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INTERNATIONAL
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SAE/USCAR-13

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STANDARD FOR IN-TANK ELECTRIC FUEL PUMPS

SUMMARY OF CONTENTS

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1.0 SCOPE:

This standard covers the operational characteristics, environment, durability procedures, and test procedures for in-tank electric fuel pumps for automotive gasoline applications. Specific performance and test criteria used in conjunction with this procedure are specified on the pump drawing. Particular sections of this document may be required for all applications. This standard is intended to evaluate specific characteristics as a supplement to normal material inspections, dimensional checking, and in-process controls, and should in no way adversely influence other inspection operations.

1.1 Hazardous Material Control:

Products furnished to the customer and products and processes used by suppliers to manufacture those products must conform to employee and consumer health, employee safety, and environmental requirements.

2.0 OUTLINE:

2.1 General:

Diagrams are provided where necessary to clarify the details of the test procedures. Use fig. 1 for general setup unless otherwise specified. A glossary of terms and equipment are provided in Appendix A. All test procedures and apparatus must meet all applicable codes and shall be the responsibility of the supplier to design such equipment.

3.0 REFERENCE DOCUMENTS AND DEFINITIONS:

Requirement Hierarchy - In the event there is a conflict between this standard, part drawings, and other related standards or specifications, prioritize the order in which requirements are determined as follows:

1st - Applicable part drawing(s)
2nd - Application Specific Requirements
3rd - USCAR Standards
4th - Design Verification, Production Validation and Continuing Conformance Requirements
5th - Other related standards and specifications

3.1 Symbols:

Safety, noise, emission, or theft prevention significance will apply to this standard only when the corresponding drawing depicts the standard with the respective symbol. To determine which portions of a specification have safety, noise, emission, or theft prevention significance, a review of the part drawing may be necessary.

3.2 Part Drawing:

The part drawing for the fuel pump should contain or reference the following:

A. All dimensional requirements

- Wherever possible the applicable electrical connector should be used in conducting the test sequences contained in this document to simulate actual in-vehicle conditions.

- The circuitry shall be terminated using connectors that comply with SAE/USCAR-2, Standard for Automotive Electrical Connection Systems, and the SAE/USCAR-12, Wiring Component Design Guidelines.

B. Performance requirements
C. Supplier part number
D. Reference to applicable portions of this and other specifications
E. The typical mating connector and terminals
F. Federal Motor Vehicle Safety Standard (FMVSS) Requirement, if applicable

3.3 Application Specific Requirements:

The application specific requirements shall identify the parameters that differ from the general specifications in this document. The application specific requirements may or may not be an integral part of the part drawing.

3.4 Development Tests:

Development tests are frequently used to evaluate specific areas of the design. They are a tool for evaluating design alternatives, proposed improvements, cost reduction proposals, or determining root causes of field problems.

3.4.1 Validation Tests: Validation tests or sample approval tests are acceptance-type tests. Consideration shall be given to the inherent repeatability or subjectivity of certain tests outlined by this specification before designation as a validation or compliance test.

4.0 GENERAL REQUIREMENTS:

4.1 Record Retention:

The supplier shall maintain a central file for the storage of laboratory reports and calibration records. A record retention policy concerning these records shall comply with QS-9000. Customer specific files shall be made available to any and all customer personnel upon request, including but not limited to representatives from the following functions: product engineering, purchasing, quality, and reliability.

4.1.1 Objectives of Record Retention: The following are the main objectives for record retention:

A. Retain records that will evidence compliance so that the supplier can appropriately respond when or if product compliance is challenged. Files shall exist for the storage of all laboratory records, data, and calibration records. The files shall be available at any time for audit or inspection.

B. Retain records as needed to assist in evidencing the exercise of "due care" in matters relating to product compliance to government requirements or product liability.

C. Comply with statutory requirements for the maintenance and retention of specific records to substantiate compliance with legal requirements.

4.1.2 Retention Methods: Method of retention must conform to the suppliers corporate procedures and may include retention of original documents, the use of film, or electronic storage equipment. Records must be stored so that they are accessible in a reasonable amount of time. Storage areas should provide adequate protection from unauthorized access, moisture, and fire.

4.2 Sample Documentation:

Engineering test samples shall be identified by part number and serial number unless otherwise noted.

4.2.1 Required Data Package:

4.2.2 Master Samples: Master samples for performance, noise, or construction, if required by the customer, will be provided at the time of approval.

4.3 Sample Sizes:

Sample sizes will be documented in the application specification.

4.4 Materials and Process Standards:

Suppliers are expected to subscribe to appropriate Materials and Process Standards that are called out by this specification.

The supplier shall not change any material or process requirements subsequent to Design Verification approval without the written consent of the customer's releasing department.

Unless otherwise specified or required by law, suppliers should use the most recent versions of any applicable reference documents or standards.

4.5 Measurement Resolution:

Meters and gages used in measurements of the test sample shall be capable of measuring to one count less than the specified value. For example, even though a 0.1 mm and 0.10 mm might be the same diameter, calipers capable of 0.01 mm resolution may be used to measure the first wire but a micrometer with 0.001 mm resolution is required to measure the second wire.

4.6 Test Repeatability and Calibration:

Repeatability studies shall be performed on all laboratory equipment after initial calibration and before use for product evaluation. Individual gages and meters must be calibrated to the manufacturer's specifications on a regular basis.

4.7 Conformance Determination:

Test conformance shall be determined by the performance requirements of the test being performed. All samples shall satisfy the performance requirements regardless of age, cycles, or temperature, unless otherwise noted on the part drawing.

4.8 Disposition of Samples:

Should a premature test nonconformance occur, contact the requesting party to determine if the test is to be continued to gain additional product experience or if testing is to be suspended. When contact cannot be immediately made, the type of test shall determine the disposition of the samples. If the test order indicates that the test is investigative in nature, continue until the requesting party or parties are available. If the test order is for sample approval or validation, stop the test until the requesting party can be contacted.

4.9 Quality Control:

A supplier who furnishes finished parts is responsible for the quality of all components of the shipped assembly or end item, whether component parts are processed/ manufactured by the supplier or purchased from another source. If required, parts shall be purchased only from customer-approved sources.

4.10 Pump Performance Stabilization:

Before testing, pumps must be run to a stabilization condition. The amount of time required for stabilization will depend on the pump technology. It's expected that this will not exceed 24 h.

4.11 Assembly Plant Performance:

The fuel pump must meet minimum performance requirements dictated by the assembly drawing as received by the customer.

5.0 PERFORMANCE TESTS:

Prior to performance measurements, the fuel pumps shall be run on the test stand at test voltage and pump outlet pressure (according to the approved specification) to stabilize the functional data.

5.1 Pump Output:

Measure flow and current at the following conditions:

- Emission Test Fuel
- 20°C ± 2°C, -30°C ± 2°C
- 12.0 ± 0.1V
- Pump Outlet Pressure (per approved specification)

5.1.1 Forward Check Valve Leakage (if required):

5.1.1.1 Procedure: Test leakage in the forward direction after soaking in emission test fuel for 10 min. (See test setup in fig. 2.) An air test may be substituted for the In-Process test with suitable correlation data ($r^2 \geq 0.9$ and $n \geq 30$ samples) and approval from the customer.

5.1.2 Reverse Check Valve Leakage: The fuel pump check valve shall not exceed the leakage rate shown in the chart when tested in the reverse direction after soaking in emission test fuel for 10 min. (See test setup in fig. 3.)

Check Valve Leakage Chart

Direction	Leakage Rate	Pressure – Kpa
Forward	3.0 ml/min	30
Reverse	1.0 ml/hr	10% of Pump Outlet Pressure

Perform all tests at -30°C, 20°C, and 40°C, ±2°C.

5.2 Pressure Relief Valve Maximum Pressure:

The maximum pressure the fuel pump is allowed to achieve is 1000 kPa (145 psig) at 15.2 ± 0.1V and zero flow (dead-head).

5.3 Start-Up Current:

5.3.1 Procedure:

A. Set up test according to fig. 7. Repeat three times with 10 s intervals to ensure prime and air purge. Ensure the third time start up is under fuel pump outlet pressure. Use emission test fuel.

B. Apply 12.0 ± 0.1V to the pump terminals using a power supply capable of 40 A minimum at 24 ± 0.1V and energize the pump with a step function of 5 ms or less to close the circuit.

C. Record the peak current using an appropriate wave form analyzer or equivalent.

5.3.2 Acceptance Criteria: The instantaneous start-up current at 12.0 ± 0.1V and 20°C ± 2°C on the third start up shall not exceed the value as indicated according to approved specification for the applicable pump assembly operating in emission test fuel.

5.4 Module Fill Performance (if required):

This requirement only applies to fuel pumps with an integral aspirator jet tube as specified on the pump drawing. The flow output from the aspirator outlet shall exceed the minimum requirement specified on the pump drawing when a minimum 63.5 mm (2.5 in) fluid head height is maintained above the centerline of the aspirator.

5.5 Module Prime (if required):

The pump must purge itself of air and vapor and generate the pump outlet pressure in less than 10 s after the application of 12.0 ± 0.1V to the pump. Test each sample pump for each temperature in the Temperature Chart of section 5.5.2.

5.5.1 Test Conditions: Fig. 4 defines the test stand schematic and depicts the fuel level and pump orientation during reprime.

5.5.2 Temperature Chart:

Fuel Temperature at Run-Out	Temperature of the New Fuel	Ambient Air Temperature
-30°C ± 2°C (-22°F)	-30°C ± 2°C (-22°F)	-30°C ± 2°C (-22°F)
27°C ± 2°C (80°F)	21°C ± 2°C (70°F)	21°C ± 2°C (70°F)
49°C ± 2°C (120°F)	27°C ± 2°C (80°F)	32°C ± 2°C (90°F)
71°C ± 2°C (160°F)	35°C ± 2°C (95°F)	51°C ± 2°C (124°F)

5.5.3 Test Procedure:

A. Position the fuel pump module in the fuel tank at its designed height and orientation angle. If the pump is part of a fuel pump module, it must be tested within the module for this test.

B. Pour 11.4 L (3.0 gal) of emission test fuel, with a Reid Vapor Pressure (RVP) raised to 83 kPa (12 psig) into the tank.

C. Apply 12.0 ± 0.1V to the pump and run the pump as described below until run-out (5.5.3 D, E, F, G, & H).

D. Set pressure to pump outlet pressure.

E. Heat or cool the fuel to the desired temperature.

F. Drain 7.6 L (2 gal) of fuel from the tank.

5.5.3 (Continued):

G. Open flow control valve and set flow rate at 9.1 kg/hr (20 lb/hr).

H. Run the pump until the fuel pressure has fallen below 1/3 of the pump outlet pressure. Turn off fuel pump and fuel heating system.

I. Add into the tank fresh 83 kPa (12 psig) minimum RVP emission test fuel, mixed with 10% ethanol, to the level of 12 mm from step F simulating 3.8 L (1.0 gal). The new fuel temperature shall correspond to the fuel pump temperature value in the "Temperature Chart" of section 5.5.2.

J. Measure the pump prime by applying 12.0 ± 0.1V to the pump while recording the pump current and pressure traces with a two-channel strip chart recorder, or equivalent.

5.6 Radial/Axial/Torsional and Hydraulic Pressure Pulsation:

5.6.1 Production Testing by the Supplier: The pump shall not exceed the radial/axial/torsional vibration and outlet hydraulic pressure pulsation shown on the print. Test the pump at the applied voltage and operating pressure according to approved specification.

5.7 Subjective Noise Evaluation:

The pump shall not produce an objectionable noise as determined by the customer inside or outside the applicable vehicle when the pump is mounted in the production intent module and fuel tank. The customer will perform the noise evaluation on production intent pumps.

5.8 Check Valve Noise:

5.8.1 Procedure:

A. Operate the pump as indicated in fig. 1 with the outlet pressure regulated to the appropriate pressure specified on the print.

B. Ramp the voltage from 6 to 16V ± 0.1V to obtain a 20 g/s per min ramp rate.

C. Repeat the procedure starting at 16 ± 0.1V and ending at 6 ± 0.1V. Report any objectionable check valve noise at the corresponding flow rate. (Note: This is a subjective test and must be conducted by personnel knowledgeable in check-valve stability testing.)

5.8.2 Acceptance Criteria: The check valve assembly shall not generate objectionable noise when operated.

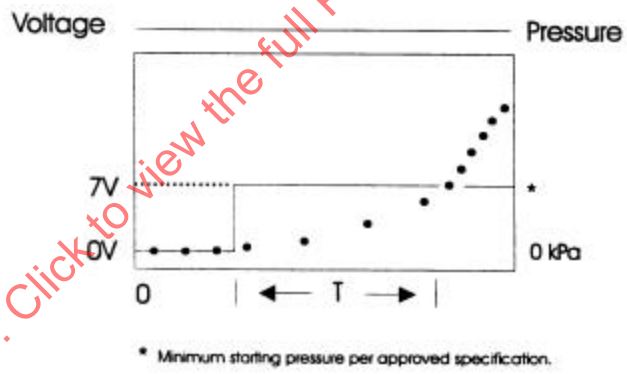
5.9 Hot Fuel Handling:

The fuel pump shall meet the required flow when heated from room temperature to the maximum temperature. The required flow, maximum temperature, fuel, and operating cycle shall comply with the approved specification.

5.10 Pressure Rise Time:

Use setup in fig. 7. Set pressure regulator to pump outlet pressure. Use emission test fuel. Apply a 7V ± 0.1V step input to the pump until final pressure is attained. (Before starting test, energize pump to fill lines with test fluid.) The pump must meet pressure rise requirements in the approved specification. Conduct the test at two temperatures: -30°C and 20°C ± 2°C.

Test Parameters:
Flow = 0 LPH
Initial Pressure = 1-5 kPa



5.11 RFI/EMI (C):

The pump shall meet the EMC requirements of the customer. The supplier of the pump is responsible for conducting prescribed compliance tests for EMC requirements and submitting a test report to the customer.

Categories of testing will typically include -- but not be limited to -- the following:

- Conducted Electromagnetic Emissions
- Conducted Transient Emissions
- Electrical Supply Transient Susceptibility
- Over Voltage/Reverse Voltage Test
- Radio Frequency Interference (RFI)

Vehicle Testing

The final product test is with the motor installed in a representative vehicle. The customer will run vehicle system tests to ensure a quality product. As a result, the customer may change the specific EMC requirements.

5.11.1 Acceptance Criteria: Supplier-conducted pump tests shall include the respective acceptance criteria within the test descriptions.

Customer-conducted vehicle tests will typically require that the pump not adversely affect the various computer modules and electronic systems of the vehicle.

5.12 Anti-Ignition:

The fuel pump shall not ignite a combustible air/fuel mixture during operation. Testing involves powering the pump in an explosion-proof chamber, which contains a combustible air/fuel mixture, as shown in fig. 8.

5.12.1 Procedure:

A. Install fuel pump inside of the chamber and introduce fuel to achieve a homogeneous stoichiometric air/fuel mixture.

B. Power the pump with 13.5, 18, and 24 VDC for 5 s. Repeat for 5 on/off cycles. Ensure through thermocouple no ignition was present.

C. Ignite the atmosphere inside the chamber to verify its combustibility.

6.0 DURABILITY TESTS:

Acceptance Criteria

All pumps must meet requirements in sections 5.1, 5.2, 5.3, 5.4, 5.6, 5.9, 5.10, and 5.13 before and after tests, unless otherwise specified.

6.1 Cold Magnet Knockdown:

6.1.1 Procedure:

A. Soak the pump for 2 h in emission test fuel at a temperature of -40°C ± 2°C (-40°F).

B. Energize the pump twice for 5 s at 18 ± 0.1V.

6.2 Thermal Cycle Durability Test:

The pump shall be alternately heated and cooled from +70°C (176°F) to -40°C ± 2°C (-40°F) for 20 cycles. Run the test according to fig. 6 with the pump dry and not in fuel. Do not apply voltage to the pump during the test.

6.3 Pressure Cycling:

Perform the initial performance test according to sections 5.1 - 5.3. Operate the fuel pump in emission test fuel with 12.0 ± 0.1V applied to the terminals and the outlet pressure regulated to pump outlet pressure using a pressure checking regulator. Cycle the pump according to the temperature profile in fig. 6 while simultaneously interrupting the pump power 10 times per min, 3 s on and 3 s off. Energize the pump with a step function of 5 ms or less in the pump D.C. power line to cycle the power on and off. Repeat this for 14 temperature cycles. Upon test completion, allow the pump to stabilize at room temperature and repeat the initial performance tests.

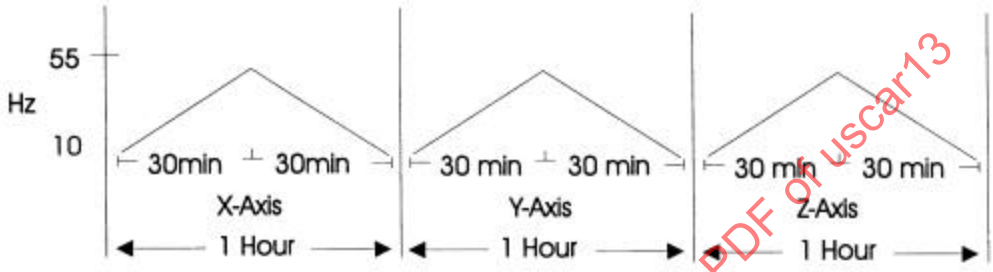
In addition to the overall criteria, test for section 5.11.

6.4 Vibration:

Ensure fixture pump is in vertical position, then run the following test sequence:

- Vibrate using a sinusoidal forcing function according to the cycle below for a total of 3 h (1 h in each of the axis shown). Total excursion of 0.75 mm (ref. max. 4.5 g's).

  Test Parameters:



Note: Fuel pump is not energized or in test fluid for this test.

6.5 Dry Operation:

The Dry Operation test is to be performed at room temperature. Different pumps can be evaluated at each test temperature.

6.5.1 Procedure:

A. Run the pump in emission test fuel at 12.0 ± 0.1V and pump outlet pressure at the test temperature specified above.

B. Turn the pump off and immediately raise it out of the fuel. Remove the strainer and operate the pump at 12.0 ± 0.1V for 5 s with the pump oriented outlet down.

C. Run the pump in air for 10.0 ± 0.1 voltage cycles. A voltage cycle is 12.0 ± 0.1V for 30 s followed by 0V for 10 s.

6.6 Corrosion Resistance:

Use fuel [C(M15)]A. The test sequence, in accordance with SAE J1681, is as follows:

- Use sufficient amount of fuel to submerge fuel pumps and thoroughly wet all internal components.
- Run for 5 min.
- Soak pumps for 30 days.

6.7 Contaminated Fuel (Dust Resistance):

Use test setup in fig. 9 in conducting this test. Use only emission test fuel and a production intent inlet filter.

Test Parameters:

(Note: Before fuel change, flush pumps and perform tests.)

- Voltage = 13.2 ± 0.1V & Pump Outlet Pressure
- SAE Fine Dust: 10 mg/L
- Fuel and Contaminant Change: 168 h w/o filter disturbance or change
- Temperature Range Allowed: = 20°C to 40°C ± 2°C
- Duration = 1,000 h
- 6 L/pump

6.8 Over Pressure:

Test the pump for 1000 h in emission test fuel. Regulate the fuel pressure at 100 kPa (14.5 psig) above the pump outlet pressure.

6.9 Exposure to Humidity:

6.9.1 Procedure: Expose pump to 95% relative humidity at 38°C ± 2°C for 96 h. Allow pumps to return to room temperature and test at room temperature according to fig. 1 using the test parameters in the approved specification.

6.9.2 Performance at High Temperature and Storage: Flush using production intent procedure. Prepare pump for shipping (cap, bag, etc.) as it is (will be) done in production. Store at 60°C ± 2°C for 500 h, then remove pumps. Allow pumps to return to room temperature and test at room temperature according to fig. 1 using the test parameters in the approved specification.

6.9.3 Performance at Low Temperature and Storage: Flush using production intent procedure. Prepare pump for shipping (cap, bag, etc.) as it is (will be) done in production. Store at -30°C ± 2°C for 500 h, then remove pumps. Allow pumps to return to room temperature and test at room temperature according to fig. 1 using the test parameters in the approved specification.

6.10 Operational Durability:

6.10.1 Procedure:

A. Orientation: Mount the pump as required by the application.

B. Fluid Level: Cover the inlet filter with fuel in at least one half of the pump body.

C. Fluid Volume: Ensure a minimum of 6.0 L of fuel per pump assembly.

D. Fuel Freshness: Change fuel once per week. Aggressive fuel and/or higher temperature testing may require more frequent changes.

E. Electrical Input: Apply 13.5 ± 0.1 VDC to pump terminals.

F. Power Interruption: Turn off pump every 10 min for 6 ± 2 s throughout the duration of the test.

G. Outlet Flow and Pressure: Regulate pump output to flow and outlet pressure shown on the approved specification.

H. Extreme-Temperature Durability: Test the pump for 3200 h in emission test fuel according to the following voltage cycle:

Voltage	Time
0	6 ± 2 s
13.5 ± .1	10 ± 0.1 min

6.10.1 (Continued):

Regulate the fuel pressure at the pump outlet pressure during the test. Operate the pump according to the following temperature cycle:

Return Fuel System Temperature	Non-Return Fuel System Temperature	Hours
49°C (120°F) ± 2°C	40°C ± 2° C (104°F)	800 +/- 50 Hours
70°C (158°F) ± 2°C	60°C ± 2° C (140°F)	100 +/- 5 Hours
-30°C (-22°F) ± 2°C	-30°C ± 2° C (-22°F)	100 +/- 5 Hours
49°C (120°F) ± 2°C	40°C ± 2° C (104°F)	1000 +/- 50 Hours
70°C (158°F) ± 2°C	60°C ± 2° C (140°F)	100 +/- 5 Hours
-30°C (-22°F) ± 2°C	-30°C ± 2° C (-22°F)	100 +/- 5 Hours
49°C (120°F) ± 2°C	40°C ± 2° C (104°F)	1000 +- 50 Hours

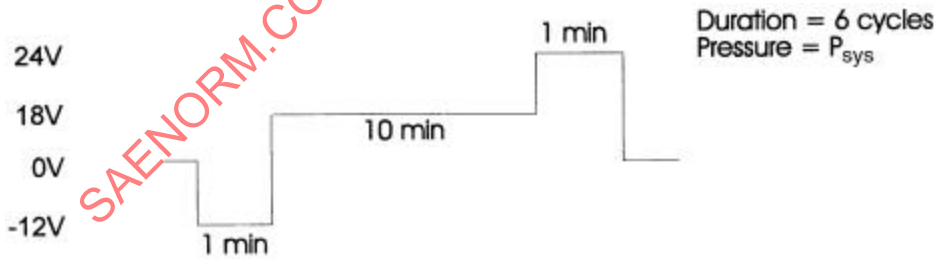
l. Additional Test Fuel and Profile: Operate the pumps in the fuel type for the duration and temperature profile in the approved specification.

6.10.2 Acceptance Criteria: The fuel pump shall meet the performance requirements at each 500-h interval and upon completion of the durability test.

6.11 Over Voltage:

Operate the pump according to the cycle shown below. Follow the test setup in fig. 1 and use emission test fuel.

Test Parameters:



7.0 CONTROL:

7.1 Product Change:

All subsequent changes, including those made to accommodate production tooling, must be approved by the customer before shipment of changed parts. QS-9000 procedures are to be followed.

7.2 Production Parts:

Production parts, as received, shall

A. meet all requirements of this standard,
B. conform in all respects to the approved samples,
C. be free of environmental and/or handling damage.

The fuel pump inlet and outlet orifices shall be covered during shipment and shall be approved by the customer.

A supplier who furnishes finished parts to the customer is responsible for the quality of all components of the shipped assembly or end item, whether component parts are manufactured by the supplier or purchased from another source.

APPENDICES

APPENDIX A

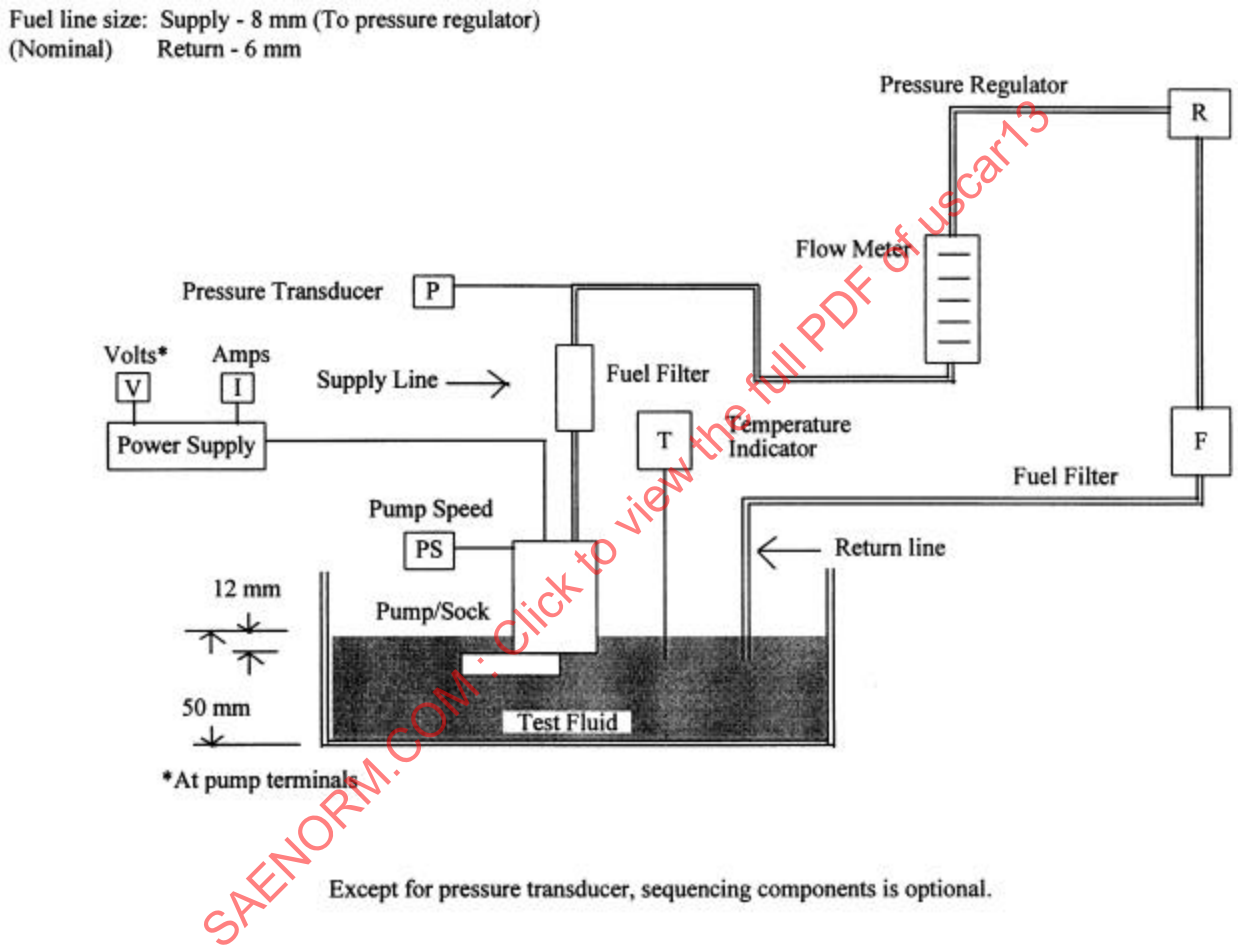


FIGURE 1 - Fuel Pump Performance Test Setup

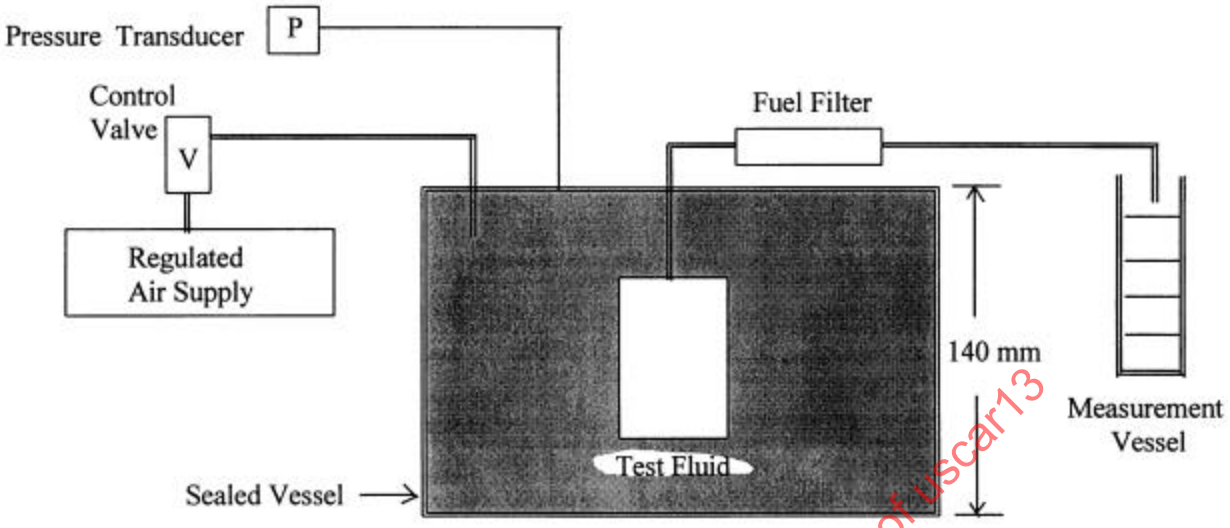
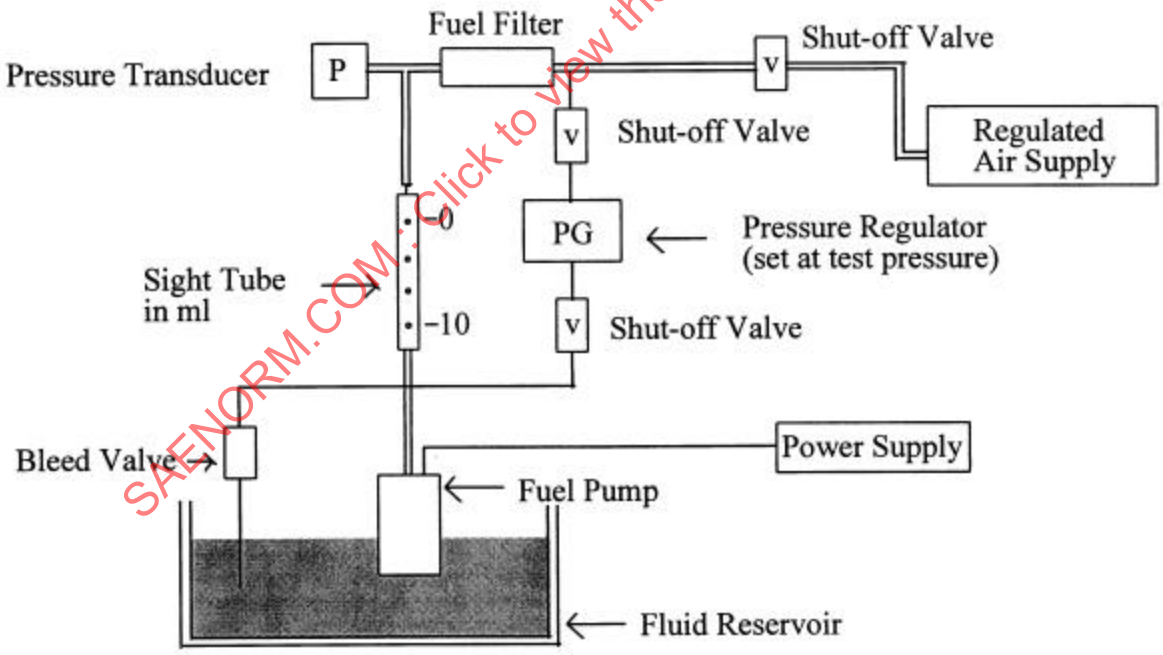
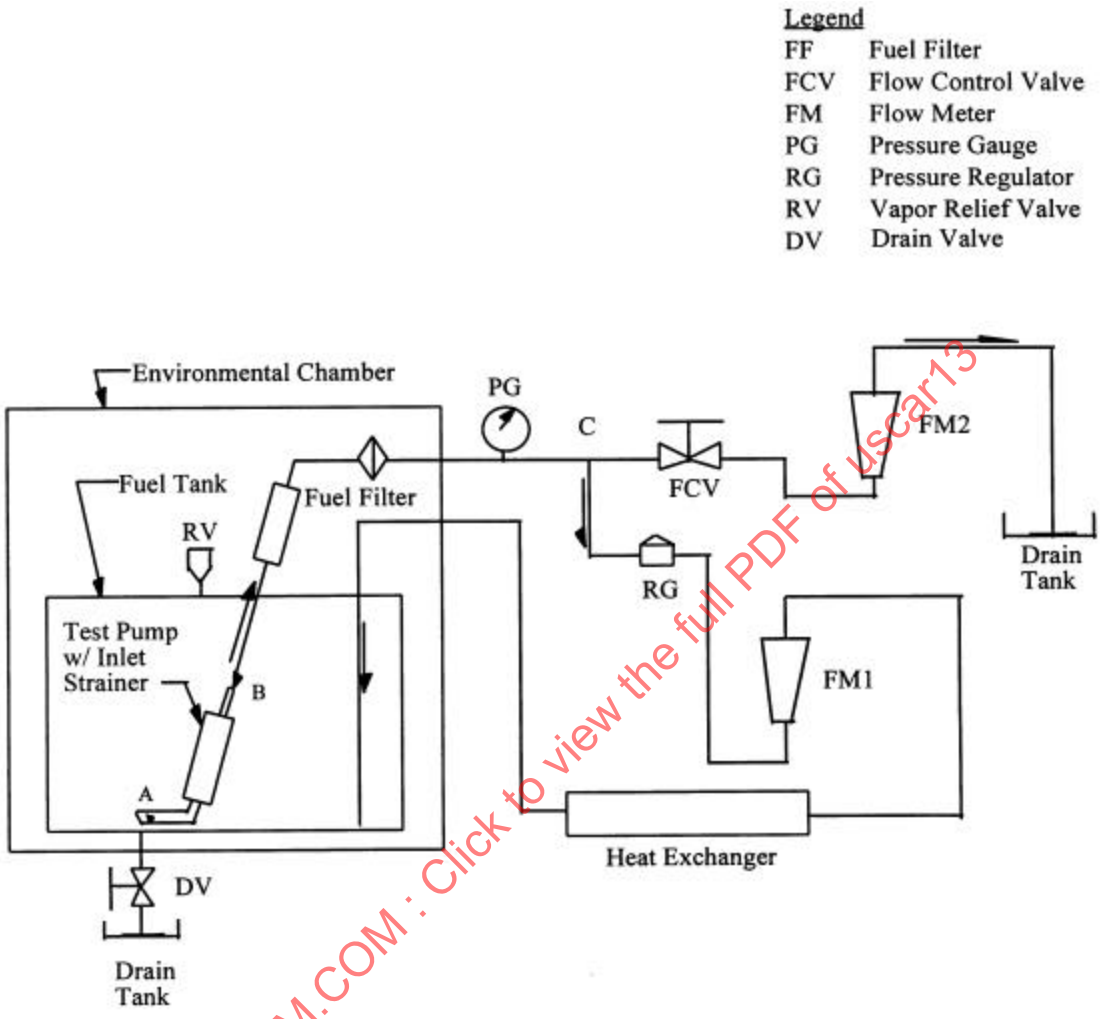


FIGURE 2 - Check Valve Leakage Test Setup Forward



Note: Energize pump to prime system with fluid

FIGURE 3 - Check Valve Leakage Test Setup Reverse



Notes:
a. Line length between B-C is 4.0 meters (13.0 feet).
b. Difference in elevation between A-C is 560 mm (22 in.)
c. Keep other line lengths to a minimum.
d. Line diameter is 8 mm (0.375 in.)
e. Gasoline to Water heat Exchanger (other heat exchanger types and configurations may be used by the supplier.

FIGURE 4 - Priming/High-Temperature Performance Test Stand Schematic