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Validation Testing of Electric Fuel Pumps for Gasoline Fuel Injection Systems

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE Gasoline Fuel Injection Standards Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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1. ***Scope***—This SAE Recommended Practice defines the minimum design verification testing required to verify the suitability of in-tank mounted electric motor driven fuel pumps used for pumping gasoline or gasoline blend fuels.

Additional tests not specified in SAE J1537 will be required for frame mounted pump applications or pumps intended for use on aircraft, motorcycles, or marine equipment.

1.1 **Purpose**—J1537 is intended to provide a nucleus of basic validation tests which the users and suppliers of electric fuel pumps agree are required to qualify a particular pump for use with automotive gasoline fuel injection systems. Numerous tests found in the unique specifications of both users and suppliers have been omitted from SAE J1537 because common agreement as to their value could not be reached. The seven basic tests defined in Section 4 include the most expensive, most time-consuming tests in a validation program. By providing an industry wide standard, SAE J1537 reduces the cost of validation to the benefit of all concerned. However, it is to be expected that the unique applications and experience of both users and suppliers will dictate that additional tests be conducted to complete qualification for any specific application.

2. ***References***

2.1 **Applicable Publication**—The following publication forms a part of this specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1113—Electromagnetic Susceptibility Measurement Procedures for Vehicle Component (Except Aircraft)

3. ***Fuel Pump Flow Performance Testing***—This section describes the equipment, set up, and procedure for measuring fuel pump flow performance. All tests in Section 4 require that the pumps used in these tests be flowed and their performance recorded prior to the running of these tests. All new pumps must receive a break-in period of at least 30 min prior to measuring initial flow.

3.1 Fuel Pump Flow Test Equipment (See Figure 1):—This section describes the basic equipment and interconnection considerations required to produce repeatable flow performance data from different test set ups.

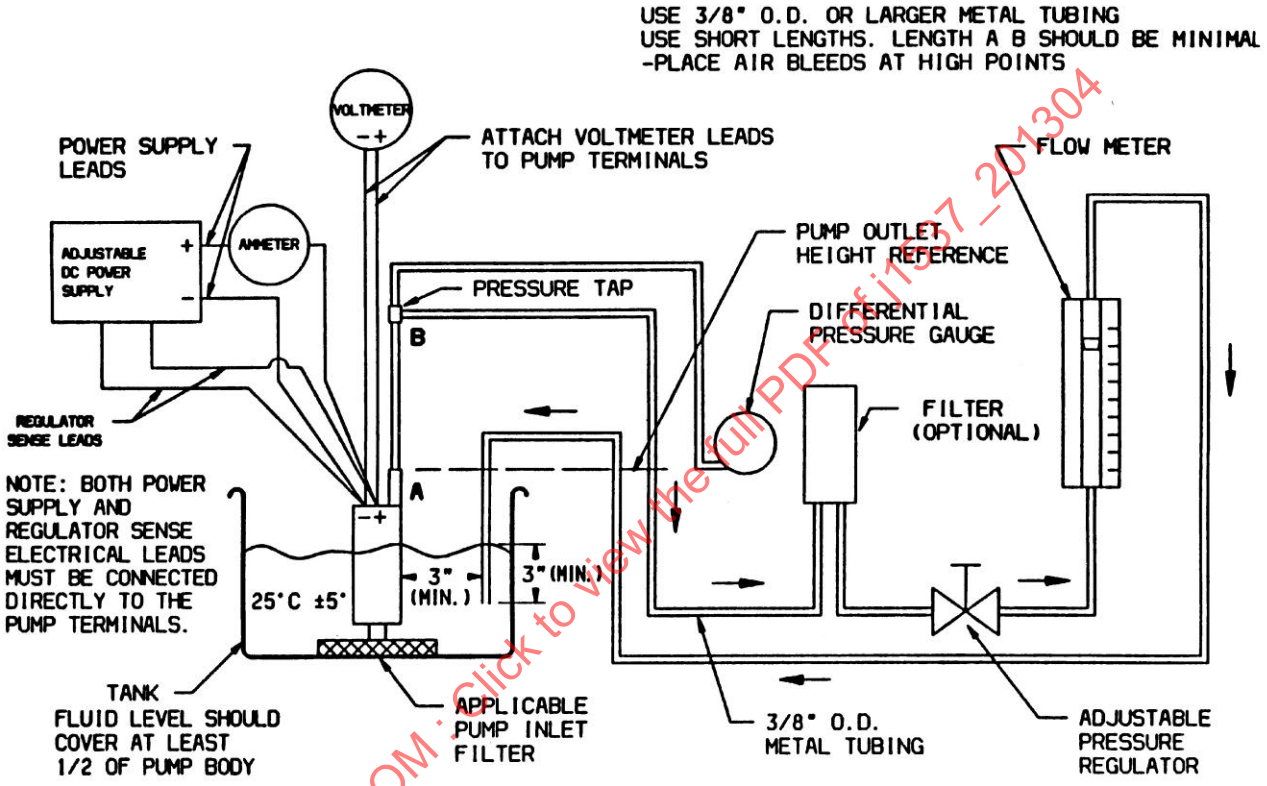

FIGURE 1—ELECTRIC FUEL PUMP FLOW PERFORMANCE TEST SET-UP

The basic test set-up must provide:

a. Measurement of four electric fuel pump parameters as shown in Figure 2:
b. Adjustment of two electric fuel pump parameters:

1. Voltage
2. Pressure

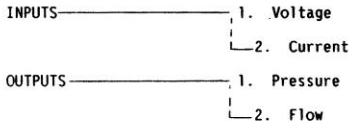

FIGURE 2—ELECTRIC FUEL PUMP PARAMETERS

3.1.1 ADJUSTABLE DC POWER SUPPLY

a. Voltage Range: 0 to 24 V DC
b. Current Range: 0 to 20 Amps (Minimum)
c. Stability: Must maintain set voltages at the pump terminals during flow measurement within ±0.1 V.

A power supply with external voltage sense capability allows the power supply to sense and stabilize the voltage at the pump terminals.

3.1.2 DC AMMETER

a. Current Range: 0 to 20 Amps DC
b. Accuracy: ±0.1 Amp

3.1.3 DC VOLTMETER

a. Voltage Range: 0 to 24 V DC
b. Accuracy: ±0.1 V
c. Connection: Voltmeter leads are to be connected directly to pump terminals (see Figure 1).

3.1.4 PRESSURE GAGE (TRANSDUCER, MANOMETER, ETC.)

a. Pressure Ranges:

1. 0 to 138 kPa (0 to 20 psi)
2. 0 to 690 kPa (0 to 100 psi)
3. Higher pressure ranges may be required depending on the pump type and application.

b. Accuracy: ±1% of full scale
c. Location: The differential gage must be referenced to the same level as the pump outlet (see Figure 1).

3.1.5 FILTER (OPTIONAL)—Maximum pressure differential at a flow of 40 g/s = 3 kPa..

The filter should contain an air bleed or have a configuration which eliminates trapped air.

3.1.6 ADJUSTABLE FLOW RESTRICTOR OR PRESSURE REGULATOR—Maximum pressure differential with restrictor wide open at flow of 40 g/s = 7 kPa. Maximum restriction: full closed.

3.1.7 FLOWMETER

a. Type: Mass flow
b. Range: 0 to 50 g/s
c. Accuracy: ±0.5 g/s, with Stoddard solvent test fluid

3.1.8 TUBING

a. Size: 3/8 O.D. (minimum)
b. Length: Short as possible
c. Bends: None preferable
d. Materials:

1. 1st choice - Metal tubing
2. 2nd choice - Steel braided rubber hose
3. Not recommended - Cloth, braided, or nonreinforced rubber hose

3.1.9 TANK

3.1.9.1 *Size*—Large enough for the test fluid to cover at least one-half of a vertically mounted fuel pump and to allow the fluid return tube to be at least 3 in away from the pump inlet.

3.1.10 TEST FLUID FOR FLOW TESTING—MIL-C-7024B (Type II) Laboratory Test Fluid, for example, Stoddard solvent.

The test fluid temperature should be maintained at 25 °C ± 5 °C during performance testing. Test fluids should be changed periodically to prevent the accumulation of contaminants.

Alternate test fluids to Stoddard solvent are mineral spirits, Esso Varsol 130/180, Amosol Naphtha No. 395 HF and other fluids which have properties approximating the Stoddard solvent values speciifed in MIL-C-7024B.

NOTE—There is a difference between these test fluids and gasoline which varies in its effect on performance according to pump type and design. It is, therefore, the manufacturer's responsibility to develop the correlation factor between the fluid used and actual flow performance in gasoline for his pump.

3.2 Flow Stand Operating Procedure

3.2.1 PUMP INSTALLATION—Install the fuel pump with its appropriate inlet filter into the test tank maintaining the conditions prescribed in Figure 1. Note particularly the position of the pressure gage in relation to the pump outlet, the point of connection for the voltmeter leads, and the position of the return line in relation to the pump and the anticipated fluid height.

3.2.2 ADDING THE TEST FLUID—Add the test fluid (3.1.10) to the tank and make sure that at least one half of the pump body and at least 3 in of the return line is submerged in the fluid (see Figure 1). Test fluid temperature must be maintained between 20 and 30 °C.

3.2.3 FLOW TESTING THE PUMP—A break-in period of at least 30 min should be given to new pumps before running a performance test.

Turn on the power supply and adjust the voltage applied to the pump terminals.

Adjust the test stand regulator to the specified operating pressure.

Observe the flow meter for stable output. If stable flow readings cannot be obtained, check to be sure the return line is not too close to the pump inlet (see Figure 1), and that fuel temperature is within specified limits. If instability persists, cycle the regulator several times to increase flow and/or bleed the system to purge entrapped air.

With system reset at the desired operating pressure and voltage, record the pump flow. As flow data are taken, regulated pressure should be verified, adjusting as required.

3.2.4 FLOW STAND SHUTDOWN—After all the desired flow data have been obtained, the system should be shut down with pressure removed from the system first and electrical power to the pump shut off before disconnecting power and voltmeter lead wires. Pump fluid lines should be disconnected only after the verifying pressure in the system is at zero.

3.3 Presentation of Performance Data—The sample data sheet (see Figure 3) provides a format for recording and reporting validation test data. At the top of the sheet are spaces to fill in pump identification numbers, the regulated pressure at which the pump was tested, the test fluid used in the flow test, and the nominal pressure drop of the inlet filter used, if any.

CONDITIONS:

Pump Serial No.: _____ Model: _____
Regulated Pressure: _____ kPa
Test Fluid: _____ at 25°C + 5
Inlet Filter (Optional): _____ ΔP, kPa

INITIAL FLOW TEST:

Operating Volts DC	Spec.	Pump Flow g/s	Current Draw-Amp
6			
8			
10			
12			
14			
16			
18			

TEST RESULTS SECTION: _____

FINAL FLOW (Same Conditions As Above):

Operating Volts DC	Spec.	Pump Flow g/s	Current Draw-Amp
6			
8			
10			
12			
14			
16			
18			

CHANGE IN FLOW (Initial Flow Minus Final Flow):

Operating Volts DC	Spec.	Pump Flow g/s	Current Draw-Amp
6			
8			
10			
12			
14			
16			
18			

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FIGURE 3—TEST DATA SHEET

The next data block provides a format for recording the results of the Initial Flow Test which is obtained after a minimum break-in of 30 min but prior to running any particular test from Section 4 for which the pump was chosen. It is intended that flow data be obtained in g/s mass flow units but a blank column is also provided for conversion to or from alternate units. If the pump performance is to be characterized as a function of pressure, as well as voltage, a new data sheet for each operating pressure should be used. A blank line is provided between 12 and 14 V for those who wish to measure pump performance at the charging system voltage.

The next section of the data sheet provides a space to identify the tests in Section 4 that the flow data are validating and to record any noteworthy observations about the test or deviations from the procedure that might aid in interpreting the data.

The Final Flow section is for recording the flow data obtained after the particular test in Section 4 has been completed.

The last section is for presenting the Change in Flow (initial flow minus final flow) which can be attributed to the wear and tear inflicted upon the pump by the particular test in Section 4.

4. ***Validation Test Requirements*****—**The following seven tests comprise the SAE J1537 validation test requirements:

4.1 Vibration—The pump is to be vibrated in a mounting fixture as shown in Figure 4 for a total of 3 h, 1 h in each of the three major, mutually perpendicular planes of the pump as mounted. The test is to be urn with the pump dry and no voltage applied to the pump terminals.

a. Vibration Displacement: 0.75 mm
b. Frequency Range: 10 Hz to 55 Hz
c. Max. Acceleration (reference): 4.5 g
d. Cycle time: 60 s (10-55-10 Hz)

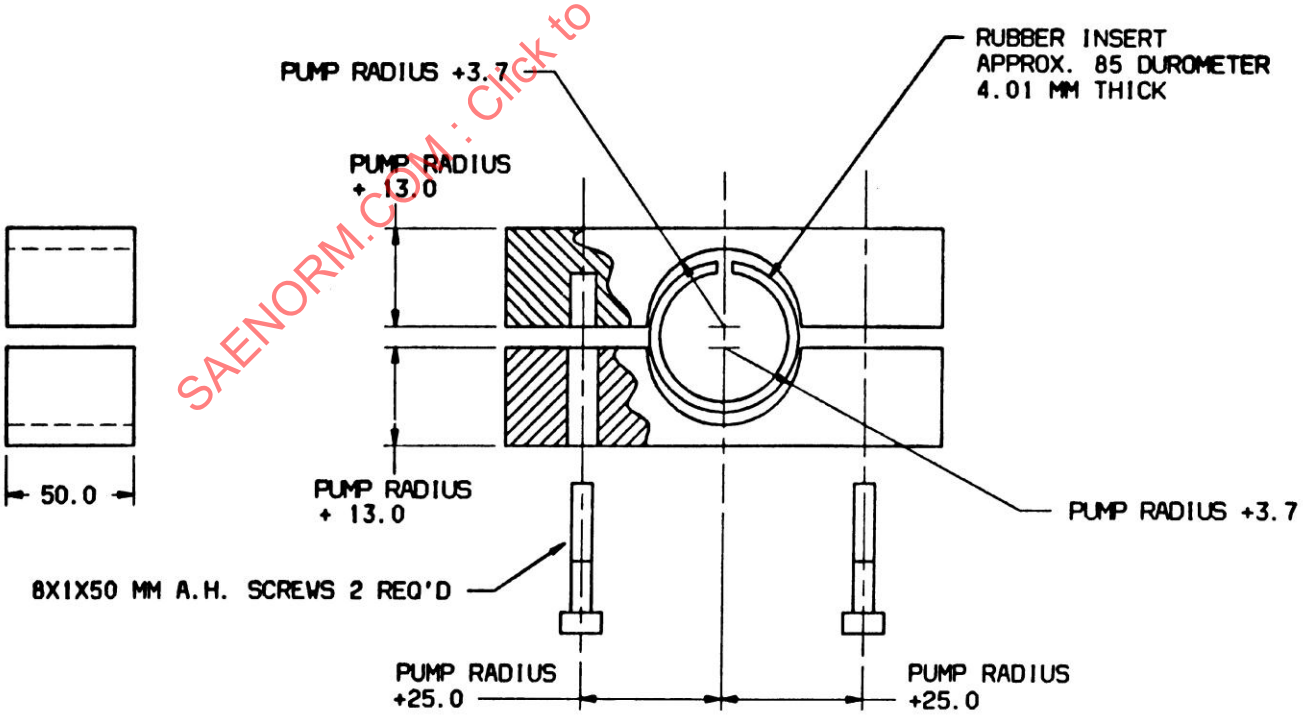

FIGURE 4—PUMP VIBRATION TEST FIXTURE TYPICAL STATION

4.1.1 VALIDATION REQUIREMENTS—The pump must meet or exceed the rated flow established for the pump.

4.2 Temperature Cycling (see Figure 5):—The pump shall be alternately heated and cooled from +65 to −30 °C for 20 cycles. The test is to run per Figure 5. The pump is not to be run in fuel (that is, the test should be run with the pump dry). No voltage is to be applied to the pump terminals during the test.

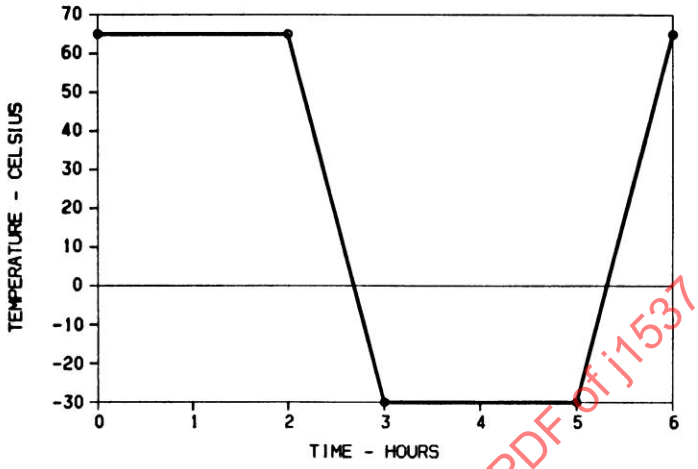

FIGURE 5—TEMPERATURE CYCLE TEST SCHEDULE

4.2.1 VALIDATION REQUIREMENTS—The pump must meet or exceed the rated flow established for the pump.

4.3 Compatibility with Fuels

4.3.1 CHEMICAL EXPOSURE—Pumps are to be immersed in the solutions listed as follows (1/2 to 1 L/pump). The pumps are to be run a few seconds to fill them with solution. The container is then to be sealed and maintained for 30 d at 20 °C ± 10 °C.

a. Commercial grade of unleaded gasoline.
b. Unleaded gasoline with 0.05% thiophene added (contains sulphur).
c. Unleaded gasoline with 250 ppm tertiary butyl hydroperoxide.
d. Unleaded gasoline with 10% by volume, methanol.
e. Unleaded gasoline with 10% by volume, ethanol.
f. Unleaded gasoline with 10% by volume, methyl tertiary butyl ether.
g. Unleaded gasoline with 10% by volume, isopropyl alcohol.
h. Leaded gasoline (3 g/gal lead).

4.3.2 VALIDATION REQUIREMENTS—The pump must start unassisted in the test fluid with 10 V DC applied to the terminals. The pump must meet or exceed its rated flow at rated voltage within 5 min of operation.

4.4 Hot Fuel Handling (Priming)

CAUTION—This test requires extreme caution. Both the test stand and room must be "explosion proof,": all electrical equipment should meet NEC Class I, Division I, Group D requirements.

The Hot Fuel Handling Test involves submerging the pump completely in fuel contained in a tank wherein a small regulated pressure is maintained. The fuel temperature is then increased from 20 to 65 °C. The "time-to-prime" and the pump flow at 12 V DC are to be measured at every 5 degrees of temperature rise.

4.4.1 VALIDATION REQUIREMENTS

a. Time-to-prime:

1. 3 s 20 to 50 °C
2. 5 s 50 to 65 °C

b. Both flow and pressure are to be measured and recorded. Flow must be no less than 75% of the rated flow within the time span specified in 4.4.9.

4.4.2 DEFINITIONS—Time-to-prime shall be the time between application of pump voltage and the attaining of 75% of the pump's rated pressure.

4.4.3 FUEL—Unleaded gasoline is to be used:

12 RVP ± 0.5 (initial measure)

4.4.4 FUEL VOLUME

a. The fuel volume in the tank must be approximately 30 Liters and must be sufficient to completely cover the pump inlet throughout the test.
b. The priming volume must be a minimum of 300 mL. The priming volume is the volume in the fuel line between the pump outlet and the pressure regulator including the flowmeter.

4.4.5 HEATING THE FUEL (REQUIRES EXTREME CAUTION!) (SEE FIGURE 6)—The fuel should be heated indirectly by circulating the fuel in the tank through an external heat exchanger. This process can be done safely only by placing the test tank inside an explosion proof thermal environmental chamber. Some experimentation will be necessary to determine the flow rates through the heat exchanger, the temperature feeding into the heat exchanger, and the temperature in the environmental chamber required to produce the required fuel heating rate.

4.4.6 FUEL HEATING RATE (SEE FIGURE 7):—The rate of temperature increase of the fuel shall be as shown in Figure 7:

a. 1 °C/min from 20 to 50 °C
b. 1/2 °C/min from 50 to 65 °C

4.4.7 PRESSURE SETTINGS—The tank pressure regulator shall be set not to exceed 15 kPa.

The pump pressure regulator shall be set at system-rated pressure with the pump operating at rated flow at 12 V DC.

4.4.8 OPERATING VOLTAGE—The applied pump voltage shall be 12 V DC ± 0.1 V DC during the test.