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Alternative Fuels Evaluation Program

Alternative Fuel Light Duty Vehicle Project

Data Collection Responsibilities, Techniques, and Test Procedures

Prepared by the staff of the NREL Alternative Fuels Utilization Management Office

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Section 1.0

Introduction

This report has been prepared for/by the National Renewable Energy Laboratory (NREL) Alternative Fuel Evaluation Program to provide a consistent basis for data gathering and analysis in support of the Department of Energy's (DOE) implementation of the Alternative Motor Fuels Act (AMFA) of 1988.

One objective of AMFA is to assist federal, state, and local government agencies in the testing of light duty vehicles (LDVs) capable of operating on alcohols and natural gas fuels. Such testing will be aimed at producing data on emissions, durability, safety, fuel economy, and other issues to benefit industry and other organizations interested in using alternative fuel LDVs.

This report specifically addresses test procedures, analytical methods, and data protocols, consisting of four main areas:

- A methodology to collect and analyze the data in an efficient manner
- Specification of test procedures and analytical procedures
- Data transfer plan to collect the prescribed tests and transfer the data to NREL in an orderly and timely manner
- A suggested division of responsibilities for conducting the LDV demonstration.

This report should provide greater focus for demonstrating the environmental, economic, and performance characteristics to determine the commercial viability of alternative fuel fleets. It will also educate engine/vehicle manufacturers as well as the general public on the relative merits of using alternative fuels for LDV transportation applications.

Section 2.0

Data Protocol Methodology

Data collection methods/procedures for the LDV fleets participating in AMFA will demand efficient means of reducing raw data collected at the fleet sites, as well as proper analysis procedures to check the validity of the data and to provide a common basis for comparisons between alternative and conventional fuels. This section describes the data collection and analysis methodologies proposed for LDV fleets participating in AMFA.

The goal of the data collection process is to provide an efficient method of collecting and organizing the vast array of information collected in an attempt to provide complete vehicle comparisons using a responsive information retrieval system.

Two levels of data collection are envisioned in order to assess the operational and performance characteristics of selected alternative fuel LDVs from the total number of vehicles in the participating fleets. The two data set groupings, representing different levels of collection detail, are illustrated in Figure 2-1. The Level 1 data set is more subjective in nature and is focused on the driver's daily assessment of vehicle operation, "in-use" fuel economy, and related issues. Level 2 is more quantitative and relies on "industry standard" test methods, such as chassis dynamometer tests, evaporative emission tests, and in some cases, on-board electronic data collection systems that assess vehicle operating parameters/duty cycles. Vehicles used to generate Level 2 data will also provide Level 1 data. By selecting a statistically significant number of fleet vehicles, proper characterization of overall vehicle operation and a comprehensive understanding of engine/vehicle performance can be gained.

Once the AMFA fleet test vehicles have been placed, vehicles within the fleet will be designated as "Level 1" or "Level 2" vehicles. Information from these vehicles will be loaded into a data base. The following sections will discuss the data base and data types for further categorizing the extensive body of vehicle and fleet information.

ALTERNATIVE FUELS EVALUATION PROGRAM

Light Duty Vehicles Project
Fuel System Types

- Control Vehicles
- Alcohol Vehicles
- Dual Energy Vehicles
- Natural Gas Vehicles
- Natural Gas/Dual Energy Vehicles

LEVEL 1 DATA SET

Goals and Objectives

- Focus on data requiring large number of observations from numerous vehicles to obtain statistical significance
- Rely primarily on external data collection via manual completion of forms
- Select fleet vehicles based on mission and location
- Compare overall vehicle operation
  - Driveability (Survey Only)
  - Durability
  - Fuel Economy (In-use)
- Assess relative commercial viability
  - Driver acceptance
  - Safety
  - Life cycle cost
  - In-use fuel economy
  - Incidence of repair/maintenance

LEVEL 2 DATA SET

Goals and Objectives

- Focus on data requiring close monitoring of vehicle operating variables from a small, carefully selected subset of vehicles (typically 10% to 15% of the vehicle models involved in the AMFA program
- May use comprehensive on-board data collection system
- Select vehicles based on use proximity to testing facilities, representativeness, etc.
- Closely assess vehicle performance, durability, emissions, fuel economy, etc., based on usage
- Perform detail comparative evaluations
  - Emissions (Federal Test Procedures, Sealed Housing Evaporative Determination, Hydrocarbon Speciation)
  - Driveability
  - Performance
  - Fuel economy

Figure 2-1. Data collection methodology

2.1 NREL Data Base

As a means of providing for efficient raw data storage and information retrieval, a data base has been established that comprises and organizes all the data collected.

The preferred data transmission method is by electronic communication or magnetic disk. An example of the data types being collected is shown in Figure 2-2. The preferred format of data sent to NREL is "ASCII, delimited files." NREL currently uses Paradox™ and Quatro Pro™ software for processing the incoming data stream.

These data can then be analyzed by data category, such as fleet, cost, and fuel economy. The data base will reside in the Alternative Fuels Data Center (AFDC), and will be accessible to government, industry, and fleet users through a menu-driven program featuring ORACLE™ relational data base software.

Field Name	* Field	Field Name	* Field
Vehicle Decal ID	A8	Check Engine Light	N
Date	D	Gallons of Fuel Added	N
Beginning Odometer	N	Type of Fuel Added	A1
Ending Odometer	N	Fuel Added Odometer	N
Hard to Start	N	Quarts of Oil Added	N
Stalled After Starting	N	Oil Added Odometer	N
Stalled in Traffic	N	Maintenance Scheduled	N
Idle Quality	N	Maintenance Unscheduled	N
Hesitation, Coughing	N	Maintenance Comments	A240
Lack of Power	N	Performance Comments	A240
Pinging	N		

* "N" denotes a numeric field
A000 denotes a character field
"D" denotes a date field

Figure 2-2. Data file format

2.2 Data Collection and Validation

In order to validate and expedite the data collected from the test vehicles at each fleet site, it is imperative to perform periodic data checks and analysis to detect early problems or malfunctions with vehicle performance or fleet operations. A summary of the data validation routine is shown below.

Data Validation Summary

Site Coordinators:	Perform visual checks of the log sheets and provide immediate feedback to NREL, the General Services Administration (GSA) drivers, and original equipment manufacturers (OEMs)
Data Entry Screen:	Provides data validation to reduce data entry errors
NREL QA/QC Procedure:	Thoroughly checks data using computer routines and human interface before data are loaded into the data base
Periodic Reports:	Serve to assess the quality of the data in the data base based on engineering calculations such as fuel economy.

The types of data to be collected from each of the vehicles include:

- Basic vehicle/fleet data
- Basic powertrain data
- Performance data
- Driveability data
- Durability data
- Cost data
- Accident data.

For Level 1 vehicles, driver survey questionnaires should be completed daily and transmitted weekly. By comparing information from weekly driver survey questionnaires from a particular vehicle, a check on overall vehicle fuel economy and driveability can be performed. The site coordinator should follow up on critical problems by timely communication with the driver, NREL, the dealership, and/or the OEM, as appropriate. Fuel economy should be compared with past records for similar vehicles and to the control vehicles. By recording the date, vehicle odometer reading, and fuel used at each refueling, the fuel economy can be determined. If the value exceeds the boundary limits of previous and expected fuel economy measurements, follow-up action is recommended, such as cross-checking with refueling facility records.

A system to record refueling at the refueling facility should be employed. This can take the form of a card reader, log sheet, or similar system, but must require identification of the vehicle being refueled, mileage, and fuel quantity. This will provide a cross-check of the driver's logs and reduce the chance of refueling data errors.

Level 2 vehicles may incorporate the use of data loggers to collect specific duty cycle and operating information. Some level 2 data, such as mileage and fuel economy, may be cross-referenced with the Level 1 data for that vehicle to further validate the data.

The data flow is depicted in Figure 2-3a and b.

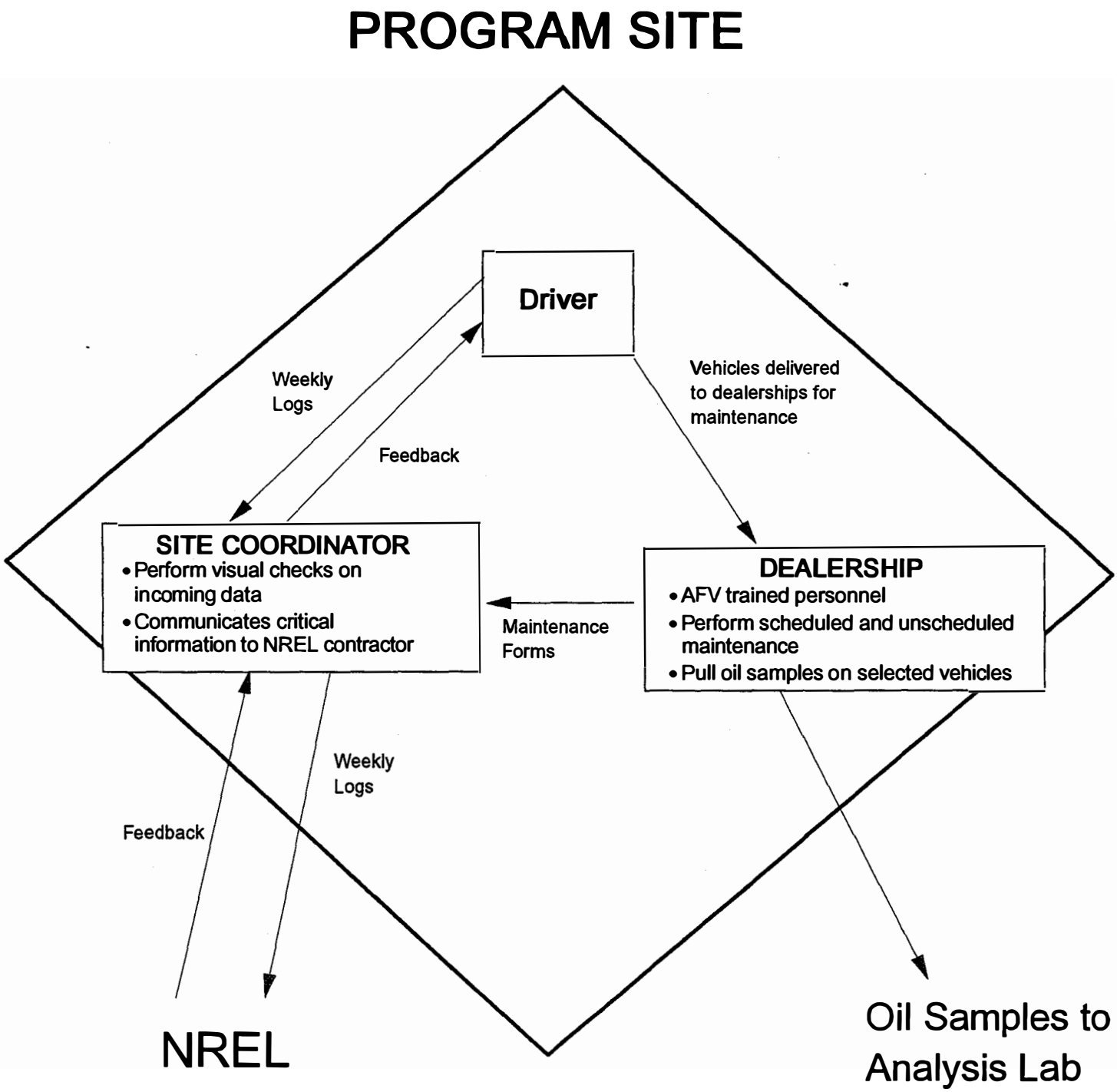

Figure 2-3a. Data flow

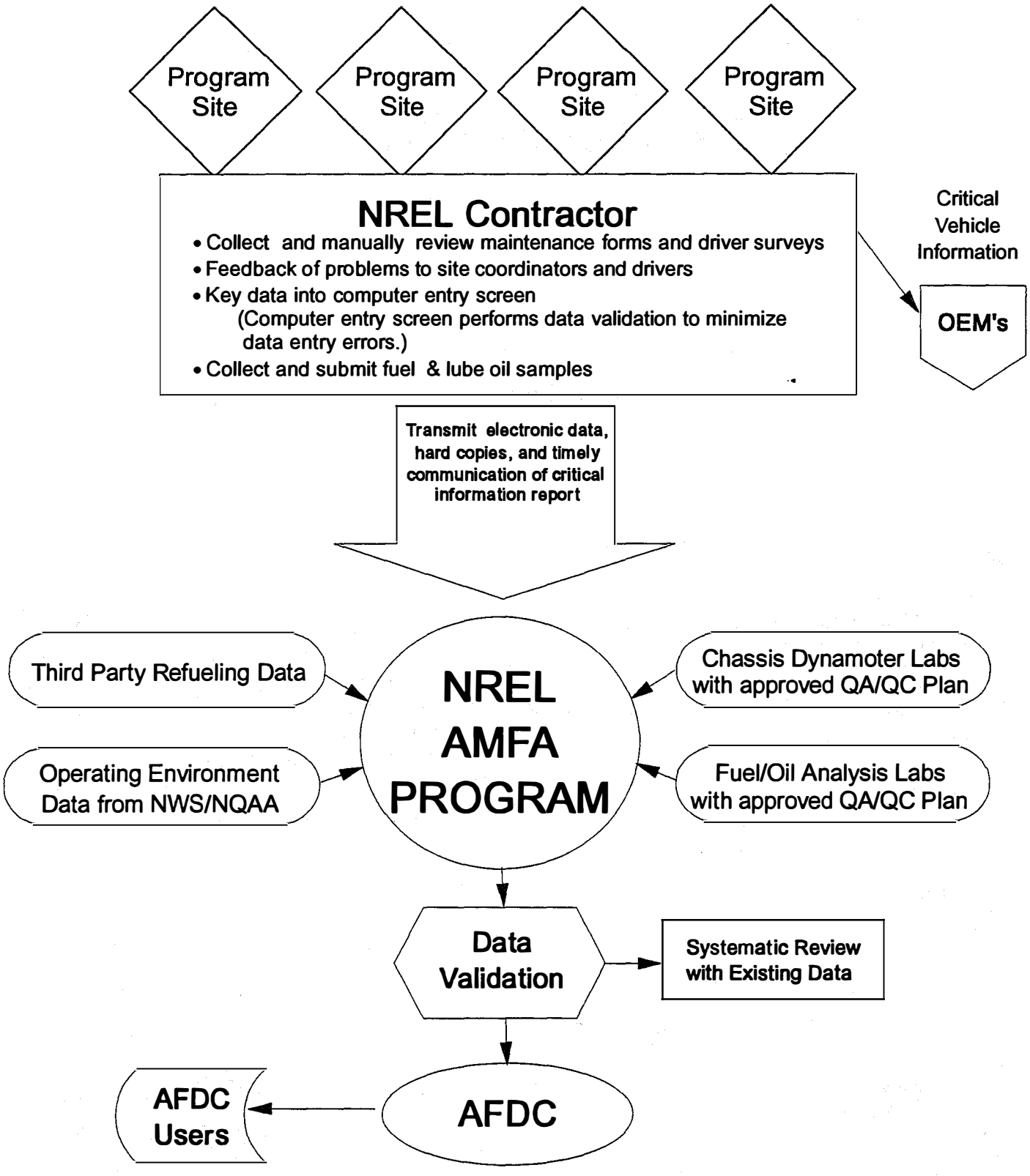

Figure 2-3b. Data flow

Section 3.0

Test Procedure Specifications and Data Protocols

The test procedures and data protocols required to properly collect and analyze the data from the participating fleets will establish a basis for valid comparisons between the control and alternative fuel vehicles. Commercial viability can be established by evaluating vehicle performance, fuel economy, driveability, durability, emissions, costs, and safety.

The data collection and analysis system and the reporting responsibilities will be discussed in the following sections. Table 3-1 shows the division of responsibilities.

Sample data forms are provided in Appendix C.

3.1 Division of Responsibilities

The following division of responsibilities is provided as a general guideline to the tasks and duties of the various personnel involved in the demonstration program. Specific conditions unique to some fleets may warrant deviation from this plan, but the on-site coordinator is responsible for ensuring that all tasks have been assigned, and that all personnel understand their assignments.

3.1.1 Vehicle Operator

The vehicle operator is responsible for completing the log sheets on a daily basis (submitted weekly), and accurately describing all vehicle operating problems that are observed. The operator is also responsible for completing the fuel usage log sheet, along with any fuel log information or electronic recording information kept at the refueling site (such as a credit card reader, etc.). The operator will provide all data forms to the fleet manager or on-site coordinator on a weekly basis.

3.1.2 On-site Coordinator

The on-site coordinator (an NREL subcontractor) is responsible for supplying the initial vehicle/powertrain/fleet data on a one-time basis when vehicles are put into operation. The on-site coordinator will provide all maintenance and repair records, as well as accident data, on the demonstration vehicles. The on-site coordinator will also collect the log sheets and refueling data from the operators and resolve all issues of missing or incomplete data.

The on-site coordinator is responsible for collecting and transmitting the data to NREL in the format specified by NREL. The preferred method of data transmission is by electronic transmission or magnetic disk. NREL will support the on-site coordinator by providing an electronic mail service and data entry screens.

Table 3-1. Division of Responsibilities

Driver	On-site Coordinator	Dealership	NREL Subcontractor	NREL
Complete and mail weekly log sheets	Collect/transmit data sheets from drivers and input data into appropriate data screens	Perform maintenance and repairs as required	Perform emissions tests as designated by NREL	Arrange subcontracts as required
Report unscheduled maintenance events	Provide shuttle service for test vehicles to designated test facilities	Supply repair and maintenance data to on-site coordinator	Perform fuel and oil analysis as designated by NREL	Designate Level 2 vehicles and tests to be performed
Arrange for vehicle service according to prescribed schedule	Collect fuel samples and deliver samples to designated labs	Pull oil samples		Perform QC/QA all incoming data
Complete fuel usage information required at refueling sites	Issue critical problems report to appropriate project participant			Provide data entry screens and electronic communication software/system
	Download data loggers			

3.1.3 Dealerships

The vehicle manufacturers' dealerships will perform maintenance and repairs on the vehicles as required, and supply repair and maintenance data to the on-site coordinator whenever requested. It is expected that one or more dealership technicians will receive factory training on the alternative fuel vehicles.

3.1.4 NREL Subcontractors

NREL subcontractors will perform emissions testing, fuel and oil sample testing, driveability testing, and other special tests if required. NREL will coordinate these tests.

3.1.5 NREL

NREL will arrange subcontracts for on-site coordination, emissions testing, fuel and oil sample testing, driveability testing, and any other special tests required. NREL will obtain the vehicle data, verify data quality, and store the data in the AFDC. NREL will make the data available to the public.

3.2 Basic Vehicle/Fleet and Powertrain Data

The basic vehicle/fleet data identifies individual vehicles within a given fleet and the configuration of a specific fleet. The basic powertrain data identifies the engine and drivetrain configuration for a specific vehicle in a given fleet. All these data should be stored in the vehicle data base. A summary of the data collection methods for both data types is provided below.

- Data contents - see Table 3-2
- Source - information to be obtained from vehicle owners manual, vehicle purchase documents, engine/vehicle manufacturers, suppliers, etc. Driver information to be supplied by the driver
- Format - to be completed on forms provided by NREL (see Appendix C)
- Frequency - vehicle and fleet information to be completed at each fleet site at the initiation of the project and submitted to NREL. Any subsequent modifications must be conveyed to NREL
- Transmission mode - data sheets to be submitted to NREL by mail (hard copy), FAX, "E-mail," or modem.

3.3 Performance Data

The objective of the performance tests is to measure key vehicle parameters at the start of the program and during normal vehicle operation to identify and compare in-use performance and driveability. The initial vehicle tests should be conducted at the start of the program to establish baseline performance results for later comparisons and evaluations with identical and similar vehicles. Data from in-use vehicle performance tests should be collected primarily through the use of an on-board data acquisition system (on select Level 2 vehicles). The following sections

Table 3-2. Vehicle/Powertrain/Fleet Data

Vehicle Data	Powertrain Data
• Vehicle Identification Number • GSA Tag Number • NREL Vehicle Number • Type (Pickup, Utility, etc.) • Body Style • Year of Manufacture • Curb Weight/Gross Vehicle Weight • Load Capacity • Towing Capacity • Tire Size Front/Rear • Number of Axles • Number of Tires • Fuel Tank Volume • Initial Odometer Reading • Air Conditioning (Y/N) • Vehicle Modifications (Y/N) - Fuel System (stainless, plastic, etc.) - Suspension (heavy-duty, adjustable) - Brakes (ABS) • Environmental Protection Agency (EPA) Fuel Economy	• Engine Model Number/Family • Engine Manufacturer • Fuel Type • Engine Displacement (liter) • Engine type (inline/60 deg/etc.) • Engine Horsepower Rating • Compression Ratio • Oil Capacity • Valvetrain configuration • OHC/DOHC/Pushrod/etc. • Valves/Cylinder • Number of Cylinders • Fuel System (Carburetor/FI/etc.) • Turbo/Non-Turbo • Spark/Glow Plugs
Operator Information	**Drivetrain Data**
• Name • Location • Phone Number • GSA Fleet Manager	• Transmission (Manual/Automatic) • Electronic Control (Y/N) • Lockup (Y/N) • Number of Gears • Drive Ratios - 1st Gear - 2nd Gear - 3rd Gear - 4th Gear - 5th Gear • Axle Ratio • System (2WD/4WD) - If 2WD – FWD or RWD - If 4WD – Full or Part-Time

will discuss the performance test procedures required for identifying the baseline and in-use vehicle performance during the program.

3.3.1 Initial Vehicle Inspection

An initial inspection should include checks of engine, fuel system, and exhaust components for conformance to manufacturer specifications and for proper vehicle operation.

Test procedures for obtaining emissions data for vehicles at the start of the project should follow the Federal Test Procedure (FTP) emission schedules. This procedure is further described in Section 3.6 of this report.

3.3.2 In-use Performance Tests

Comprehensive monitoring of critical vehicle parameters will aid in assessing in-use vehicle performance and operational characteristics. To monitor the data, a computer-based acquisition system should be installed on select Level 2 vehicles to measure specific vehicle and engine parameters. Date and vehicle distance traveled should be recorded on a form for each vehicle trip.

The data collection methods for in-use performance are shown below.

- Source - data to be gathered via an on-board data acquisition system and/or forms on selected Level 2 vehicles
- Frequency - data to be recorded daily or for each trip
- Transmission mode - data to be downloaded daily at the fleet site and transmitted to NREL via computer modem for further data processing. Forms to be sent via electronic mail, if possible.

On selected Level 2 vehicles, information should be gathered electronically for the following parameters:

- Vehicle speed (average, maximum, range)
- Acceleration/deceleration
- Cranking time to engine start
- Engine run time
- Distance traveled
- Engine speed, temperature
- Fuel temperature, pressure
- Oil temperature
- Number of cold/warm starts
- Ambient conditions.

3.3.3 Fuel Economy Data

To assess the relative fuel economy among vehicles, dynamometer test and calculated in-use vehicle fuel consumption measurements will be collected. In-use fuel economy, calculated from

the distance traveled and fuel used, should be used in determining actual fuel economy. Dynamometer fuel economy testing, as outlined in the FTP, should be used for comparison of test and control vehicles.

In-use fuel economy testing is accomplished by the vehicle operator recording the following on the refueling log sheet:

- Vehicle Number
- Date
- Mileage
- Fuel quantity
- Fuel type.

In addition, a fuel usage monitoring system should be maintained at the refueling site. This, in its simplest form, would be a log entry of fuel dispensed with odometer reading recorded.

The recommended test procedure for an objective determination of fuel economy is the FTP schedule used by the U.S. government for the certification of new vehicles. Effective in 1978, the actual distance driven using this driving schedule is used to calculate official "city" fuel economy values. The Highway Fuel Economy Test Schedule (HWFET) consists of two 765-s driving cycles. The average speed of each 10.2-mile cycle is 48.6 mph. This schedule is used in the United States to obtain the official "highway" fuel economy figures.

3.4 Driveability Data

The objective of obtaining driveability data is to gather and assimilate the vehicle driving characteristics according to operator opinions and desired acceptance criteria.

Driveability data will be collected from the weekly driver survey questionnaires on all Level 1 and 2 vehicles. Some Level 2 vehicles may have a Coordinating Research Council (CRC) driveability test procedure conducted at intervals, in order to assess the driveability performance more accurately. This would be arranged by NREL or a designated subcontractor.

Driveability data to be collected for Level 1 and 2 vehicles include

- Date
- Start/finish odometer reading
- Vehicle driveability rating by superior/good/average/poor
  - cold starting (cranking time, stalling, etc.)
  - warm starting
  - idle quality (misfire, non-steady, etc.)
  - transmission shift quality
  - overall driveability (hesitation, lack of power, etc.)
  - additional comments.

By assigning numerical values to the raw data, elementary mathematical operations such as summing and averaging over selected time periods or dates can be accomplished in an attempt to understand trends in vehicle driveability.

The CRC test procedure should be followed for selected Level 2 vehicles in order to accurately assess and compare vehicle driveability. This would be arranged by NREL as a separate test and would not be considered the agency's responsibility.

The following is a brief description of the methods for gathering the driveability data.

- Data contents - see the list shown previously for Level 1 vehicles
- Source - driveability data to be gathered for Level 1 and 2 vehicles. Drivers to record their assessment on a particular vehicle and return completed forms to the addressee identified on the form
- Format - to be completed on forms distributed to vehicle operators (see sample form in Appendix C)
- Frequency - completed forms to be filled out daily and submitted on a weekly basis to the addressee identified on the form
- Transmission mode - completed driveability data sheets to be submitted by mail to the addressee, who will key the information into a computer-based entry screen, which will then be sent to NREL by electronic mail.

3.5 Durability Data

The objective of measuring durability data is to quantify vehicle maintenance, component failures, and engine wear characteristics. Once maintenance practices and durability characteristics are quantified, future improvements can be evaluated.

Engine teardown procedures may occur at the end of the program with a visual inspection of all the major internal components. Wear surfaces should be measured (pistons, piston rings, bearings, cam surfaces, etc.), for each of the major engine components. The engine oil should be analyzed at every oil change (Level 2 vehicles) per the recommended test procedure (included as Appendix A). Fuel quality measurements should be conducted monthly or for every batch of fuel, and should follow the test procedures included as Appendix B. NREL subcontractors will perform sample collection and analyses.

Failure tests should be conducted if component breaks or wears excessively. A trained failure analysis representative from the vehicle manufacturer should examine the component(s), determine the cause, and recommend possible action to correct the problem. A failure report identifying and describing the component(s) failure should be completed following the analysis and submitted to NREL.

Identical maintenance procedures for scheduled services should be followed for the same vehicle models across all the fleets. Scheduled service should follow the suggested vehicle manufacturers' specifications, with additional data recorded such as date, vehicle odometer reading, and any special requirements. Similarly, unscheduled service should include a brief description of the type of service performed, duration of work, and parts and labor costs, as well as a description of the problem.

It is expected that vehicle manufacturers will train mechanics within designated local dealerships to support the operation and maintenance of the alternative fuel capable (AFC) vehicles. In order to reduce vehicle downtime, regularly used or worn parts should be stocked at designated local dealerships and the supply reviewed periodically for adequate parts inventory.

3.6 Emissions Data

The objective of testing the exhaust and evaporative emissions from Level 2 vehicles is to provide a means of comparing emissions from the alternative fuel and control vehicles. Emission data will be obtained at specified mileage accumulation intervals. The results should indicate trends in emission levels as the vehicles age.

Test procedures for obtaining emissions data will consist of FTP tests for Level 2 vehicles. FTP emission test schedules should be performed at mileage intervals of 4K, 10K, 20K, 30K, 40K, etc.

The FTP schedule procedure for accurately measuring emission levels is detailed in the Code of Federal Regulations Title 40: Part 86 Subpart B - Emission Regulations for 1977 and Later Model Year New Light-Duty Vehicles and New Light-Duty Trucks; Test Procedures. An overview of the test procedure is described in Section 86.127-82, with the general test sequence requirements detailed in Section 86.130-78. The test consists of engine startups and vehicle operation on a chassis dynamometer, through a specified driving schedule.

Exhaust emissions may be influenced by other measured data such as

- Fuel consumption
- Engine performance and wear
- Fuel quality
- Oil quality.

Data recorded in the emissions data base should include

- Test date
- Test number
- Test laboratory
- Test conditions
- Test fuel number
- Test fuel type - on flexible fuel vehicles, alternative fuel and gasoline should both be tested.
- Vehicle odometer reading
- Test title and description
- Test results in grams per mile:
  - hydrocarbons (methane and non-methane)
  - CO
  - CO_2
  - NO_x
  - particulates (diesel cycle vehicles only)
  - total aldehydes
  - formaldehyde

- speciation of all hydrocarbons using gas chromatograph (GC) or Fourier transform infrared (FTIR) instrumentation.

A list of the exhaust and evaporative emission compounds that should be speciated is given in Table 3-3. This listing is not a complete or extensive representation of the entire vehicle emission constituents; however, it represents a minimum list and should provide general information. The GC analysis output should also quantify the total percent volume of paraffins, olefins, and aromatics. Generally, laboratories under contract to NREL for chassis dynamometer tests will use their own GC analytical procedure. Each laboratory will be expected to maintain an adequate QA/QC program to defend the accuracy of their measurements.

3.7 Cost Data

The purpose of collecting cost data is to provide an accurate assessment of the vehicle operating costs in actual fleet conditions. The costs associated with purchasing, operating, maintaining, and salvaging an alternative fuel vehicle will be recorded into a cost data base for further processing.

- Data contents - operating costs, maintenance costs, initial purchase cost, and vehicle salvage value
- Source - cost data to be obtained from each of the participating fleet sites through maintenance service records and fuel logs
- Format - to be completed on forms distributed to each fleet site
- Frequency - forms to be completed as required based on vehicle service/repair and parts replacement
- Transmission mode - vehicle maintenance information to be submitted to the on-site coordinator, who in turn will submit the information to NREL via electronic mail.

The total and incremental costs associated with operating a vehicle can be used in determining the total life cycle cost of operating a fleet of vehicles, and also provide for valid comparisons to other alternative fuel and conventional vehicles.

3.8 Accident Data

The objective of collecting accident data is to understand the safety impact associated with using an alternative fuel vehicle compared to a conventional vehicle under similar operating conditions. In the case of an accident, such as a fire or vehicle collision, an accident report should be completed that documents the specific events leading to the accident, as well as a report of property damage and injuries. Also, recommendations should be made on the future precautions necessary to prevent further occurrences. Proper documentation of accidents will lead to improvements in maintenance and safety procedures, refueling procedures, and vehicle design.

Table 3-3. Emissions Speciation List (Example)

Compounds	Gasoline/Diesel	Alcohol	Natural Gas
Methane	■	■	■
Ethylene	■	■	■
Ethane	■	■	■
Acetylene	■	■	■
Propylene	■	■	■
Propane	■	■	■
Methylacetylene	■	■	
Propadiene	■	■	■
Isobutane	■	■	■
Isobutylene	■	■	
1-Butene	■	■	
1,3-Butadiene	■	■	
Butane	■	■	■
Trans-2-Butene	■	■	
2,2-Dimethylpropane	■	■	
CIS-2-Butene	■	■	
3-Methyl-1-Butene	■	■	
Methanol		■	
Isopentane	■	■	■
1-Pentene	■	■	
2-Methyl-1-Butene	■	■	■
Pentane	■	■	
Benzene	■		
Toluene	■		
Ethylbenzene	■		
Metaxylene/Para-	■		
Ethanol		■	
Methyl Tertiary Butyl Ether	■	■	
Formaldehyde	■	■	
Acetaldehyde	■	■	

Shaded areas indicate that a measurement of the specified component should be made.

Appendix A

Oil Analysis Test Procedures

Table A-1. Engine Lubricating Oil[1]

Analysis	Test Procedure
Solids (percent volume)	ASTM D 893
Glycol Content	ASTM D 2982
Fuel Dilution	ASTM D 322 or D 3525 (gasoline), ASTM D 3524 (diesel fuel)
Engine Oil Viscosity and Viscosity Index	SAE J300; ASTM D 445 and D 2161; ASTM D 2270
Total Base Number (TBN)/Total Acid Number (TAN)	ASTM D 2896
Spectrochemical Analyses (wear metals, solubles)[2]	no ASTM or SAE method
Flash Point	ASTM D 92
Water Dilution	ASTM D 95
Cloud Point	ASTM D 2500
Carbon Residue	ASTM D 524
Appearance and Odor	Chevron (see "Testing Used Engine Oils")
API Gravity	ASTM D 287/API 2544
Pour Point	ASTM D 97
Ash Content	ASTM D 874

See "Specification for Automotive Engine Oils," ASTM D 4485, and "Physical and Chemical Properties of Engine Oils," SAE Information Report J357, for more detailed information about the purpose of the tests and how they are to be conducted.

[2] This includes Fe, Cr, Pb, Cu, Sn, Al, Ni, Ag, Mn, Si, B, Na, Mg, Ca, Ba, P, Zn, Mo, Ti, V, and Cd.

Appendix B

Fuel Quality Test Procedures

Table B-1. Gasoline[1]

Analysis	Test Procedure
Distillation	ASTM D 86
Vapor/Liquid Ratio	ASTM D 2533
Vapor Pressure	ASTM D 4814
Research Octane Number	ASTM D 2699 or D 2885
Motor Octane Number	ASTM D 2700 or D 2885
Corrosion	ASTM D 130
Existent Gum	ASTM D 381
Sulfur Content	ASTM D 1266 or D 2622
Lead Content	ASTM D 2547, D 3116, D 3229, or D 3341
Oxidation Stability	ASTM D 525
Phosphorus Content	ASTM D 3231
Hydrogen Content[2]	ASTM D 3343
Gravity/Density[2]	ASTM D 1298
Heating Value[2]	ASTM D 240 or D 2382

[1] These analyses and test procedures are specified in greater detail in "Specification for Automotive Gasoline," ASTM D 439. See also "Automotive Gasolines," SAE J312, and "Specification for Spark-Ignition Automotive Engine Fuel," ASTM D 4814.

[2] Not included as part of ASTM D 439.

Table B-2. Diesel Fuel[1]

Analysis	Test Procedure
Flash Point	ASTM D 93
Cloud Point	ASTM D 2500
Water and Sediment Content	ASTM D 1796
Carbon Residue	ASTM D 524
Ash	ASTM D 482
Distillation	ASTM D 86
Viscosity	ASTM D 445
Sulfur Content	ASTM D 129
Corrosion	ASTM D 130
Cetane Number	ASTM D 613
Color	ASTM D 1500
Gravity/Density	ASTM D 287 or D 1298
Pour Point	ASTM D 97
Wax Point	ASTM D 3117
Oxidation Stability	ASTM D 2274
Rust Protection	ASTM D 605

[1] These analyses are described in greater detail in "Specification for Diesel Fuel Oils," ASTM D 975. See also "Diesel Fuels," SAE J313.

Table B-3. Methanol, Ethanol, 85% Blends[1]

Analysis	Test Procedure
Total Acids	ASTM D 1613
Suspended Solids	ASTM D 2276
Vapor Pressure	ASTM D 4814
Copper Content	ASTM D 1688
Phosphorus Content	ASTM D 3231
Manganese Content	ASTM D 3831
Water and Sediment	ASTM D 1796
Lead Content	ASTM D 3237
Gravity/Density	ASTM D 287 or D 1298
Hydrocarbon Content[2]	ASTM D 1319
Chlorine	ASTM D 808 or D 1317
Sodium	ASTM D 811

[1] See also "Specification for Spark-Ignition Automotive Engine Fuel," ASTM D 4814; "Alternative Automotive Fuels," SAE J1297, and "Impacts of Alternative Fuels on Engine Test and Reporting Procedures," SAE J1515.

[2] For alcohol/hydrocarbon blends.

Note: Specifications and analytical test procedures for 99.85% pure methanol are given in "Standard Specification for Methyl Alcohol," ASTM D 1152. However, this standard has apparently been made without special consideration of methanol as an automotive fuel and thus should not be used instead of, but in addition to, ASTM D 4814.

Table B-4. Methane (Natural Gas)[1]

Analysis	Test Procedure
Heating Value	ASTM D 1826
Total Sulfur Content	ASTM D 3031
Specific Gravity	ASTM D 1070
Hydrogen Sulfide and Mercaptan Sulfur	ASTM D 2385, D 2727, or D 4084
Non-condensible Gases	ASTM D 2504
Methane, CO_2, N_2, He, C_2, C_3, and Higher Hydrocarbon Contents	ASTM D 1945
Water Content	ASTM D 1142

[1] See "Alternative Automotive Fuels," SAE J1297, and "Impacts of Alternative Fuels on Engine Test and Reporting Procedures," SAE J1515.

Appendix C

Data Collection Forms

BASIC VEHICLE DATA

Date:

Vehicle identification number:

Fleet Information:

Fleet name:		Fleet vehicle number:
Fleet type:		Fleet size:
Street address:		
City:	State:	Zip:
Contact fleet manager:		
Phone number:		

Vehicle Information

Type:	Body Style: Year:
Curb weight/GVW:	Load capacity:
Towing capacity:	Tire size front: rear:
Fuel tank volume:	Air conditioning (Y/N):
Initial odometer reading:	EPA fuel economy:

Vehicle Modifications

Fuel system:
Suspension:
Brakes:

BASIC POWERTRAIN DATA

Date:

Vehicle identification number:

Fleet Information:

Fleet name:		Fleet vehicle number:
Fleet type:		Fleet size:
Street address:		
City:	State:	Zip:
Contact fleet manager:		
Phone number:		

Engine

Engine model number:	Engine manufacturer:
Fuel type:	Engine displacement (L):
Engine type (inline, 60 deg., etc.):	Engine HP:
Compression ratio:	Oil capacity:
Valve train configuration (OHC, DOHC, pushrod, etc.):	
Valves/cylinder:	Number of cylinders:
Fuel system (carburetor, FI, etc.):	
Turbo/nonturbo:	Spark/glowplugs:

Drive Train

Transmission (manual/auto.)		
Electronic control (Y/N):		Lockup (Y/N):
Number of gears:		
Drive ratios	1st gear:	2nd gear:
3rd gear:	4th gear:	5th gear:
Axle ratio:		System (2WD, 4WD):
If 2 WD -- FWD or RWD:		If 4WD -- full or part time:

MAINTENANCE REPORT

Vehicle Identification Number:	GSA Tag Number:

Fleet Information:

Date:	Work Order Number:
Odometer:	
Fault reported:	
Work description:	

Parts Replaced:

Costs:

Parts cost:
Labor cost:
Overhead cost:
Total cost:

C4

VEHICLE WEEKLY LOG SHEET

(Revision #4, Oct. 91)

Contact Person:_____ Phone: (_____) _____ - _____ Organization: _____

Vehicle Decal #_____ License #_____ Data Collection for Week Beginning (Monday): _____ / _____ /1991

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Starting Odometer Reading:							
Ending Odometer Reading:							

Please evaluate the performance of your vehicle by responding to the performance catagories listed in the table below.
Responses are: **S = Superior; ✓ = No Problem; A = Mildly Annoying; T = Very Troublesome**

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Hard to Start							
Stalled After Starting							
Stalled in Traffic							
Idle Quality							
Acceleration Quality							
Hesitation, Coughing							
Lack of Power							
Pinging							
Check Engine Light Problems							

Regardless of severity, if any problem occurred, describe the type of driving (e.g., city, freeway), time of occurrence, and approximately weather condition (temp./moisture) for each problem occurrence.

_____

_____

_____

	FUEL ADDED			OIL ADDED		
	# Gallons	Fuel Type	Odometer	# Qts.	Odometer	
Monday						Maintenance Performed? _____ Scheduled
Tuesday						Yes_____ No_____ _____ Unscheduled
Wednesday						If yes, Date: _____
Thursday						Type of Maintenance: _____
Friday						**Return Completed Form via U.S. Mail To:**
Saturday						**E.A. Mueller; 1401 South Edgewood Street; Baltimore, MD 21227-1084;**
Sunday						**Attn: Daryl Marinetti 1-800-333-2624**

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