



Fuel Pump Subsystem Noise and Vibration Evaluation Procedure

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. The purpose of this procedure is to measure fuel pump noise and vibration performance at the subsystem level. The data acquired are used to assess the performance of GM and competitive Fuel Pump Modules (FPM), establish noise and vibration requirements and validate to those requirements.

1.2 Applicability. This procedure is appropriate for use with all electric FPM subsystems that are used in Electronic Return-less Fuel Systems (ERFS) and Mechanical Return-less Fuel Systems (MRFS) to supply pressurized fuel to an Internal Combustion (IC) engine.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

IEC 651

2.2 GM Standards/Specifications.

GMW14081 GMW14172

2.3 Additional References.

- American Refining Group Inc. (77 North Kendall Avenue Bradford, PA)
- Component Technical Specifications (CTS)
- Subsystem Technical Specifications (SSTS)

3 Resources

3.1 Facilities. The test (measurements) shall be performed in a semi-anechoic environment with a hard, flat floor surface. The ambient background noise level must be a minimum of 5 dB(A) below the signal being measured. For best signal-to-noise ratio, 10 dB(A) of separation is recommended.

The test shall be performed with the ambient fuel temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ as the standard measurement condition. Careful attention should be used when testing for long periods of time since the FPM, while running, is a heat source. The test facility must have capability for fuel vapor ventilation if fuel is to be used for testing. Otherwise, the use of Stoddard solvent is recommended (e.g., CAS P/N 64742-47-8 available from American Refining Group, Inc.)

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 Microphones. Three (3) free-field microphones with a range of 0 kHz to 25 kHz fitted with a preamplifier and appropriate signal conditioning and cables, meeting Class 1 accuracy corresponding to IEC 651 or

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April 2018

Page 1 of 8



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equivalent for the application (precision ± 7 dB(A) or $\pm 8\%$) shall be used. Microphones must be calibrated using a pistonphone or similar device at the beginning of each testing session.

3.2.2 Accelerometers. High sensitivity tri-axial accelerometers (minimum of 10 mV/(m/s²)) with a flat frequency response between 2 Hz and 2 kHz and a temperature range of 10 °C to 50 °C or greater shall be used.

3.2.3 Data Acquisition System. Multi-channel data acquisition hardware capable of calculating frequency domain results between 22 Hz and 11 200 Hz with a minimum of 80 dB dynamic range. This hardware shall meet Class 1 accuracy corresponding to IEC 651, or be equivalent for the application (precision ± 7 dB(A) or $\pm 8\%$).

3.2.4 Data Acquisition Software. Utilize a Fast Fourier Transform (FFT) dynamic spectrum analyzer capable of calculating the overall level, narrow band analysis, order tracking, time signal, sound quality and modal analysis (optional).

3.3 Test Vehicle/Test Piece. All testing shall be performed on a production of development tank for which the test FPM is installed and represents the design of intent.

3.3.1 Fuel Description. Use Stoddard solvent or fuel if applicable.

3.3.2 Needle Valve. Utilize a needle valve capable of regulating fluid flow to idle test flow speeds between 0.002 gpm and 0.02 gpm for ERFS.

3.3.3 Tank Isolation. Utilize two (2) separate Spill Berm blocks (P/N 25896, available from Lab Safety Supply, Inc.) with dimensions equal to 5.5 cm tall, 10 cm wide and long enough to completely support the tank in each strap location. Spill Berm stiffness must be soft enough to allow the first rigid mode frequency of the supported tank to be < 10 Hz.

3.3.4 Variable Direct Current (DC) Power Supply. A power supply capable of 4 V to 16 V and 0.1 A to 30 A with a single low incremental voltage adjustment knob to perform sweep analyses.

3.3.5 Digital Voltmeter. A digital voltmeter for monitoring voltage of the fuel pump.

3.3.6 Current Meter. Utilize a current meter for monitoring the current to the fuel pump and to track the speed of the fuel pump.

3.4 Test Time.

Calendar time: 1.5 d (Includes test setup, measurement of one (1) FPM and test teardown)

Test time: 2 h (Per FPM measured)

Coordination time: 3 h

3.5 Test Required Information. Record the program number, intended vehicle, FPM manufacturer, FPM serial number, fuel type, fuel level, fuel temperature, fuel Reid Vapor Pressure (RVP) if applicable, idle speed of engine, the engine block pressure at idle and other pertinent information. The following data should be collected during the analysis at a minimum sampling rate:

- Sound pressure level (microphone) at 48 kHz sampling rate.
- Vibration level at 4 kHz sampling rate (due to mounting limitations of accelerometers).
- Voltage (V) at 100 Hz sampling rate.
- Current (I) at 48 Hz sampling rate.
- Pressure (P) at 100 Hz sampling rate.
- Flow rate (Q) at 100 Hz sampling rate.
- Pump rpm at 48 kHz sampling rate.
- Temperature at 100 Hz sampling rate.

3.5.1 FPM Instrumentation. Fluid temperature measurement shall be located in the bottom of the FPM bucket using a standard K Type thermocouple. Fluid flow shall be measured using an axial flow meter. RPM shall be calculated from motor commutator level crossings of the 48 kHz current channel.

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April 2018

Page 2 of 8



Documents
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3.5.2 Microphones/Accelerometer Location. Install three (3) microphones. The first microphone shall be directed toward the FPM, 1.5 m from the FPM centerline and at the same level above ground as the top surface of the FPM flange. The second microphone shall be located 20 cm above the top surface of the FPM and directed towards the FPM. The third microphone shall be located 20 cm below the bottom surface of the tank and directed towards the FPM. Reference Appendix A, Figure A1.

Install two (2) tri-axial accelerometers. The first on the top surface of the FPM flange and the second on the outside bottom of the tank directly below the FPM bucket. Measure acceleration in the fore/aft, lateral and vertical directions. Reference Appendix A, Figure A1.

3.6 Personnel/Skills. One (1) qualified engineer or technician trained in the use of data acquisition and recording equipment and having basic knowledge of noise and vibration signal processing.

4 Procedure

4.1 Preparation. Ensure that the tank contains the intended type and amount of Stoddard solvent/fuel and that the FPM meets the requirements of 3.3. Ensure that the Stoddard solvent/fuel and all components are at the intended testing temperature.

4.1.1 Subsystem/Component Setup. Support the fuel tank with material described in 3.3.3. Ensure the center portion of the tank (or the portion of the tank where the FPM resides) remains open. The Spill Berm shall be placed and centered in the same location and geometry as the location of the tank straps. Reference Appendix A, Figure A1.

Install the FPM in to the tank. Connect the fuel line to the FPM output. Isolate the fuel line from the fuel tank by using a representative "jumper" feed line as part of the testing system. Attach the fuel line to the inline flow valve. Route any necessary wire to apply voltage to the FPM connector such that rattles do not occur. Utilize the representative wire harness and connector. Correct for any voltage drops to allow for any current draws or drops. Fill the fuel tank to the appropriate test fill volume and document. After setup is complete, recheck voltage at the FPM input.

Adjust the fuel flow needle valve to produce the appropriate fluid flow rate (or system pressure if MRFS) for the engine idle condition (0.002 gpm to 0.02 gpm). Before beginning any sound measurements scans, break in a green motor by running it for 60 minutes at 12 V, 400 kPa (58 psi). If the motor has been previously broken in, perform a warm up (system purge) for 10 minutes at 12 V, 400 kPa (58 psi).

4.2 Conditions.

4.2.1 Environmental Conditions. Check that the environmental conditions meet the requirements outlined in 3.1. If conditions are outside of the specified range, make a note in the final test report.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.2.3 Standard Test Conditions. Perform testing for all applicable fuel types such as diesel, gasoline RVP, E85 or E100. For testing, the standard gasoline RVP is 62 kPa (9 psi).

4.2.3.1 MRFS Module Testing.

4.2.3.1.1 Steady State (optional). Operate the FPM at the Component Technical Specifications (CTS) parameters for constant applied voltage and measure the steady state fuel pump noise levels. Test from the nominal operating voltage, ± 0.5 V for 25 s. If CTS parameters are not available, use the following recommendation. Based on the color map and order tracking plots generated from the sweep data, select rpms where peaks occur for steady state testing. Adjust the needle valve and voltage to achieve idle conditions in 4.2.3.1.2, then adjust voltage to achieve desired rpm ± 50 rpm and record FPM noise for 25 s.

4.2.3.1.2 Speed Sweep (required). Adjust the needle valve and voltage to achieve the following idle conditions:

- Gas 3.4 LPH at 300 kPa (43.5 psi).
- Diesel 40 LPH at 400 kPa (58 psi).

Next, drop the voltage to 4 V and measure the FPM noise while sweeping to 14 V in 120 s (depending on pump or stand limitations, 14 V may be too high to achieve without instrumentation damage or solvent/fuel leakage).

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April 2018

Page 3 of 8



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