

## ■ Chilled Water System Assessment Guidelines

### General Chilled Water System Assessment Procedure

1. Get copies of mechanical drawings (determine chiller layout).
2. Determine type of chillers (centrifugal, reciprocating, screw, etc.).
3. Fill out chilled water system data collection forms and sketch out the system configuration.
4. Get a copy of the chiller engineering specifications.
5. After the assessment, send the chiller manufacturer the worksheet to develop part load and leaving chilled water temperature (LCHWT), entering condenser water temperature (ECWT) performance curves.
6. Take screen shots of the chilled water system through the direct digital control (DDC) system.
7. Go through the list of potential DDC points and determine the points that are currently available and the points that would be needed to implement sub-metering and continuous commissioning of the chilled water system. Note: If a trend log hasn't been started prior to the assessment, start trending the following points every 30 minutes:
  - Chiller On/Off Status
  - Chiller kilowatts (kW)
  - Chiller entering water temperature (EWT)
  - Chiller leaving water temperature (LWT)
  - Chilled Water Supply Temperature to Loads
  - Chilled Water Temperature Setpoint
  - Primary Chilled Water Flow Rate
  - Secondary Chilled Water Flow Rate to Loads
  - Chilled Water Return Temp from Loads
  - Pump Status On/Off
  - Pump Speed
  - Distribution Static Pressure
  - Static Pressure Setpoint
  - Tower Fan On/Off Status
  - Tower Fan Speed
  - Tower EWT
  - Tower LWT
8. Chiller energy use is primarily a function of evaporator load (part load), ECWT and LCHWT, although the energy use of the unit is primarily driven by part load performance. Because most chilled water plants are designed with constant volume primary chilled water loops and condenser water loops, in-field measurements of entering and leaving chilled water and condenser water temperature can be analyzed to develop actual chiller performance curves. In addition, chilled water supply temperature and entering condenser water temperature are usually fixed, making it easier to measure part load performance.
  - Chilled water and condenser water temperatures should be trended and current transformers should be installed to the chillers to measure power output.
  - Chilled water and condenser water flow rates can be taken from pump curves, as described in the pumping section.
  - Induced loads should be programmed into the control sequence during off-peak hours to develop an in-situ performance curve (i.e., set the space temperatures to 55°F during unoccupied hours to simulate full chiller load).

*Note: The following retro-commissioning information was taken directly from PECCI's functional testing guide ([www.peci.org/ftguide/](http://www.peci.org/ftguide/)) and modified for this energy assessment training.*

This section highlights key functional testing issues for chillers, including system integration with pumps and condensers.

- Verify that the chiller meets the specified performance requirements for temperature or part-load operation, as well as specified energy efficiency requirements.
  - In some instances, verifying chiller capacity and/or efficiency at peak load may be required. However, creating a peak load operating condition and testing the system at ARI (American Refrigeration Institute) atmospheric conditions may be difficult, especially if the system is tested during off-peak months. Verifying part load performance can be an easier and more cost-effective solution than attempting to test peak load performance since most systems operate at part load a majority of the time.

### Staging

- Verify that isolation valves are installed and operating correctly.
  - When an individual chiller is not operating, the isolation valve should be closed to prevent water from circulating through the unit. This configuration reduces pumping energy and prevents dilution of the chilled water temperature due to blending of warm return water flowing through the non-operational chillers with chilled water coming from the operating unit(s).
- Verify that the chillers and primary CHW pumps stage up and down appropriately, per the sequence of operations.
  - This is especially important if multiple units are installed and they are unequal in size. Close coordination between chiller staging and actual load will minimize energy usage. For example, it is beneficial to use a small chiller with good turn-down efficiency to meet low loads and to enable a larger chiller only when the load surpasses the cooling capacity of the smaller chiller. When this occurs, the small chiller should be turned off until load exceeds the large chiller capacity, then both chillers operate to meet the load.

### Reset Controls

- Verify proper reset parameters, which are verified per the design sequence of operations.
  - The sequence may be revised to optimize system operation relative to atmospheric conditions and system load. Since resetting the chilled water supply temperature is a fairly common control strategy, it warrants close attention. Reset strategies can impact chiller capacity controls and staging. Typically, the chilled water supply temperature setpoint will be reset based on some parameter(s) that characterize(s) system load, such as valve position, outside air temperature, and damper position.
- Verify proper coordination between individual setpoints and reset strategies.
  - The chilled water temperature reset strategy should be coordinated with the discharge air temperature (DAT) reset for each air handling unit (AHU). Without this coordination, excess equipment may be operated and energy will be wasted. To illustrate this point, assume the chilled water setpoint is reset based on outside air temperature but the AHU discharge air temperature setpoint is reset based on the variable air flow box damper position. Without close coordination between the two reset strategies, it is possible that the chilled water temperature could exceed the discharge air temperature setpoint. Additional chillers and pumps may be staged ON due to the increased flow, wasting significant pumping and chiller energy.
- Verify that the chilled water supply temperature reset does not adversely impact supply air dehumidification.
  - Resetting the chilled water supply temperature upward will save chiller energy but may prevent proper dehumidification of the supply air. This can result in discomfort and indoor air quality issues within the space(s) served.

## Cooling Towers

Regardless of whether the system is an open-circuit or closed-circuit cooling tower, heat rejection is based on both convective and evaporative heat transfer principles. Condenser water temperature is controlled primarily by the modulation of air flow through the tower. The purpose of the tests is to ensure that individual components are installed and integrated to operate on a system level per the design intent and sequence of operations.

### Actuation and Sequencing

- Verify proper stroke for control valves to ensure that they open and close completely (for example, isolation valves and coil valves).
    - Control valve leakage testing should reveal no detectable leakage when the valve is commanded closed under normal operating conditions.
  - Verify proper cooling tower staging, water control, and fan control (including water distribution across the fill and fan modulation) to maintain design condenser water temperature setpoint per the specific sequence of operations.
    - When an individual cooling tower is not operating, the isolation valve should be closed to prevent condenser water from circulating through the unit. Depending on the control sequence, this configuration should reduce pumping energy and prevent control problems.
  - Verify proper control of both the spray pump and tower fan for evaporative and “fluid” coolers to maintain the fluid temperature setpoint per the specific sequence of operations.
    - Typically, the first stage of heat rejection in a closed-circuit system is to spray water over the coils and then modulate the tower fan to achieve the condenser water temperature setpoint. This control strategy may be altered during winter months to prevent operational problems or tower freezing: Some portion of the condenser water may flow through a bypass valve, rather than over the tower fill. Testing will ensure proper system performance throughout all operating conditions.
  - **Note:** *A control strategy with potential to reduce cooling tower fan energy is to distribute condenser water across the entire fill (in multiple cooling tower applications) before modulating the fans to maintain water temperature. Care must be exercised to ensure that the expected performance is achieved.*
- Verify proper cooling tower fan control and staging, especially if multiple units are installed.
    - Regardless of the type of tower, optimizing the control strategy used to maintain the condenser water at setpoint is important. For example, every tower system will vary the amount of air flowing across the heat transfer elements as part of the control strategy. Commissioning the system and making sure that the particular control strategy (fan cycling, two-speed motor, or variable frequency drive [VFD]) is optimized will reduce system energy usage.
  - Verify proper condenser water pump staging and VFD control (if applicable).
    - Many condenser systems are designed to provide a constant flow of water through the chiller condenser bundle, and the condenser water pumps should stage on and off per the design sequence. However, variable condenser water flow is becoming increasingly accepted as a way to further reduce energy consumption and improve chiller performance. For example, the flow rate may be modulated based on maintaining a constant temperature differential across the chiller condenser. Another example of variable flow would be a heat pump loop: As individual heat pumps cycle on and off, two-way valves open and close to vary the flow of condenser water through the entire loop. Testing will ensure that the control strategy operates as designed.

### Setpoints and Reset Controls

- Verify the optimum condenser water temperature setpoint. The condenser water temperature setpoint is sometimes held constant based on the performance characteristics of the chiller being served.
  - Some chillers use less energy with lower condenser water temperature, but the cooling tower will expend additional energy to achieve the lower temperature setpoint. Testing will help determine the optimum setpoint to minimize overall system energy usage.
- Verify the condenser water temperature setpoint reset strategy per the sequence of operations.
  - The sequence may be revised to optimize system operation relative to atmospheric conditions, chiller energy, and tower fan (energy). For example, if the current atmospheric conditions will not allow the condenser system to achieve setpoint, then the setpoint may be raised to reduce condenser energy in exchange for a slight increase in chiller energy usage. A condenser water reset control strategy can be complicated and must be tested in order to achieve design intent and proper system operation.