AND PAYMENT shall not apply. Prime Coat shall be applied to subgrade, aggregate base course, and concrete treated base course a minimum of 12 hours prior to placing the asphalt concrete pavement, as directed by the SDR. Traffic shall not be permitted on the prime coat prior to construction of the asphalt concrete pavement.

2. Immediately prior to prime coat application, an inspection of the surface shall be made by the SDR. The surface to be primed shall be in a uniform and well compacted condition, true to grade and cross section. All loose and foreign material shall be removed by light sweeping prior to application. Loose material shall not be mixed with asphalt concrete.

3. Prime coat shall be applied uniformly at the rate of 0.10 to 0.30 gallon per square yard. It shall be applied when the air temperature is 40ºF and rising, as authorized by the SDR.

4. In order to prevent lapping at the joint of two applications, the distributor shall be promptly shut off. A hand spray shall be used to touch up all spots missed by the distributor.

5. The pressure distributor used for applying prime coat material shall be equipped with pneumatic tires and shall be so designed and operated as to distribute the prime material in a uniform spray without atomization, in the amount and between the limits of temperature specified. It shall be equipped with a speed tachometer registering feet per minute and so located as to be visible to the truck driver to enable him to maintain the constant speed required for application at the specified rate.

6. The pressure distributor shall be equipped with a tachometer registering the pump speed pressure gauge, and a volume gauge. The rates of application shall not vary from the rates specified by more than 10 percent. Suitable means for accuracy indicating at all times the temperature of the prime material shall be provided. The thermometer well shall be so placed as not to be in contact with a heating tube.

7. The distributor shall be so designed that the normal width of application shall be not less than 6 feet, with provisions for the application "of lesser width" when necessary. If the distributor is equipped with heating attachments, the prime coat material shall be circulated or agitated to provide the application temperature specified by the manufacturer.

8. If the prime coat has not been completely absorbed prior to the start of placing the asphalt concrete pavement, sufficient sand shall be spread over the surface to blot the excess and prevent tracking under traffic. Sand shall be applied as directed by the SDR. Prior to placing the asphalt concrete pavement, loose or excess sand shall be swept from the base. If a sand cover is specified in the Supplementary Specifications or noted on the drawings to cover a prime coat, it shall be applied within 4 hours after the application of prime coat, as authorized by the SDR.

9. A prime coat shall be prevented from spraying upon adjacent pavements, structures, guard rails, guide posts, culvert markers, trees, and shrubbery that are not to be removed; adjacent property and improvements; and other facilities or that portion of the traveled way being used by traffic.

10. The CONTRACTOR shall protect a prime coat against all damage and markings, both from foot and other traffic. Barricades shall be placed where necessary to protect a prime coat. Damaged prime coat shall be repaired by the CONTRACTOR, at his expense. Asphalt concrete pavement shall not be placed until a prime coat has been accepted by the SDR.

C. TACK COAT

1. If the asphalt concrete pavement is being constructed directly upon an existing hard surfaced pavement, a tack coat shall be evenly and uniformly applied to existing pavement preceding the placing of the asphalt concrete, as directed by the SDR. The surface shall be free of water, all foreign material, or dust when the tack coat is applied. No greater area shall be treated in any one day than will be covered by the asphalt concrete during the same day. Traffic will not be permitted over tack coat.

2. Tack coat shall consist of cationic emulsified asphalt as specified in COA Section 113 except that if the prime contract between SNL and the CONTRACTOR is Firm Fixed price or Variant of a Firm Fixed Price 113.6 MEASUREMENT AND PAYMENT shall not apply.. Application rate shall be 0.03 to 0.12 gallon per square yard.

3. A tack coat shall be applied to the surface of any course if, in the opinion of the SDR, the surface is such that a satisfactory bond cannot be obtained between it and the succeeding course.

4. The contact surfaces of all cold pavement joints, curbs, gutters, manholes, and the like shall be painted with a tack coat immediately before the adjoining asphalt concrete is placed. Surfaces where a tack coat is required shall be cleaned of all loose material before the tack coat is applied.

Part 3 – Execution

3.1 Placement

A. Asphalt concrete may be placed when the ground temperature is 40ºF and rising and the weather is favorable, as authorized by the SDR. Quiet asphalt concrete and plant mixed seal coat may be placed when the pavement temperature is 60ºF and rising, and the weather is favorable to construction, as authorized by the SDR. Materials may not be placed in either wet weather, or on a wet or damp surface, or on frozen supporting material.

B. An asphalt concrete pavement lift shall be placed uniformly, at a temperature within the compaction range specified in the authorized job mix formula, without segregation, to such a depth that after compaction it will comply with the specified cross section and grade, specified in the plans and specifications. The temperature of the mat shall be in a uniform range of 15ºF transverse the mat after placement behind the paver. Asphalt concrete shall be placed and compacted in uniform layers/lifts, ± 3/16 inch in 10 feet of the lift finish grade. The compacted thickness of a layer/lift shall be equal or greater than two (2) times the maximum size aggregate but less than or equal 4.0 inches for SP-II aggregate gradations. The compacted thickness of a layer/lift shall be equal or greater than two (2) times the maximum size aggregate, but less than or equal to 3 inches for Types SP-III, SP-IV, B, C, and D aggregate gradations. Pavement lift thickness shall be selected to use the maximum size aggregate. Lift thickness (es) and asphalt concrete type, designating the maximum nominal size aggregate, shall be either specified in the CONTRACT documents, or as directed by the SDR. SP-II gradation mixes shall not be used for the surface course.

C. Placement shall be continuous, without interruption. No greater amount of the mixture shall be delivered in any one day than can be placed, compacted and finished that same day.

D. No asphalt concrete surface course shall be placed which cannot be finished within daylight hours of the same day it is laid unless authorized by the SDR.

E. In narrow, deep, irregular sections, intersections, turning radiuses, turnouts, cul de sacs, or driveways, where it is impractical to spread and finish the base and level the surface mixtures by machine methods, the CONTRACTOR may use placement equipment or acceptable hand methods, as authorized by the SDR. The CONTRACTOR shall place material in lifts a specified and not exceed the limits of depth of the compaction equipment. Hand placed and compacted material shall be placed in lifts not greater than 2 inches maximum compacted depth. The finish surface shall be checked with a

10 feet straight edge, true and level to the adjacent asphalt concrete pavement. Humps shall be milled true and level and depressions shall be filled and finished to comply with this specification.

F. Pavement cuts of 10 feet or more in width and 100 feet or more in length must be paved with an approved bituminous paving machine. Asphalt concrete should be placed with a paving machine for all sections if a paver is available.

G. Depositing and spreading of the Asphaltic concrete shall be accomplished by means of a bituminous paver except as specified in 3.01 Placement Subpart E. Bituminous pavers shall be self-contained, self-propelled units, provided with an automated leveling activated screed or a strike off assembly, with heating capabilities, and capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the lifts and thickness specified in the plans and specifications. Pavers shall be free of fluid leaks. Pavers detected to have leaks shall not be allowed on the project.

H. The paver shall be equipped with a receiving hopper having sufficient capacity for uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed. The hopper shall be operated at 50% or greater capacity during paving operations. Paving shall not be allowed when the hopper is at less than 50% capacity.

I. The screed or strike off assembly shall effectively produce a uniform surface and texture without tearing, shoving or gouging the mixture. The paver shall be operated at a forward speed consistent with satisfactory laying of the mixture.

J. The paver shall be operated with an automatic leveling device controlled from an external guide, approved by the SDR. The screed shall be zeroed by the CONTRACTOR on a template or blocks set to the same depth as the loose mat behind the paver, prior to start of placement of each lift of a material, as directed by the SDR. Verification of the target loose lift thickness shall be made at regular intervals during the placement. The loose lift thickness, lift thickness behind the paver shall be defined by the CONTRACTOR and reported to the SDR for reference prior to startup of a lift placement. Broadcasting of excess edge material over the surface of a pre-compacted lift shall not be permitted.

3.2 Compaction

A. Asphalt concrete compaction shall begin when the asphalt concrete temperature is in the compaction temperature range specified in the authorized job mix formula. Compaction shall be completed before the temperature of the material cools to less than 200ºF. Compaction may be allowed on material with a temperature less than 200ºF and greater than 185ºF, as authorized by the SDR. Compaction on a lift shall not be allowed when the temperature of the lift is less than 185ºF. The material shall be compacted to a density of at least 93% and not greater than 97% of the theoretical maximum density as determined by ASTM D2041.

B. The CONTRACTOR shall be responsible for the development and implementation of the compaction program. A reference compaction program shall be defined by the CONTRACTOR, to include equipment type and description, and procedures, reported in writing to the SDR for each job mix formula/lift thickness to be used on a project. Changes in the compaction program shall be reported to the SDR as they may occur.

C. A CONTRACTOR may construct a test strip, a minimum of 10 feet wide and 250 feet long, to establish the rolling pattern for an asphalt mix and lift thickness to be placed on a project, as directed by the SDR. The test strip shall be paid for in accordance with the requirements of the CONTRACT, as authorized by the SDR.

D. Compaction equipment shall be steel wheeled, pneumatic wheeled, and hand plate tampers, free of fluid leaks, selected by the CONTRACTOR, and authorized by the SDR. Compaction equipment detected to have leaks shall not be allowed on the project.

E. Compaction may be either static or dynamic (vibratory). All equipment shall be ballasted and operated as recommended by the manufacturer. Motorized wheeled dynamic (vibratory) compaction equipment shall have the frequency rate and amplitude setting readily available for review by the SDR. Frequency rate and amplitude adjustability shall be operable on so equipped motorized wheeled dynamic (vibratory) compaction equipment. Motorized compaction equipment with inoperable frequency rate and amplitude adjustment features shall not be used on the project.

F. Motorized compaction equipment shall be equipped with automatic wheel spray systems to apply release agents to prevent tracking of asphalt concrete. Diesel fuel or other petroleum based solvents shall not be used as a release agent to prevent buildup of the asphalt material. Material contaminated with diesel fuel or other petroleum based solvents shall be removed and replaced with complying material by the CONTRACTOR, as directed by the SDR, at no cost to SNL/NM.

G. Repair and replacement of damaged adjacent property and structures, resulting from the use of vibratory rolling equipment, shall be the responsibility of the CONTRACTOR, at no cost to SNL/NM.

3.3 Joints

A. Care shall be exercised in connection with the construction of joints to insure that the surface of the pavement is true to grade and cross section across the joint. Periodically, joints shall be tested with a 10 feet straight edge to verify the smoothness of the surfaces of adjacent material(s). A 10 feet long straight edge shall be placed perpendicular to the joint extending equally on both sides of the joint. The smoothness of the surfaces across the joint shall comply with the requirements of this specification.

B. After construction of a joint along any adjoining edge such as a curb, gutter, or an adjoining pavement lift free edge, and after the hot mixture is placed by the finishing machine, sufficient hot material shall be carried back to fill any space left open. This joint shall be properly “SET UP” with the back of a rake at proper height and level to receive the maximum compaction. The work of "setting up" this joint shall be performed by competent workmen who are capable of making a correct, clean, and neat joint. Excess material shall be removed. Broadcasting excess material onto the adjacent asphalt concrete pavement surface will not be allowed. Excess material at an edge joint shall be removed and discarded if not required for compaction.

C. Longitudinal and transverse joints shall be made in a careful manner. Well bonded and sealed joints are required. Joints between old and new pavements or between successive day's work shall be carefully made in such a manner as to insure a thorough and continuous bond between the old and new surfaces. In the case of surface course, the edge of the old surface course shall be cut back for its full depth so as to expose a fresh surface and, if necessary to obtain a well bonded joint, shall be painted with a tack coat after which the hot surface mixture shall be placed in contact with it and raked to a proper depth and grade. Before placing mixture against contact surfaces of curbs, gutters, headers, manholes, etc., they shall be painted with a tack coat. Joints shall be tested with a 10 feet straight edge to verify the smoothness of the surfaces transition of adjacent material(s). A 10 feet long straight edge shall be placed perpendicular to the joint extending equally on both sides of the joint. The smoothness of the surfaces across the joint shall comply with the requirements of this specification. Longitudinal and transverse joints shall be compacted parallel to the joint. Transverse and longitudinal joints shall be staggered a minimum of 1 foot offset from the joint of a lift either below or above, and completely bonded.

3.4 Pavement Penetrations, Manholes, and Valve Covers

A. Manhole frames and valve covers shall be adjusted as per the Standard Drawings, or as directed by the SDR. The finish surface at the top of all asphalt concrete pavement penetrations, to include but not be limited to manhole frames and valve covers, shall be constructed to and be parallel in all directions the finish surface of the surrounding asphalt concrete pavement prior to placing the surface course.

3.5 Smoothness

A. Upon completion, the pavement shall be true to grade and cross section. Except any changes of grade, when a 10 feet straight edge is laid on the finished surface of the roadway, the surface shall not vary from the edge of the straightedge more than 3/16 inch. After the completion of final rolling, the smoothness of the course shall be checked, and the irregularities that exceed the specified tolerances and/or retain water on the surface shall be corrected by the CONTRACTOR at no cost to the OWNER (SNL/NM), as directed by the SDR.

3.6 Sampling and Testing

A. Asphalt concrete tests shall be performed in accordance with the requirements of this specification, the Supplemental Technical Specifications, or as directed by the SDR. Asphalt concrete analysis shall be performed in a laboratory accredited in accordance with the requirements of the New Mexico State Highway and Transportation Department "Procedure for Approval of Testing Laboratories to Perform Inspection, Testing, and Mix Design Services", April 13, 1998 Edition. Testing equipment used in the performance of specified testing shall be calibrated annually with calibration standards traceable to the National Bureau of Standards. Certification records shall be maintained at the Laboratory for review by the SDR. A copy of the certifications shall be submitted to the SDR upon request. The sampling and testing shall be performed by a technician certified under the New Mexico State Highway and Transportation Department/Associated Contractors of New Mexico Technical Training and Certification Program for ASPHALT and SUPERPAVE™.

B. Material Sampling: A quality assurance asphalt concrete material field sample shall be taken in accordance with the requirements of ASTM D979 for each job mix delivered. The materials shall be sampled at the greater rate of either one sample for each 250 tons, or one sample per day, for each typed of material placed on a project, as directed by the SDR. The sample shall be of such size to provide material for all tests specified and a split sample to perform verification/referee tests for gradation and binder content, if required.

C. MATERIAL TESTING

1. Asphalt concrete quality assurance sampling and testing shall be performed in accordance with the requirements of this Specification, the Supplemental Technical Specifications, or as directed by the SDR.

2. A quality assurance asphalt concrete sample shall be sampled, tested, and reported in accordance with the requirements and procedures of SNL/NM Standard Specification 32 12 16.02, "Asphalt Concrete Material", Section 3.4 MATERIAL SAMPLING AND TESTING.

3. A CONTRACTOR may challenge production material test results, binder content and aggregate gradation, and request that the retained split asphalt concrete sample of record be released to his assigned laboratory and tested for compliance, as authorized by the SDR. A challenge notification shall be made in writing to the SDR by the CONTRACTOR within 28 calendar days from date of sampling. Challenge test results shall be submitted to the SDR for evaluation no later than 42 calendar days from date of sampling. Challenge test results will be evaluated in accordance with the "multi-laboratory" precision tolerances specified, T53 for binder content, ASTM C117 and C136 for aggregate gradation. Challenge and record test results that comply with precision tolerances will be averaged with the companion test results of record and the material pay factor, Pm_f, recalculated as directed by the SDR. Challenge and record test results that do not comply with the precision tolerances will direct the disqualification of the challenged and record samples, as directed by the SDR. Cut/core sample(s) will be taken from the area(s) represented by the disqualified challenge samples(s) and evaluated by the lab of record under the observation of the CONTRACTOR, in accordance with the requirements of these specifications and replace the disqualified sample test results. Analysis of the replacement cut/core sample(s) may not be challenged. The CONTRACTOR will submit challenge test results in writing to the SDR for each split sample released to his assigned laboratory of record. Challenges filed after the time limitations will not be considered. SNL/NM shall pay for all complying tests.

D. COMPACTION TESTING

1. Asphalt concrete pavement quality assurance compaction sampling and testing shall be performed in accordance with the requirements of this specification, the Supplemental Technical Specifications, as directed by the SDR. Each lift, for each type of asphalt concrete pavement placed each day, shall be tested for compaction.

2. An asphalt concrete pavement compaction test shall be performed in accordance with the requirements of this specification, as directed by the SDR. A test shall determine the compaction at a location of a freshly constructed asphalt concrete roadway lift. Compaction shall be calculated as the field density at a location of a LOT lift, determined by the applicable methods allowed in this specification, divided by the average of the maximum theoretical density (G_{mm}) of the acceptance sample(s) taken for that day's placement, reported to the nearest one tenth of a percent, xxx.x%. A maximum theoretical density (G_{mm}) shall be determined in accordance with ASTM D2041.

3. The field density at a location for a lift of SP-II material shall be determined from a core sample. One core sample shall be taken for each lift of 250 tons, or fraction thereof, placed each day, but not less than 3 cores per day, as directed by the SDR. The density of a core shall be determined in accordance with the requirements of ASTM D2726 and reported to the nearest one-tenth pound per cubic foot.

4. FIELD COMPACTION TESTING

   a. The field compaction at a location for Type B, C, D, E, SP-III, and SP-IV materials, shall be measured in accordance with the requirements of ASTM D2950 Density of Bituminous Concrete in Place by Nuclear Methods, at the minimum rate of three tests per lift of 500 sy, or fraction thereof, for each type of asphalt material placed in a day, as directed by the SDR.

   b. A reference density test of the support material, for the asphalt concrete roadway lift to be constructed, shall be taken prior to the placement of the fresh asphalt concrete lift, or defined from previous test results. The density of the support material shall be used as reference in performing the density test of a fresh asphalt concrete lift in accordance with the requirements ASTM D2950, placed over the support material. A density test of the support material shall be taken at the rate of one (1) test for each 500 sy of surface or less to be paved over in a day, as directed by the SDR. The density of the support material shall be reported as "reference support material density" in the compaction test report of the constructed asphalt concrete pavement over the area represented by the support material compaction test.

   c. Core samples of the compacted asphalt pavement of SP-III, SP-IV, B, C, D, and E asphalt concrete, may be taken and tested to determine conformance of the finished pavement with the specified requirements either as requested by the CONTRACTOR, as directed by the SDR. Samples shall be taken and tested in accordance with the requirements of ASTM D2726 and ASTM D3203 at the rate of three (3) core samples per LOT lift, as directed by the SDR, and paid by the OWNER (SNL/NM). Compaction determined from cores shall supersede tests performed in accordance with the requirements ASTM D2950. The CONTRACTOR shall be responsible for asphalt concrete pavement replacement at no cost to the OWNER (SNL/NM) where core samples are taken. The OWNER (SNL/NM) shall pay for all complying tests.

5. Field compaction tests shall be taken at random locations on an asphalt concrete pavement lift, as directed by the SDR. Three (3) general areas at which a test should be taken are either adjacent to the free edge of the mat, or the mat interior, or adjacent to a joint. The number of tests taken will vary but the total number of tests taken on any project shall be in the approximate proportions specified in TABLE 321216.03-336A.

6. Testing shall be as follows:

TABLE 321216.03-336A – Asphalt Concrete Pavement Lift Compaction Test Location Proportions

Location	% of Total Tests
Free Edge of Mat[1]	20 to 33
Mat Interior	33 to 60
Joints[2]	20 to 33

NOTES:

1 The Free Edge of Mat test shall be taken in the area between one (1) foot and two (2) feet inform a free edge of a lift.

2 Joints shall include the longitudinal and transverse butt joints between adjacent lifts of asphalt having the same finish elevation. Tests may be taken on material placed against a cold joint edge of formed surface.

7. Full depth cores of asphalt concrete shall be taken to determine the depth of structure and the depth pay factor, $PF_{1)}$, defined in TABLE 321216.03-336E, as directed by the SDR. A minimum of three (3) cores, having an outside diameter equal or greater than four (4) inches, shall be taken at random for each 1000 sy, or fraction thereof, placed. Cores shall be evaluated in accordance with the requirements of 3.7 PAYMENT ADJUSTMENT FOR FAILING TESTS. The core length, depth of the pavement, shall be determined based on the average of three measurements of the length of the core, measured from circular ends of a sample. All measurements shall be reported to the nearest 0.125” (1/8 inch). Plant mixed seal coat shall not be included in the depth of structure.

E. TEST REPORTS

1. REPORT FORMAT

TABLE 321216.03-336B – TEST REPORT(s)	
A	Field Data and Test Results:
1	Date of Sampling/Test
2.	SNL Project Number or Permit Number
3.	Project Title
4.	Asphalt Concrete Supplier
5.	Delivery Ticket Number (asphalt concrete sample-only)
6.	Job Mix Formula Number
7.	Location of Sample/Test as Defined by Contract Documents
8.	Time of Sampling/Testing
9.	Material Temperature at Time of Sampling, °F
10.	Ambient Temperature at Time of Sampling, °F
11.	Field Test Results with Reference Specification Limits (compaction test)
B.	Laboratory Test Results
1.	Laboratory Results as defined in TABLE 116.F (asphalt concrete material)
2.	Field Test Data as required in COA 336.11.4 (compaction reports)
3.	Pavement Structure Depth (individual cores and average depths for LOT)
C.	Recommended Pay Adjustment Factor for a LOT
1.	C_{LM}, Material Factor, see TABLE 321216.03-336C
2.	C_{LC}, Placement/Compaction Factor, see TABLE 321216.03-336D
3.	$PF_{1)}$, Depth Factor, see TABLE 321216.03-336E.

2. Test results shall be reported to the SDR, CONTRACTOR, and Supplier in writing, within 7 working days of completion of the sampling of the asphalt and/or the field testing. Non-complying test shall be reported to the SDR, CONTRACTOR, and Supplier within 1 working day of completion of the test.

3. The New Mexico Registered Professional Engineer in direct charge of the laboratory shall certify on a quality assurance test report that the test procedures used to generate the report complied with the specifications.

3.7 Payment and Adjustment for Failing Tests

A. If there are failing tests on the asphaltic concrete for material properties, placement, compaction or thickness, the SDR may, at his discretion, make reductions in the amount paid to the CONTRACTOR for asphaltic concrete paving as determined in B. PAYMENT ADJUSTMENTS below:

B. PAYMENT ADJUSTMENTS

1. Asphalt concrete pavement placed in an area of 10 feet or more in width and 100 feet or more in length (requiring machine laydown) shall be divided into LOTS and paid at the unit price, as determined by the schedule of values, and as adjusted as specified in this section, as authorized by the SDR.

2. Asphalt concrete pavement placed in an area less than 10 feet in width and/or less than 100 feet in length shall be paid at the adjusted unit price, as determined by the schedule of values, and as adjusted as specified in this section, as authorized by the SDR.

3. A LOT of asphalt concrete pavement shall be paid at a unit price, as determined by the schedule of values, equal to the sum of the unit prices of its SUBLOTS, each lift of asphalt in a LOT, the sum adjusted for deviation of full depth of structure from CONTRACT specification. The unit price for a LOT shall be calculated in accordance with the equation below.

$$UP^1 = PF_D \text{ x } UP_{SUBLOTS}$$

UP^1 LOT Unit Price
PF_D Depth Factor defined in TABLE 321216.03-336.D
$UP_{SUBLOTS}$, $UP'_{SLI} + UP'_{SL2} + \ldots + UP_{SLN}$, sum of SUBLOTS' unit prices, see COA 336.11.2.2

4. A SUBLOT, a lift of asphalt concrete in a LOT, shall be paid at the adjusted unit price determined in accordance with the equation below:

$$UP'_{SLN} = F_N \text{ x } UP_{SLN}$$

F_N, 0.5 x ($C_{LM} + C_{LC}$), SUBLOT Adjustment Factor
C_{LM} Material Factor, see TABLE 321216.03-336.C
C_{LC}, Placement/Compaction Factor, See TABLE 321216.03-336.D
UP_{SLN}, Unit Price, as determined by the schedule of values, for a SUBLOT

d. The material factor, C_{LM}, is the material acceptance factor for a SUBLOT determined in accordance with TABLE 321216.03-336.C, based on the absolute value of the deviation of the average value, or arithmetic mean (M), of the daily acceptance sample(s) test results for the SUBLOT, deviation from the CONTRACT authorized job mix formula targets (T), for either combined aggregate gradation or binder content.

e. If the deviation is equal or less than the allowable deviation, D', the corresponding material pay factor, C_{LM}, shall be used.

f. The SUBLOT placement/compaction factor, C_{LC}, shall be defined in accordance with TABLE 321216.03-336.D, as directed by the SDR. The factor is determined based on the average of the compaction tests taken for a SUBLOT, with no single test neither less than 90.0% nor greater than 97.9%. Acceptance compaction tests shall be performed in accordance with the requirements of this specification. A SUBLOT having a compaction test(s) either less than 90.0% or greater than 97.9% shall be evaluated and an appropriate pay factor assigned, as directed by the SDR.

g. The depth factor, PF_D, shall be defined in accordance with TABLE 321216.03-336.E, based on the average depth of a minimum of three full depth cores taken at random for each 1000 sy, or fraction thereof, with no single core less than the specified section depth less 0.75 in. (19 mm), as directed by the SDR. If core(s) are identified at a depth less than 0.75 in (19b mm), additional cores shall be taken to verify the condition. The condition shall be evaluated and either an appropriate pay factor assigned or the asphalt concrete pavement removed and replaced with complying pavement, as directed by the SDR.

TABLE 321216.03-336C – MATERIAL FACTOR, C_{LM}, FOR GRADATION & ASPHALT BINDER CONTENT

NUMBER OF DAILY SAMPLES	D', MAXIMUM ALLOWABLE DEVIATION [1, 2, 3]		
1	1.40D	1.20D	D
2	D + R	D + 0.37R	D – 0.10R
3	D + 0.30R	D + 0.07R	D – 0.14R
4	D + 0.16R	D - 0.01R	D – 0.17R
5	D + 0.11R	D - 0.03R	D – 0.20R
6	D + 0.09R	D – 0.05R	D – 0.22R
7	D + 0.07R	D – 0.07R	D – 0.24R
8	D + 0.06R	D – 0.08R	D – 0.25R
9	D + 0.05R	D – 0.09R	D – 0.26R
10 OR MORE	D + 0.04R	D – 0.10R	D – 0.27R
MATERIAL FACTOR, C_{LM} [3]	0.85	0.95	1.00

[1] D, production tolerance ± %, see COA 336.5.1.2, and authorized job mix formula; R, of test values, maximum – minimum values; M, average test value of a SUBLOT's acceptance samples test results; T, target value specified in authorized job mix formula.

[2] The material factor, C_{LM}, shall be the lowest factor selected for $|T\text{-}M| \leq D'$ calculated for either (a) the combined aggregate gradation and material passing the nominal maximum size aggregate screen, 3/8 inch (9.5 mm), and smaller screens of the project authorized job mix formula, or (b) the asphalt binder content.

[3] If the absolute value of the deviation of the daily mean from the target exceeds the maximum allowable deviation a SUBLOT, $|T\text{-}M| \geq D'$, the SUBLOT shall be removed and replaced with material complying with this specification, at no cost to the OWNER (SNL/NM), and directed by the SDR. If it is determined by the Sedro be more practical to accept the SUBLOT material, it may be accepted under written agreement between the OWNER (SNL/NM) and the CONTRACTOR, at an assigned pay factor, $C_{LM} = 0.70$, for a SUBLOT having a compaction factor, $C_{LC} \geq 0.90$, as directed by the SDR.

TABLE 321216.03-336D – SUBLOT PLACEMENT/COMPACTION FACTOR, C_{LC}

Average Test Results	Factor, C_{LC}
98.0% and greater	[1]
97.1 to 97.9	0.85
93.0 to 97.0	1.00
92.0 to 92.9	0.95
91.0 to 91.9	0.90 [2]
90.0 to 90.9	0.85 [2]
less than 90.0%	[1], [2]

[1] The lift defined for the SUBLOT shall be removed and replaced by the CONTRACTOR with asphalt concrete pavement complying with this specification at no cost to the OWNER (SNL/NM), as directed by the SDR. If it is determined by the SDR to be more practical to accept the SUBLOT, it may be accepted under written agreement between the OWNER (SNL/NM) and the CONTRACTOR at an assigned compaction pay factor, $C_{LC} = 0.50$, for the SUBLOT, if the SUBLOT has a material pay factor $C_{LM} \geq 0.85$, as authorized by the SDR.

[2] When the lift accepted at this factor is a final surface course of a street having a posted speed limit less than 40 mph, the lift shall have a FOG SEAL applied and sanded by the CONTRACTOR at no cost to the OWNER (SNL/NM), as directed by the SDR.

TABLE 321216.03-336E DEPTH FACTOR, PF_D

Deficient Pavement Depth					PF_D
0	$\leq$	$D_S - d_A$	$\leq$	0.25 in (6 mm)	1.00
0.25 in (6 mm)	$<$	$D_S - d_A$	$\leq$	0.50 in (12.5 mm)	$(d)^2/(D)^2$
		$D_S - d_A$	$>$	0.50 in (12.5 mm)	[A]
Excessive Pavement Depth, d-D					PF_D
		$D_S - d_A$	$<$	0	1.00

NOTES:

- d_A average depth of the pavement structure as determined by field cores
- D_S specified depth of the pavement structure of a LOT
- [A] Correct deficiencies at no cost to the OWNER (SNL/NM), as directed by the SDR, constructing the pavement to the depth, grade, crown, and cross slope drainage, specified in the CONTRACT documents.

END OF SECTION 32 12 16.03

Exceptional service in the national interest

Sandia National Laboratories

Section 32 12 16.03 – Asphalt Concrete Installation

February 2018

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Review Date: 02/19/2021

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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Sandia National Laboratories

Section 32 12 16.03 – Asphalt Concrete Installation

Table of Contents

Tables

Change Log

Date	Changes Made By	Type	Change Description
4/18/16	Freeman Leaming	General	Updated format to 2004 CSI. Differentiated better between this spec and the asphalt concrete material spec including moving placement and compaction completely to this spec.
2/19/18	Tim Peterson	None	3-year review performed. No changes made.

Section 32 12 16.03 – Asphalt Concrete Installation

Part 1 – General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections: Refer to the following sections for related work.

1. Section 32 12 16.02, "Asphalt Concrete Material" for asphalt concrete material to be placed.

2. Section 32 12 16.01, "Paving Asphalt Binder" for asphalt binder used herein.

C. References:

1. City of Albuquerque "Standard Specifications for Public Works Construction", latest edition.

Section 113 Emulsified Asphalts
Section 117 Asphalt Rejuvenating Agents
Section 118 Hydrated Lime Filler
Section 336 Asphalt Concrete Pavement

1.2 Summary

A. Section Includes: Installation (placement, compaction, etc.) and field testing relating to installation of a delivered asphalt concrete material. It does not include the mix design, material testing, furnishing, and delivery of asphalt concrete ready for placement. That is covered in Section 32 12 16.02, "Asphalt Concrete Material".

B. Asphalt concrete pavement shall consist of a mixture of mineral aggregate and asphalt binder, placed and compacted on either a prepared subgrade, or base, or asphalt concrete pavement, in conformity with the lines, grades, and dimensions shown on the plans or as specified in the supplementary Specifications, and this specification. The asphalt concrete including materials, mixing, and hauling shall comply with the requirements of SNL/NM Standard Specification Sections 32 12 16.01, "Paving Asphalt Binder" and 32 12 16.02, "Asphalt Concrete Material" and the supplementary technical specifications. The CONTRACTOR shall be solely responsible for the asphalt concrete pavement supplied under section 32 12 16.02, placement, and compaction.

C. For construction and reconstruction street projects requiring asphalt concrete pavement placement equal or greater than either 500 tons of asphalt concrete per day, the CONTRACTOR shall have a full time asphalt pavement construction supervisor on site to direct the asphalt concrete pavement construction during test sections and pavement construction operations. The supervisor shall be certified under the New Mexico State Highway and Transportation Department/Associated Contractors of New Mexico Technical Training and Certification Program for ASPHALT and SUPERPAVE™. The supervisor shall be identified by the CONTRACTOR at the preconstruction meeting and shall be the contact person for the SDR during asphalt concrete pavement construction. Supervisor certification shall be made available to the SDR upon request.

D. At the direction of the SDR, a Pre-Paving Conference shall be held no later than seven calendar days prior to the start of asphalt concrete pavement construction. The meeting agenda/assigned responsibilities shall be accomplished at the conference.

I. ENGINEER/OWNER (SNL/NM)
   A. Scope of the project.
   B. Identify construction management team and contact telephone numbers.
   C. Review CONTRACT requirements for asphalt pavement construction.
   D. Review Quality Assurance Program.

II. CONTRACTOR
   A. Review pavement construction schedules.
      1. Test strip location and placement schedules if required by the contract.
      2. Proposed pavement construction schedule for duration of the project.
   B. Identify Construction personnel and contact telephone numbers.
      1. Contractor Staff
      2. Sub-Contractor(s)
      3. Supplier(s)
      4. Safety Manager
   C. Present construction placement procedure plans.
      1. Equipment Schedule
      2. Asphalt Concrete Job Mix Formula
      3. Paving Methodology
      4. Traffic Control Plan
      5. Quality Control Plan

III. DISCUSSION AND COMMENT

1.3 Definitions

C. SNL/NM: Sandia National Laboratories New Mexico Site

D. SDR: Sandia Delegated Representative

Part 2 – Products

2.1 Materials

A. ASPHALT CONCRETE

Asphalt concrete shall be placed at the design proportions specified in the authorized job mix formula, within the specified production tolerances for combined aggregate gradation and asphalt binder content. Asphalt concrete placed at a project, sampled and tested in accordance with this specification, shall have a gradation that complies with the authorized design gradation ± the production tolerance(s) specified in the authorized job mix formula. Asphalt concrete placed at a project, sampled and tested in accordance with this specification, shall have an asphalt content that complies with the design asphalt content ± 0.5% (laboratory analysis).

B. PRIME AND TACK COAT

1. Prime coat shall comply with the requirements of COA Section 113 except that if the prime contract between SNL and the CONTRACTOR is Firm Fixed price or Variant of a Firm Fixed Price 113.6 MEASUREMENT AND PAYMENT shall not apply. Prime Coat shall be applied to subgrade, aggregate base course, and concrete treated base course a minimum of 12 hours prior to placing the asphalt concrete pavement, as directed by the SDR. Traffic shall not be permitted on the prime coat prior to construction of the asphalt concrete pavement.

2. Immediately prior to prime coat application, an inspection of the surface shall be made by the SDR. The surface to be primed shall be in a uniform and well compacted condition, true to grade and cross section. All loose and foreign material shall be removed by light sweeping prior to application. Loose material shall not be mixed with asphalt concrete.

3. Prime coat shall be applied uniformly at the rate of 0.10 to 0.30 gallon per square yard. It shall be applied when the air temperature is 40ºF and rising, as authorized by the SDR.

4. In order to prevent lapping at the joint of two applications, the distributor shall be promptly shut off. A hand spray shall be used to touch up all spots missed by the distributor.

5. The pressure distributor used for applying prime coat material shall be equipped with pneumatic tires and shall be so designed and operated as to distribute the prime material in a uniform spray without atomization, in the amount and between the limits of temperature specified. It shall be equipped with a speed tachometer registering feet per minute and so located as to be visible to the truck driver to enable him to maintain the constant speed required for application at the specified rate.

6. The pressure distributor shall be equipped with a tachometer registering the pump speed pressure gauge, and a volume gauge. The rates of application shall not vary from the rates specified by more than 10 percent. Suitable means for accuracy indicating at all times the temperature of the prime material shall be provided. The thermometer well shall be so placed as not to be in contact with a heating tube.

7. The distributor shall be so designed that the normal width of application shall be not less than 6 feet, with provisions for the application “of lesser width” when necessary. If the distributor is equipped with heating attachments, the prime coat material shall be circulated or agitated to provide the application temperature specified by the manufacturer.

8. If the prime coat has not been completely absorbed prior to the start of placing the asphalt concrete pavement, sufficient sand shall be spread over the surface to blot the excess and prevent tracking under traffic. Sand shall be applied as directed by the SDR. Prior to placing the asphalt concrete pavement, loose or excess sand shall be swept from the base. If a sand cover is specified in the Supplementary Specifications or noted on the drawings to cover a prime coat, it shall be applied within 4 hours after the application of prime coat, as authorized by the SDR.

9. A prime coat shall be prevented from spraying upon adjacent pavements, structures, guard rails, guide posts, culvert markers, trees, and shrubbery that are not to be removed; adjacent property and improvements; and other facilities or that portion of the traveled way being used by traffic.

10. The CONTRACTOR shall protect a prime coat against all damage and markings, both from foot and other traffic. Barricades shall be placed where necessary to protect a prime coat. Damaged prime coat shall be repaired by the CONTRACTOR, at his expense. Asphalt concrete pavement shall not be placed until a prime coat has been accepted by the SDR.

C. TACK COAT

1. If the asphalt concrete pavement is being constructed directly upon an existing hard surfaced pavement, a tack coat shall be evenly and uniformly applied to existing pavement preceding the placing of the asphalt concrete, as directed by the SDR. The surface shall be free of water, all foreign material, or dust when the tack coat is applied. No greater area shall be treated in any one day than will be covered by the asphalt concrete during the same day. Traffic will not be permitted over tack coat.

2. Tack coat shall consist of cationic emulsified asphalt as specified in COA Section 113 except that if the prime contract between SNL and the CONTRACTOR is Firm Fixed price or Variant of a Firm Fixed Price 113.6 MEASUREMENT AND PAYMENT shall not apply.. Application rate shall be 0.03 to 0.12 gallon per square yard.

3. A tack coat shall be applied to the surface of any course if, in the opinion of the SDR, the surface is such that a satisfactory bond cannot be obtained between it and the succeeding course.

4. The contact surfaces of all cold pavement joints, curbs, gutters, manholes, and the like shall be painted with a tack coat immediately before the adjoining asphalt concrete is placed. Surfaces where a tack coat is required shall be cleaned of all loose material before the tack coat is applied.

Part 3 – Execution

3.1 Placement

A. Asphalt concrete may be placed when the ground temperature is 40ºF and rising and the weather is favorable, as authorized by the SDR. Quiet asphalt concrete and plant mixed seal coat may be placed when the pavement temperature is 60ºF and rising, and the weather is favorable to construction, as authorized by the SDR. Materials may not be placed in either wet weather, or on a wet or damp surface, or on frozen supporting material.

B. An asphalt concrete pavement lift shall be placed uniformly, at a temperature within the compaction range specified in the authorized job mix formula, without segregation, to such a depth that after compaction it will comply with the specified cross section and grade, specified in the plans and specifications. The temperature of the mat shall be in a uniform range of 15ºF transverse the mat after placement behind the paver. Asphalt concrete shall be placed and compacted in uniform layers/lifts, ± 3/16 inch in 10 feet of the lift finish grade. The compacted thickness of a layer/lift shall be equal or greater than two (2) times the maximum size aggregate but less than or equal 4.0 inches for SP-II aggregate gradations. The compacted thickness of a layer/lift shall be equal or greater than two (2) times the maximum size aggregate, but less than or equal to 3 inches for Types SP-III, SP-IV, B, C, and D aggregate gradations. Pavement lift thickness shall be selected to use the maximum size aggregate. Lift thickness (es) and asphalt concrete type, designating the maximum nominal size aggregate, shall be either specified in the CONTRACT documents, or as directed by the SDR. SP-II gradation mixes shall not be used for the surface course.

C. Placement shall be continuous, without interruption. No greater amount of the mixture shall be delivered in any one day than can be placed, compacted and finished that same day.

D. No asphalt concrete surface course shall be placed which cannot be finished within daylight hours of the same day it is laid unless authorized by the SDR.

E. In narrow, deep, irregular sections, intersections, turning radiuses, turnouts, cul de sacs, or driveways, where it is impractical to spread and finish the base and level the surface mixtures by machine methods, the CONTRACTOR may use placement equipment or acceptable hand methods, as authorized by the SDR. The CONTRACTOR shall place material in lifts a specified and not exceed the limits of depth of the compaction equipment. Hand placed and compacted material shall be placed in lifts not greater than 2 inches maximum compacted depth. The finish surface shall be checked with a

10 feet straight edge, true and level to the adjacent asphalt concrete pavement. Humps shall be milled true and level and depressions shall be filled and finished to comply with this specification.

F. Pavement cuts of 10 feet or more in width and 100 feet or more in length must be paved with an approved bituminous paving machine. Asphalt concrete should be placed with a paving machine for all sections if a paver is available.

G. Depositing and spreading of the Asphaltic concrete shall be accomplished by means of a bituminous paver except as specified in 3.01 Placement Subpart E. Bituminous pavers shall be self-contained, self-propelled units, provided with an automated leveling activated screed or a strike off assembly, with heating capabilities, and capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the lifts and thickness specified in the plans and specifications. Pavers shall be free of fluid leaks. Pavers detected to have leaks shall not be allowed on the project.

H. The paver shall be equipped with a receiving hopper having sufficient capacity for uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed. The hopper shall be operated at 50% or greater capacity during paving operations. Paving shall not be allowed when the hopper is at less than 50% capacity.

I. The screed or strike off assembly shall effectively produce a uniform surface and texture without tearing, shoving or gouging the mixture. The paver shall be operated at a forward speed consistent with satisfactory laying of the mixture.

J. The paver shall be operated with an automatic leveling device controlled from an external guide, approved by the SDR. The screed shall be zeroed by the CONTRACTOR on a template or blocks set to the same depth as the loose mat behind the paver, prior to start of placement of each lift of a material, as directed by the SDR. Verification of the target loose lift thickness shall be made at regular intervals during the placement. The loose lift thickness, lift thickness behind the paver shall be defined by the CONTRACTOR and reported to the SDR for reference prior to startup of a lift placement. Broadcasting of excess edge material over the surface of a pre-compacted lift shall not be permitted.

3.2 Compaction

A. Asphalt concrete compaction shall begin when the asphalt concrete temperature is in the compaction temperature range specified in the authorized job mix formula. Compaction shall be completed before the temperature of the material cools to less than 200ºF. Compaction may be allowed on material with a temperature less than 200ºF and greater than 185ºF, as authorized by the SDR. Compaction on a lift shall not be allowed when the temperature of the lift is less than 185ºF. The material shall be compacted to a density of at least 93% and not greater than 97% of the theoretical maximum density as determined by ASTM D2041.

B. The CONTRACTOR shall be responsible for the development and implementation of the compaction program. A reference compaction program shall be defined by the CONTRACTOR, to include equipment type and description, and procedures, reported in writing to the SDR for each job mix formula/lift thickness to be used on a project. Changes in the compaction program shall be reported to the SDR as they may occur.

C. A CONTRACTOR may construct a test strip, a minimum of 10 feet wide and 250 feet long, to establish the rolling pattern for an asphalt mix and lift thickness to be placed on a project, as directed by the SDR. The test strip shall be paid for in accordance with the requirements of the CONTRACT, as authorized by the SDR.

D. Compaction equipment shall be steel wheeled, pneumatic wheeled, and hand plate tampers, free of fluid leaks, selected by the CONTRACTOR, and authorized by the SDR. Compaction equipment detected to have leaks shall not be allowed on the project.

E. Compaction may be either static or dynamic (vibratory). All equipment shall be ballasted and operated as recommended by the manufacturer. Motorized wheeled dynamic (vibratory) compaction equipment shall have the frequency rate and amplitude setting readily available for review by the SDR. Frequency rate and amplitude adjustability shall be operable on so equipped motorized wheeled dynamic (vibratory) compaction equipment. Motorized compaction equipment with inoperable frequency rate and amplitude adjustment features shall not be used on the project.

F. Motorized compaction equipment shall be equipped with automatic wheel spray systems to apply release agents to prevent tracking of asphalt concrete. Diesel fuel or other petroleum based solvents shall not be used as a release agent to prevent buildup of the asphalt material. Material contaminated with diesel fuel or other petroleum based solvents shall be removed and replaced with complying material by the CONTRACTOR, as directed by the SDR, at no cost to SNL/NM.

G. Repair and replacement of damaged adjacent property and structures, resulting from the use of vibratory rolling equipment, shall be the responsibility of the CONTRACTOR, at no cost to SNL/NM.

3.3 Joints

A. Care shall be exercised in connection with the construction of joints to insure that the surface of the pavement is true to grade and cross section across the joint. Periodically, joints shall be tested with a 10 feet straight edge to verify the smoothness of the surfaces of adjacent material(s). A 10 feet long straight edge shall be placed perpendicular to the joint extending equally on both sides of the joint. The smoothness of the surfaces across the joint shall comply with the requirements of this specification.

B. After construction of a joint along any adjoining edge such as a curb, gutter, or an adjoining pavement lift free edge, and after the hot mixture is placed by the finishing machine, sufficient hot material shall be carried back to fill any space left open. This joint shall be properly “SET UP” with the back of a rake at proper height and level to receive the maximum compaction. The work of "setting up" this joint shall be performed by competent workmen who are capable of making a correct, clean, and neat joint. Excess material shall be removed. Broadcasting excess material onto the adjacent asphalt concrete pavement surface will not be allowed. Excess material at an edge joint shall be removed and discarded if not required for compaction.

C. Longitudinal and transverse joints shall be made in a careful manner. Well bonded and sealed joints are required. Joints between old and new pavements or between successive day's work shall be carefully made in such a manner as to insure a thorough and continuous bond between the old and new surfaces. In the case of surface course, the edge of the old surface course shall be cut back for its full depth so as to expose a fresh surface and, if necessary to obtain a well bonded joint, shall be painted with a tack coat after which the hot surface mixture shall be placed in contact with it and raked to a proper depth and grade. Before placing mixture against contact surfaces of curbs, gutters, headers, manholes, etc., they shall be painted with a tack coat. Joints shall be tested with a 10 feet straight edge to verify the smoothness of the surfaces transition of adjacent material(s). A 10 feet long straight edge shall be placed perpendicular to the joint extending equally on both sides of the joint. The smoothness of the surfaces across the joint shall comply with the requirements of this specification. Longitudinal and transverse joints shall be compacted parallel to the joint. Transverse and longitudinal joints shall be staggered a minimum of 1 foot offset from the joint of a lift either below or above, and completely bonded.

3.4 Pavement Penetrations, Manholes, and Valve Covers

A. Manhole frames and valve covers shall be adjusted as per the Standard Drawings, or as directed by the SDR. The finish surface at the top of all asphalt concrete pavement penetrations, to include but not be limited to manhole frames and valve covers, shall be constructed to and be parallel in all directions the finish surface of the surrounding asphalt concrete pavement prior to placing the surface course.

3.5 Smoothness

A. Upon completion, the pavement shall be true to grade and cross section. Except any changes of grade, when a 10 feet straight edge is laid on the finished surface of the roadway, the surface shall not vary from the edge of the straightedge more than 3/16 inch. After the completion of final rolling, the smoothness of the course shall be checked, and the irregularities that exceed the specified tolerances and/or retain water on the surface shall be corrected by the CONTRACTOR at no cost to the OWNER (SNL/NM), as directed by the SDR.

3.6 Sampling and Testing

A. Asphalt concrete tests shall be performed in accordance with the requirements of this specification, the Supplemental Technical Specifications, or as directed by the SDR. Asphalt concrete analysis shall be performed in a laboratory accredited in accordance with the requirements of the New Mexico State Highway and Transportation Department "Procedure for Approval of Testing Laboratories to Perform Inspection, Testing, and Mix Design Services", April 13, 1998 Edition. Testing equipment used in the performance of specified testing shall be calibrated annually with calibration standards traceable to the National Bureau of Standards. Certification records shall be maintained at the Laboratory for review by the SDR. A copy of the certifications shall be submitted to the SDR upon request. The sampling and testing shall be performed by a technician certified under the New Mexico State Highway and Transportation Department/Associated Contractors of New Mexico Technical Training and Certification Program for ASPHALT and SUPERPAVE™.

B. Material Sampling: A quality assurance asphalt concrete material field sample shall be taken in accordance with the requirements of ASTM D979 for each job mix delivered. The materials shall be sampled at the greater rate of either one sample for each 250 tons, or one sample per day, for each typed of material placed on a project, as directed by the SDR. The sample shall be of such size to provide material for all tests specified and a split sample to perform verification/referee tests for gradation and binder content, if required.

C. MATERIAL TESTING

1. Asphalt concrete quality assurance sampling and testing shall be performed in accordance with the requirements of this Specification, the Supplemental Technical Specifications, or as directed by the SDR.

2. A quality assurance asphalt concrete sample shall be sampled, tested, and reported in accordance with the requirements and procedures of SNL/NM Standard Specification 32 12 16.02, "Asphalt Concrete Material", Section 3.4 MATERIAL SAMPLING AND TESTING.

3. A CONTRACTOR may challenge production material test results, binder content and aggregate gradation, and request that the retained split asphalt concrete sample of record be released to his assigned laboratory and tested for compliance, as authorized by the SDR. A challenge notification shall be made in writing to the SDR by the CONTRACTOR within 28 calendar days from date of sampling. Challenge test results shall be submitted to the SDR for evaluation no later than 42 calendar days from date of sampling. Challenge test results will be evaluated in accordance with the "multi-laboratory" precision tolerances specified, T53 for binder content, ASTM C117 and C136 for aggregate gradation. Challenge and record test results that comply with precision tolerances will be averaged with the companion test results of record and the material pay factor, Pm_f, recalculated as directed by the SDR. Challenge and record test results that do not comply with the precision tolerances will direct the disqualification of the challenged and record samples, as directed by the SDR. Cut/core sample(s) will be taken from the area(s) represented by the disqualified challenge samples(s) and evaluated by the lab of record under the observation of the CONTRACTOR, in accordance with the requirements of these specifications and replace the disqualified sample test results. Analysis of the replacement cut/core sample(s) may not be challenged. The CONTRACTOR will submit challenge test results in writing to the SDR for each split sample released to his assigned laboratory of record. Challenges filed after the time limitations will not be considered. SNL/NM shall pay for all complying tests.

D. COMPACTION TESTING

1. Asphalt concrete pavement quality assurance compaction sampling and testing shall be performed in accordance with the requirements of this specification, the Supplemental Technical Specifications, as directed by the SDR. Each lift, for each type of asphalt concrete pavement placed each day, shall be tested for compaction.

2. An asphalt concrete pavement compaction test shall be performed in accordance with the requirements of this specification, as directed by the SDR. A test shall determine the compaction at a location of a freshly constructed asphalt concrete roadway lift. Compaction shall be calculated as the field density at a location of a LOT lift, determined by the applicable methods allowed in this specification, divided by the average of the maximum theoretical density (G_{mm}) of the acceptance sample(s) taken for that day's placement, reported to the nearest one tenth of a percent, xxx.x%. A maximum theoretical density (G_{mm}) shall be determined in accordance with ASTM D2041.

3. The field density at a location for a lift of SP-II material shall be determined from a core sample. One core sample shall be taken for each lift of 250 tons, or fraction thereof, placed each day, but not less than 3 cores per day, as directed by the SDR. The density of a core shall be determined in accordance with the requirements of ASTM D2726 and reported to the nearest one-tenth pound per cubic foot.

4. FIELD COMPACTION TESTING

   a. The field compaction at a location for Type B, C, D, E, SP-III, and SP-IV materials, shall be measured in accordance with the requirements of ASTM D2950 Density of Bituminous Concrete in Place by Nuclear Methods, at the minimum rate of three tests per lift of 500 sy, or fraction thereof, for each type of asphalt material placed in a day, as directed by the SDR.

   b. A reference density test of the support material, for the asphalt concrete roadway lift to be constructed, shall be taken prior to the placement of the fresh asphalt concrete lift, or defined from previous test results. The density of the support material shall be used as reference in performing the density test of a fresh asphalt concrete lift in accordance with the requirements ASTM D2950, placed over the support material. A density test of the support material shall be taken at the rate of one (1) test for each 500 sy of surface or less to be paved over in a day, as directed by the SDR. The density of the support material shall be reported as "reference support material density" in the compaction test report of the constructed asphalt concrete pavement over the area represented by the support material compaction test.

   c. Core samples of the compacted asphalt pavement of SP-III, SP-IV, B, C, D, and E asphalt concrete, may be taken and tested to determine conformance of the finished pavement with the specified requirements either as requested by the CONTRACTOR, as directed by the SDR. Samples shall be taken and tested in accordance with the requirements of ASTM D2726 and ASTM D3203 at the rate of three (3) core samples per LOT lift, as directed by the SDR, and paid by the OWNER (SNL/NM). Compaction determined from cores shall supersede tests performed in accordance with the requirements ASTM D2950. The CONTRACTOR shall be responsible for asphalt concrete pavement replacement at no cost to the OWNER (SNL/NM) where core samples are taken. The OWNER (SNL/NM) shall pay for all complying tests.

5. Field compaction tests shall be taken at random locations on an asphalt concrete pavement lift, as directed by the SDR. Three (3) general areas at which a test should be taken are either adjacent to the free edge of the mat, or the mat interior, or adjacent to a joint. The number of tests taken will vary but the total number of tests taken on any project shall be in the approximate proportions specified in TABLE 321216.03-336A.

6. Testing shall be as follows:

TABLE 321216.03-336A – Asphalt Concrete Pavement Lift Compaction Test Location Proportions

Location	% of Total Tests
Free Edge of Mat[1]	20 to 33
Mat Interior	33 to 60
Joints[2]	20 to 33

NOTES:

1 The Free Edge of Mat test shall be taken in the area between one (1) foot and two (2) feet inform a free edge of a lift.

2 Joints shall include the longitudinal and transverse butt joints between adjacent lifts of asphalt having the same finish elevation. Tests may be taken on material placed against a cold joint edge of formed surface.

7. Full depth cores of asphalt concrete shall be taken to determine the depth of structure and the depth pay factor, $PF_{1)}$, defined in TABLE 321216.03-336E, as directed by the SDR. A minimum of three (3) cores, having an outside diameter equal or greater than four (4) inches, shall be taken at random for each 1000 sy, or fraction thereof, placed. Cores shall be evaluated in accordance with the requirements of 3.7 PAYMENT ADJUSTMENT FOR FAILING TESTS. The core length, depth of the pavement, shall be determined based on the average of three measurements of the length of the core, measured from circular ends of a sample. All measurements shall be reported to the nearest 0.125” (1/8 inch). Plant mixed seal coat shall not be included in the depth of structure.

E. TEST REPORTS

1. REPORT FORMAT

TABLE 321216.03-336B – TEST REPORT(s)	
A	Field Data and Test Results:
1	Date of Sampling/Test
2.	SNL Project Number or Permit Number
3.	Project Title
4.	Asphalt Concrete Supplier
5.	Delivery Ticket Number (asphalt concrete sample-only)
6.	Job Mix Formula Number
7.	Location of Sample/Test as Defined by Contract Documents
8.	Time of Sampling/Testing
9.	Material Temperature at Time of Sampling, °F
10.	Ambient Temperature at Time of Sampling, °F
11.	Field Test Results with Reference Specification Limits (compaction test)
B.	Laboratory Test Results
1.	Laboratory Results as defined in TABLE 116.F (asphalt concrete material)
2.	Field Test Data as required in COA 336.11.4 (compaction reports)
3.	Pavement Structure Depth (individual cores and average depths for LOT)
C.	Recommended Pay Adjustment Factor for a LOT
1.	C_{LM}, Material Factor, see TABLE 321216.03-336C
2.	C_{LC}, Placement/Compaction Factor, see TABLE 321216.03-336D
3.	$PF_{1)}$, Depth Factor, see TABLE 321216.03-336E.

2. Test results shall be reported to the SDR, CONTRACTOR, and Supplier in writing, within 7 working days of completion of the sampling of the asphalt and/or the field testing. Non-complying test shall be reported to the SDR, CONTRACTOR, and Supplier within 1 working day of completion of the test.

3. The New Mexico Registered Professional Engineer in direct charge of the laboratory shall certify on a quality assurance test report that the test procedures used to generate the report complied with the specifications.

3.7 Payment and Adjustment for Failing Tests

A. If there are failing tests on the asphaltic concrete for material properties, placement, compaction or thickness, the SDR may, at his discretion, make reductions in the amount paid to the CONTRACTOR for asphaltic concrete paving as determined in B. PAYMENT ADJUSTMENTS below:

B. PAYMENT ADJUSTMENTS

1. Asphalt concrete pavement placed in an area of 10 feet or more in width and 100 feet or more in length (requiring machine laydown) shall be divided into LOTS and paid at the unit price, as determined by the schedule of values, and as adjusted as specified in this section, as authorized by the SDR.

2. Asphalt concrete pavement placed in an area less than 10 feet in width and/or less than 100 feet in length shall be paid at the adjusted unit price, as determined by the schedule of values, and as adjusted as specified in this section, as authorized by the SDR.

3. A LOT of asphalt concrete pavement shall be paid at a unit price, as determined by the schedule of values, equal to the sum of the unit prices of its SUBLOTS, each lift of asphalt in a LOT, the sum adjusted for deviation of full depth of structure from CONTRACT specification. The unit price for a LOT shall be calculated in accordance with the equation below.

$$UP^1 = PF_D \times UP_{SUBLOTS}$$

UP^1 LOT Unit Price
PF_D Depth Factor defined in TABLE 321216.03-336.D
$UP_{SUBLOTS}$, $UP'_{SLI} + UP'_{SL2} + \ldots + UP_{SLN}$, sum of SUBLOTS' unit prices, see COA 336.11.2.2

4. A SUBLOT, a lift of asphalt concrete in a LOT, shall be paid at the adjusted unit price determined in accordance with the equation below:

$$UP'_{SLN} = F_N \times UP_{SLN}$$

F_N, 0.5 x ($C_{LM} + C_{LC}$), SUBLOT Adjustment Factor
C_{LM} Material Factor, see TABLE 321216.03-336.C
C_{LC}, Placement/Compaction Factor, See TABLE 321216.03-336.D
UP_{SLN}, Unit Price, as determined by the schedule of values, for a SUBLOT

d. The material factor, C_{LM}, is the material acceptance factor for a SUBLOT determined in accordance with TABLE 321216.03-336.C, based on the absolute value of the deviation of the average value, or arithmetic mean (M), of the daily acceptance sample(s) test results for the SUBLOT, deviation from the CONTRACT authorized job mix formula targets (T), for either combined aggregate gradation or binder content.

e. If the deviation is equal or less than the allowable deviation, D', the corresponding material pay factor, C_{LM}, shall be used.

f. The SUBLOT placement/compaction factor, C_{LC}, shall be defined in accordance with TABLE 321216.03-336.D, as directed by the SDR. The factor is determined based on the average of the compaction tests taken for a SUBLOT, with no single test neither less than 90.0% nor greater than 97.9%. Acceptance compaction tests shall be performed in accordance with the requirements of this specification. A SUBLOT having a compaction test(s) either less than 90.0% or greater than 97.9% shall be evaluated and an appropriate pay factor assigned, as directed by the SDR.

g. The depth factor, PF_D, shall be defined in accordance with TABLE 321216.03-336.E, based on the average depth of a minimum of three full depth cores taken at random for each 1000 sy, or fraction thereof, with no single core less than the specified section depth less 0.75 in. (19 mm), as directed by the SDR. If core(s) are identified at a depth less than 0.75 in (19b mm), additional cores shall be taken to verify the condition. The condition shall be evaluated and either an appropriate pay factor assigned or the asphalt concrete pavement removed and replaced with complying pavement, as directed by the SDR.

TABLE 321216.03-336C – MATERIAL FACTOR, C_{LM}, FOR GRADATION & ASPHALT BINDER CONTENT

NUMBER OF DAILY SAMPLES	D', MAXIMUM ALLOWABLE DEVIATION [1, 2, 3]		
1	1.40D	1.20D	D
2	D + R	D + 0.37R	D – 0.10R
3	D + 0.30R	D + 0.07R	D – 0.14R
4	D + 0.16R	D - 0.01R	D – 0.17R
5	D + 0.11R	D - 0.03R	D – 0.20R
6	D + 0.09R	D – 0.05R	D – 0.22R
7	D + 0.07R	D – 0.07R	D – 0.24R
8	D + 0.06R	D – 0.08R	D – 0.25R
9	D + 0.05R	D – 0.09R	D – 0.26R
10 OR MORE	D + 0.04R	D – 0.10R	D – 0.27R
MATERIAL FACTOR, C_{LM} [3]	0.85	0.95	1.00

[1] D, production tolerance ± %, see COA 336.5.1.2, and authorized job mix formula; R, of test values, maximum – minimum values; M, average test value of a SUBLOT's acceptance samples test results; T, target value specified in authorized job mix formula.

[2] The material factor, C_{LM}, shall be the lowest factor selected for $|T\text{-}M| \leq D'$ calculated for either (a) the combined aggregate gradation and material passing the nominal maximum size aggregate screen, 3/8 inch (9.5 mm), and smaller screens of the project authorized job mix formula, or (b) the asphalt binder content.

[3] If the absolute value of the deviation of the daily mean from the target exceeds the maximum allowable deviation a SUBLOT, $|T\text{-}M| \geq D'$, the SUBLOT shall be removed and replaced with material complying with this specification, at no cost to the OWNER (SNL/NM), and directed by the SDR. If it is determined by the Sedro be more practical to accept the SUBLOT material, it may be accepted under written agreement between the OWNER (SNL/NM) and the CONTRACTOR, at an assigned pay factor, $C_{LM} = 0.70$, for a SUBLOT having a compaction factor, $C_{LC} \geq 0.90$, as directed by the SDR.

TABLE 321216.03-336D – SUBLOT PLACEMENT/COMPACTION FACTOR, C_{LC}

Average Test Results	Factor, C_{LC}
98.0% and greater	[1]
97.1 to 97.9	0.85
93.0 to 97.0	1.00
92.0 to 92.9	0.95
91.0 to 91.9	0.90 [2]
90.0 to 90.9	0.85 [2]
less than 90.0%	[1], [2]

[1] The lift defined for the SUBLOT shall be removed and replaced by the CONTRACTOR with asphalt concrete pavement complying with this specification at no cost to the OWNER (SNL/NM), as directed by the SDR. If it is determined by the SDR to be more practical to accept the SUBLOT, it may be accepted under written agreement between the OWNER (SNL/NM) and the CONTRACTOR at an assigned compaction pay factor, $C_{LC} = 0.50$, for the SUBLOT, if the SUBLOT has a material pay factor $C_{LM} \geq 0.85$, as authorized by the SDR.

[2] When the lift accepted at this factor is a final surface course of a street having a posted speed limit less than 40 mph, the lift shall have a FOG SEAL applied and sanded by the CONTRACTOR at no cost to the OWNER (SNL/NM), as directed by the SDR.

TABLE 321216.03-336E DEPTH FACTOR, PF_D

Deficient Pavement Depth					PF_D
0	≤	$D_S - d_A$	≤	0.25 in (6 mm)	1.00
0.25 in (6 mm)	<	$D_S - d_A$	≤	0.50 in (12.5 mm)	$(d)^2/(D)^2$
		$D_S - d_A$	>	0.50 in (12.5 mm)	[A]
Excessive Pavement Depth, d-D					**PF_D**
		$D_S - d_A$	<	0	1.00

NOTES:

- d_A average depth of the pavement structure as determined by field cores
- D_S specified depth of the pavement structure of a LOT
- [A] Correct deficiencies at no cost to the OWNER (SNL/NM), as directed by the SDR, constructing the pavement to the depth, grade, crown, and cross slope drainage, specified in the CONTRACT documents.

END OF SECTION 32 12 16.03

Process UPS Specification Entries

480Y/277 V input

480Y/277 V output

30 minute ride-through capability at full load amps

Continuously on-line

______kVA Capacity

Lead-Acid Batteries

Load Circuit Breaker

Options

System

● Parallel redundant N+N, N+1 system configuration.

● Special mains input voltages up to 690 VAC and frequency 60 Hz.

● Tropicalized control electronics boards.

● Input/Output/Bypass isolation transformer.

● Rectifier input CB or fuse or switch.

● Battery CB or fuse box.

● Load CB, fuse or switch.

● Bypass input CB or fuse or switch.

● AC distribution.???

● Battery cabinet.

Alarms and measurement

● Analogue meters.

● Additional LED alarm indicators.

● Additional relay cards 2 x 8 free contacts.

● Low battery electrolyte level alarm.

● Temperature dependent battery charging with temp. probe.

● Temperature alarm.

UMB AC40 schematic

● Battery circuit failure alarm.

● Ground fault alarm.

● High rate interlock.

Control options

● Communication:

• TCP / IP interface

• Protocol converters Profibus DP

• J-bus DNP3

• IEC 61850

• Monitoring and management software.

Mechanical

● Protection up to IP 54.

● Vermin proof.

● Top cable entry.

● Interior cabinet light.

● AC 1-phase socket.

● Cabinet heater.

● Special colour.

● Protection plates.

● Special cable marking (both ends).

● Air filters at air inlet.

● No single point of failure.

● UPS power range up to 320 kW.

● Single cabinet up to 200 kW.

● High efficiency in double conversion.

● Single, N+1 and N+N configurations.

● Hot Swappable Power Modules for very low MTTR.

● Scalability for future power growth.

● High power density.

● Low Current Harmonics (THDi).