



Fuel Pump Module Specification

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. This standard establishes the component level requirements for in-tank Fuel Pump Module (FPM) assemblies. This standard document shall be used in conjunction with application specific documents based on template CG969 to define fuel pump module requirements for an individual application. These documents complement other requirements included in the Statement of Requirements (SOR).

1.2 Applicability. The FPM is intended for use in vehicles sold worldwide. Fuel/mechanization classifications used within this document are defined in 1.2.1 thru 1.2.11. More than one classification may apply to a given application. The term "FPM" may refer to primary or secondary/transfer modules. See program document(s) for specific requirements.

1.2.1 Electronically Regulated Fuel System (ERFS). The FPM flow and pressure are controlled by a remote electronic control module which varies voltage via pulse width modulated input.

1.2.2 Mechanically Regulated Fuel System (MRFS). The FPM pressure is controlled with a mechanical regulator internal to the assembly.

1.2.3 Return Fuel System. The FPM pressure is controlled remotely (typically by a fuel rail-mounted regulator which may be referenced to engine manifold pressure) with unused fuel returned to the FPM lower module.

1.2.3.1 Return Fuel System, Forced Air. The FPM pressure is controlled remotely (typically by a fuel rail-mounted regulator, which may be referenced to engine manifold pressure) with unused fuel returned to the FPM lower module. Pressure is based on state of turbo or super charging, which influences manifold pressure.

1.2.4 E85 Flex Fuel System. The FPM is designed for use in markets where ethanol content up to 85% may be available.

1.2.5 E100 Flex Fuel System. This FPM is designed for use in markets where ethanol content up to 100% ethanol, including up to 6% water and high levels of contamination, may be available. This system does not include an integral fuel filter.

1.2.6 Remote Filter System. The FPM does not include an integral fuel filter. Fuel is delivered to an external fuel filter. Filtered fuel is channeled from the external filter back to the FPM for pressure regulation (MRFS) or over-pressure relief (ERFS).

1.2.7 Pump Diesel System. The FPM delivers diesel fuel at a positive pressure. This system does not include an integral fuel filter.

1.2.8 Suction Diesel System. The FPM delivers diesel fuel via vacuums generated by an engine-mounted pump. This system does not include an integral fuel pump.

1.2.9 Electronic Commutation (EC) System. The FPM flow and pressure are controlled by a remote electronic control module which varies voltage via 3 phase input.

1.2.10 Dual FPM System. This FPM architecture is a single pump design for use in systems with more than one fuel chamber where an active fuel transfer feature, an auxiliary (secondary or transfer) module, and fuel transfer line are added to move fuel from one chamber to another chamber. The primary module typically houses the active fuel transfer feature to draw fuel from the secondary module into the primary reservoir. Fuel transfer lines may be permanently fixed to the primary module or connected using a quick connect device.

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1.2.10.1 Transfer Module, Serviceable. A secondary or transfer module designed to complement a primary fuel module in a dual FPM system. This component typically features a fuel transfer inlet, fuel level sensor, and flange which may incorporate tank venting features.

1.2.10.2 Transfer Module, Non-Serviceable. A secondary or transfer module designed to complement a primary fuel module in a dual FPM system. This component typically features a fuel transfer inlet and a fuel level sensor. It does not include a flange or tank venting features. It attaches directly to the fuel tank bottom and is typically installed during the fuel tank molding process.

1.2.11 Auxiliary Fuel Tank Systems. The FPM is designed for an intermittent use of gasoline or diesel systems where the primary energy source is electricity or a gaseous fuel, such as Liquefied Petroleum Gas (LPG) or Compressed Natural Gas (CNG). This system may remain unpowered for extended periods of time or powered only at initial starts or high power demand situations and may require unique packaging due to space limitations. See program document(s) for specific requirements.

1.3 Remarks. The FPM is a component delivering fuel and sensing fuel quantity. The FPM shall carry out these functions while meeting specific requirements of the customer, the powertrain and other interfaces, mandated safety and emission standards, and corporate objectives.

2 References

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

2.1 External Standards/Specifications.

ABNT NBR 15754	ASTM D903	ISO 1431-1	SAE J1696
ANSI/AWS A5.8	ASTM D4169	ISO 3167	SAE J1960
ASTM 10200	ASTM D6158	ISO 12103-1	SAE J1985
ASTM A313	Edict Inmetro 301/11	SAE J905	SAE J2044
ASTM D638	ISO 527-1/2	SAE J1645	SAE J2587

2.2 GM Standards/Specifications.

9985784	GMW8466	GMW15357	GMW16331
GMW2	GMW14106	GMW15359	GMW16600
GMW3059	GMW14264	GMW15570	GMW16848
GMW3091	GMW14800	GMW15626	GMW17334
GMW3097	GMW14872	GMW15841	GMW17488
GMW3103	GMW14914	GMW15862	GMW17489
GMW3172	GMW15272	GMW15973	GMW17490
GMW3191	GMW15311	GMW15982	GMW17491
GMW4700	GMW15312	GMW15984	

2.3 Additional References.

15708574 (de-ionized water)	CG3055	GMPT-5-020	GMPT-6-019
CG969	CG3056	GMPT-5-022	GMPT-6-022
CG1752	GMPT-2-017	GMPT-5-027	GMPT-6-025
CG1854	GMPT-3-018	GMPT-5-034	GMPT-6-030
CG2021	GMPT-4-002	GMPT-5-036	GMPT-6-032
CG2308	GMPT-4-008	GMPT-6-001	GMPT-6-037
CG2503	GMPT-4-015	GMPT-6-013	
CG3053	GMPT-4-019	GMPT-6-015	
CG3054	GMPT-5-014	GMPT-6-017	

- Statement of Requirements (SOR)

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3 Requirements

3.1 System/Subsystem/Component/Part Definition. The FPM shall supply fuel to the engine and measure fuel height in tank. It may also include provisions to sense tank vapor-space pressure, manage fuel vapor generation and transport, control tank fuel-fill shutoff, transport fuel to auxiliary devices, filter fuel, and/or regulate fuel pressure.

3.1.1 Appearance. See program document(s).

3.1.2 Content. The FPM Bill of Materials (BOM) shall be developed based upon this document accompanied by program-specific documents.

3.1.2.1 Physical Content. The FPM BOM shall describe all components, materials, surface treatments (including surface treatment thicknesses, other qualifications).

3.1.2.2 Functional Content. See program document(s).

3.1.3 Ambient Environment. Sections 3.1.3.1 thru 3.1.3.2 specify the environmental conditions that the FPM will be exposed to during its lifetime.

3.1.3.1 Operating Environment. The FPM shall be capable of operating in the environments described in Table 1 and Table 2 without adverse effect to functional performance.

Table 1: Operating Conditions

Relative Humidity	2% to 100%
Barometric Pressure	56.9 kPa (g) to 106.3 kPa (g)
Grades	≤ 30%
Ozone	≤ 0.40 ppm
Ambient Temperature, Normal Operation	-48 °C to +55 °C
Ambient Temperature, Extreme Operation	Up to +70 °C (continuous), 200 h at +80 °C
Gasoline Fuel	-40 °C to +70 °C
E100 Fuel	-10 °C to +70 °C
Diesel Fuel	-40 °C to +90 °C 300 h at +120 °C (up to 5 h continuous exposure), 4 h at +130 °C (up to 15 minutes continuous exposure)
Altitude	-150 m to 4600 m
Wind	≤ 100 km/h (vehicle at rest)
Electromagnetic	GMW3091, GMW3097
Internal Pressure	0 kPa(g) to 1000 kPa(g)
Operating Voltage, MRFS	7.5 Voltage, Direct Current (Vdc) to 15.5 Vdc
Operating Voltage, ERFS	3.75 Vdc to 12.0 Vdc (RMS)
Minimum Flow Rate, Gasoline	0 L/h fuel delivered to engine
Minimum Flow Rate, Diesel	25 L/h fuel delivered to engine
Voltage, Reverse	13.5 Vdc (2 minutes)
Voltage, Jumpstart	26.0 Vdc (1 minute)
Overvoltage	18 Vdc (1 h)
Overvoltage, Demagnetization	18 Vdc (5 s bursts at -40 °C)
Hard Starts (Standard)	Up to 60 000 on/off cycles
Hard Starts (Stop/Start Hybrid)	Up to 350 000 on/off cycles
Soft Starts (Hybrid Vehicle)	Up to 1 500 000 on/off cycles
ERFS Pulse Width Modulation (PWM) Control Frequency	Between 15 kHz to 25 kHz

RMS = Root Mean Square

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Table 2: Corrosive Environment

Sodium Chloride	78 mg/cm ² /year average, 185 mg/cm ² /year maximum
Calcium Chloride	per GMW16600
Zinc Chloride	per GMW16600

3.1.3.2 Fuel Environment. Fuels to which the fuel pump module may be exposed in are defined in GMW15311, Specification for Fuel Storage and Handling Subsystem. Test fuels referenced in this document are summarized in Table 3 and described in GMW14914.

Table 3: Test Fuels

GMPT Number	Description
GMPT-6-001	Stoddard Solvent
GMPT-6-025	CE10 Fuel "C" with E10
GMPT-2-017	High Altitude Hot Fuel Handling
GMPT-3-018	RFG Tier 2 Gasoline
GMPT-4-008	E25 General Purpose
GMPT-6-022	Corrosive E22 – Tier 2
GMPT-4-015	M15 General Purpose Validation Fuel
GMPT-6-013	Particulate Fuel (RFG Tier 2 Gasoline with particulates shipped separately)
GMPT-6-017	Gasoline Containing Elemental Sulfur
GMPT-6-015	Low Lubricity
GMPT-6-019	Oxidized Gasoline
GMPT-4-002	E85 General Purpose – Summer
GMPT-6-030	Testing Fluid with 15% Methanol
GMPT-6-032	E85 Conductivity
GMPT-4-019	Brazil E100 Cert Fuel
GMPT-6-037	E100 Conductivity
GMPT-5-020	Ultra-Low Sulfur B20 Biodiesel 80/20 Unadditized
GMPT-5-022	Ultra-Low Sulfur Diesel Containing Elemental Sulfur
GMPT-5-036	Deposit Forming and Peroxide B20 Blend
GMPT-5-014	Ultra-Low Sulfur Diesel for Extreme Cold Starting
GMPT-5-027	Bad Euro 3 Diesel
GMPT-5-034	Ultra-Low Sulfur Diesel Fuel With Poor Lubricity And Low Viscosity
SAE J1696	Standard Fuel Filter Test Fluid

Note: RFG = Reformulated Gasoline

3.1.4 Interfaces.

3.1.4.1 Interface Standards and Guidelines. The FPM manufacturer shall develop and maintain FPM interface standards and guidelines to ensure standard flange and other interface features are adhered to across applications and tooling sets. A flange common feature drawing set detailing common and critical features, such as stress optimizing geometries, surface finishes, concentricity, and flatness, shall be provided.

3.1.4.2 Fuel Tank Opening Interface(s). The FPM flange shall be designed in accordance with GM common strategy, per Appendix A, Figures A1 and A2, and Table A1 based on opening size (130 mm for standard

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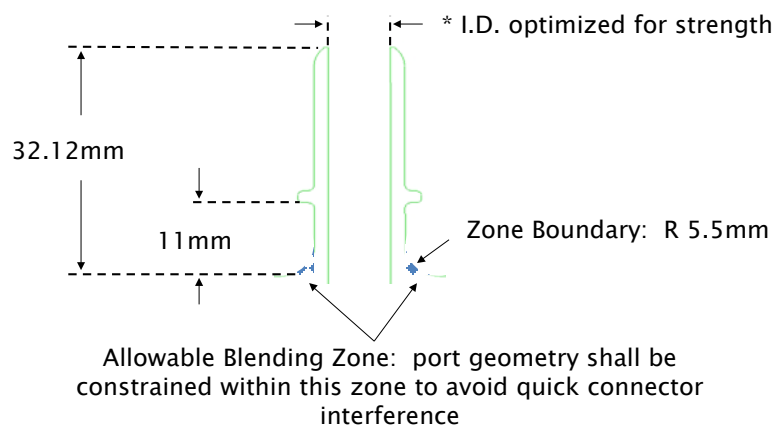
modules, 115 mm for compact modules, 95 mm for transfer modules). See program document(s) for specific requirements.

3.1.4.3 Steel Tank Isolation Interface. FPMs shall include provisions to accommodate isolation between the reservoir and tank surfaces defined in 3.2.1.48.6.

3.1.4.4 Electrical Interface. FPM shall feature either a standard 8 terminal interface or, in some cases, a 4 pin interface (legacy only - subject to Product Development Team (PDT) approval). Terminal layouts are described in Appendix B, Figures B1 thru B3. Terminal layouts not shown are subject to PDT approval. See program document(s) for specific requirements.

3.1.4.5 Interior Electrical Interfaces. FPM flange bottom-side electrical interface geometry shall feature connections consistent with GMW3191 and are subject to GM approval. Fuel level sensor connections shall be serviceable at the underside of the flange.

3.1.4.6 Mechanical Interface(s). Quick connect compatible liquid and vapor ports shall comply with SAE J2044 with exceptions to 8 mm ($\frac{5}{16}$ in) and 10 mm ($\frac{3}{8}$ in) ports provided in Figure 1. Underside flange quick connect ports shall be of common geometry compared to topside flange ports, except overall length may be up to 40 mm. Plastic port thickness shall meet the requirements called out in Appendix A, Table A1.



Note: I.D. = Inner Diameter

Figure 1: Quick Connect Port Geometry

3.1.4.7 Alternate Mechanical Interface, Auxiliary Fuel Feed. If applicable, the FPM flange may enable insertion of an auxiliary feed tube with design-specific sealing and attachment features for aftermarket modification. Figure 2 defines the worst-case parameters. Actual design parameters shall be determined by the application PDT. Target location for tube insertion shall be indicated on the exterior surface of the flange, per PDT direction. Flange accommodation for this potential aftermarket use shall not adversely affect mainstream design performance. Aftermarket flange modification shall not adversely affect performance, demonstrated by variant-specific validation plan reviewed and approved by PDT and aftermarket engineering.

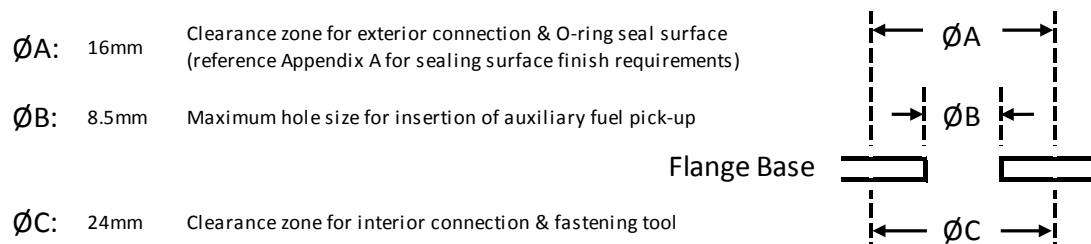


Figure 2: Auxiliary Fuel Feed Connection Zone

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3.1.4.8 Electrical Performance Interface. The FPM supplier shall complete CG3053 template to characterize electrical performance.

3.1.4.9 ERFS Calibration Interface. If applicable, the FPM supplier shall complete CG3055 template per instructions defined in CG3054 to characterize performance to duty cycle input.

3.1.4.10 Brushless Pump Control Interface. If applicable, the FPM supplier shall complete CG3056 template to characterize brushless motor control performance.

3.1.5 Usage Definition. See GMW15311.

3.1.6 Packaging Constraints. The standard FPM lower module (all components affixed to lower module) shall be designed to fit within a cylinder of 125 mm height. The complete FPM assembly packaging is based upon specific fuel tank integration design.

3.2 Product Characteristics. The following apply to all requirements unless otherwise specified:

Measurement:

Voltage: External interface, ± 0.1 Vdc.

Current: External interface, ± 0.1 A.

Pressure: FPM fuel feed port (external) or FPM return port (external, if applicable).

Fuel flow: Reported in liters per hour (L/h) ($\pm 2\%$).

Conversion Factors:

Gasoline: 1 g/s = 4.86 L/h (sg: 0.74 g/mL).

E85: 1 g/s = 4.62 L/h (sg: 0.78 g/mL).

Diesel: 1 g/s = 4.24 L/h (sg: 0.85 g/mL).

Input/Environment Control:

Applied voltage: ± 0.1 Vdc (performance).

Applied voltage: ± 0.25 Vdc (durability).

Applied Pressure: ± 3 kPa(g).

Temperature (environment): ± 2 °C.

Temperature (test fluid): ± 2 °C.

3.2.1 Performance Requirements.

3.2.1.1 Installed Height and Range. FPM installed height is defined as the distance measured from the top side of the flange (see Figure 3) to the tank inside bottom surface contact point. The FPM (bottom-referencing) shall accommodate the following movement from nominal position. These values also comprehend manufacturing tolerances (e.g., tank wall positioning) in addition to operational movement.

- **Compression:** Nominal height minus 15 mm.
- **Expansion:** Nominal height plus 25 mm.

See program document(s) for specific requirements.

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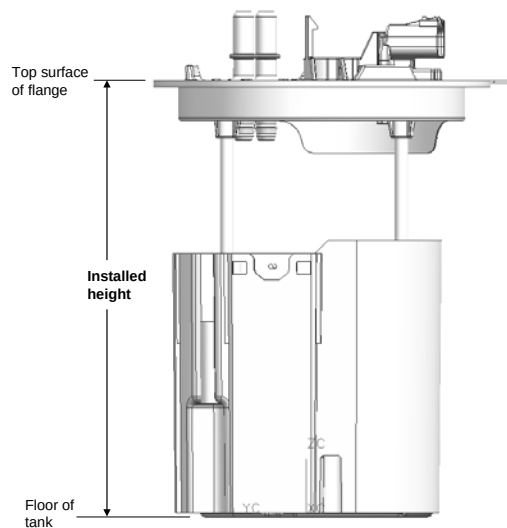


Figure 3: Installed Height

3.2.1.2 Standard FPM Flange and Lower Module Alignment. The primary FPM flange and lower module design shall accommodate the ability to rotate the lower module into multiple predetermined positions about the flange, using 2 guide rods with individual springs in offset applications (zones 2 thru 5) and 2 to 4 guide rods with springs in concentric applications (zone 1), per Figure 4. Modules greater than 300 mm may require 3 guide rods with springs, based upon ability to meet 3.2.1.6, and be limited to concentric position (zone 1) only. See program document(s) for specific requirements.

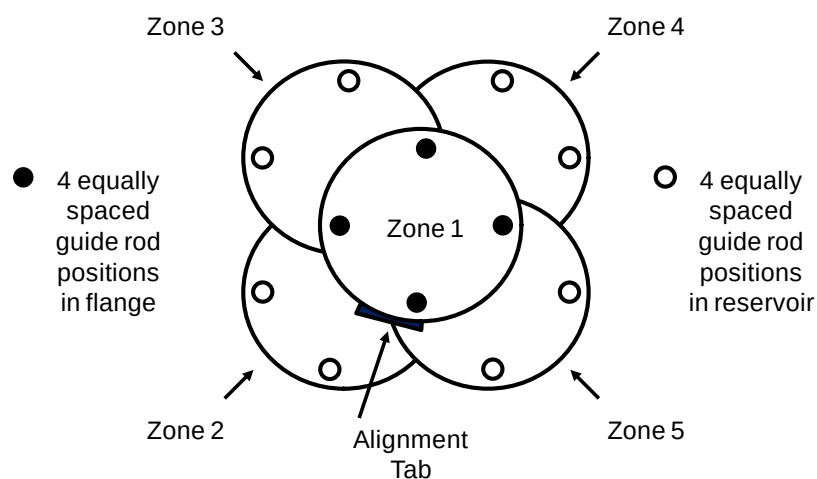


Figure 4: Lower Module Positions for Standard Module

3.2.1.3 Compact FPM Flange and Lower Module Alignment. The primary FPM flange and lower module design shall accommodate the ability to rotate the lower module into multiple predetermined positions about the flange, using two (2) guide rods with individual springs in offset applications (zones 2 and 3) and two (2) to three (3) guide rods with springs in concentric applications (zone 1), per Figure 5. Modules greater than 300 mm may require three (3) guide rods with springs, based upon ability to meet 3.2.1.6, and be limited to concentric position (zone 1) only. See program document(s) for specific requirements.

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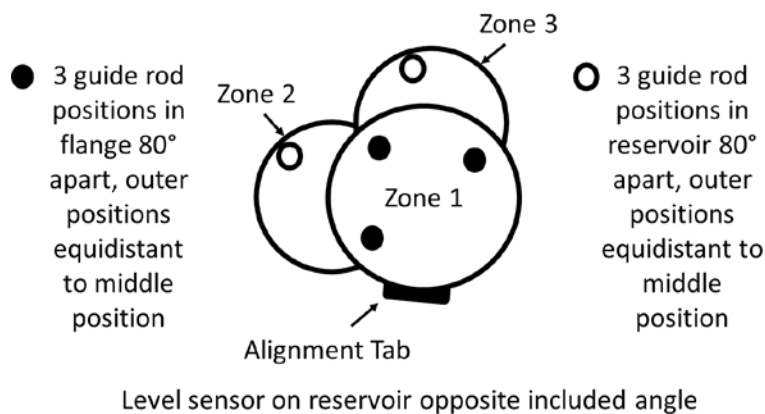


Figure 5: Lower Module Positions for Compact Module

3.2.1.4 Fuel Level Sensor Orientation. The lower module shall accommodate reversible float arm orientations, such that the float can be positioned on either side of the module and rotate clockwise or counter-clockwise from empty to full positions, per Figure 6.

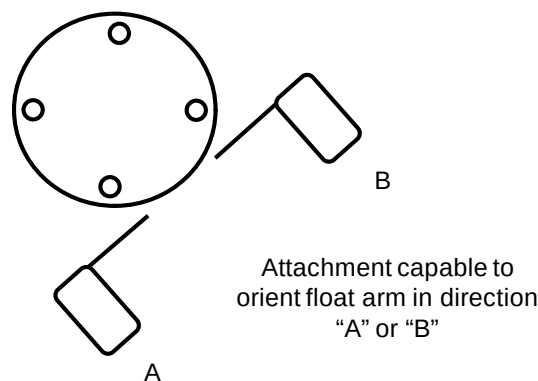


Figure 6: Fuel Level Sensor Orientation Capability

3.2.1.5 Hardware Conditioning. Where indicated, fuel pump modules shall be preconditioned in fuel prior to specific tests. Conditioning to be completed as follows immediately (24 h) prior to subject test or kept in fuel at 22 °C.

- Submerge FPM in conditioning fuel as indicated to a fuel height consistent with 100% application fuel tank volume.
- Connect external port(s) and cycle on to a pressure capable of opening pressure relief valve to purge system, cycle off, and apply a constant pressure of 95% regulator or relief pressure (maximum pressure possible while keeping relief valve closed).
- Apply constant pressure for 168 h, maintaining 70 °C fuel temperature for gasoline applications or 90 °C fuel temperature for diesel applications. Alternate time and temperature conditions subject to GM approval. Exposure fuels for gasoline and diesel are defined in items "A" and "B," respectively, unless otherwise noted in the specific paragraph:
 - a. E25/85/100 applications: use GMPT-4-008, E25 fuel.
 - b. Diesel applications: use GMPT-5-020, B20 fuel.
- Hardware shall not be allowed to dry out between hardware conditioning and specific test.

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3.2.1.6 Structural Compliance. The lower module shall rotate less than ± 10 degrees relative to the flange when subjected to a 2 N·m torque about its vertical or horizontal axis when compressed to the FPM maximum extended height (typically nominal +25 mm). On a primary module, vertical axis is defined as a line parallel to and equidistant between guide rods. On an auxiliary module, vertical axis is defined by the flange attachment structure. The horizontal axis is defined by the point at which the lower module pivots about the flange attachment point and a line parallel to the flange surface, perpendicular to the torque applied. Evaluation shall be performed at nominal, extended, and compressed installation heights. Torque is to be applied at the greatest distance from the flange (typically, the bottom of the lower module). Rotation exceeding 10 degrees shall be reviewed and approved by the fuel pump module and fuel tank PDTs. Actual compliance and influence on module and float arm operation zone to be recorded and communicated to Fuel Tank PDT.

3.2.1.7 Operational Clearances. FPM shall maintain adequate clearances between all components throughout entire height and float arm rotational range, following Hardware Conditioning (3.2.1.5) and comprehending Structural Compliance (3.2.1.6). Components which are not intended to contact other components shall maintain clearance at worst case conditions. Tubing shall maintain a minimum 5 mm clearance from guide rods and springs. FPM delivery performance shall be verified by monitoring fuel flow and reservoir fill rate to ensure no loss of function due to kinked or bent lines, any other factors which may inhibit performance at worst case conditions. Flange assembly shall maintain minimum 5 mm vertical clearance to lower module in compressed condition else provide robust hard stop strategy with structural load analysis. Routing quality assessment which comprehends potential variation and tubing elongation shall be completed to ensure worst case conditions are evaluated.

3.2.1.8 FPM Compression Force. Installation force shall be optimized to ensure constant tank bottom referencing in all conditions (i.e., maximum and minimum installation heights, tank vibration, road inputs, etc.) Spring natural frequency shall be sufficiently greater than potential driving frequencies, such as those created by fuel tank input to avoid resonance. Modal excitation shall be greater than 50 Hz. The minimum force shall be equal to or greater than 35 N and the maximum force shall not exceed 60 N at nominal installation height. Performance measurements to include force vs. compressed height in graph form in 5 mm increments. Measurement load applied at a point equidistant between guide rods. FPM compression force (at any given compression through entire compression range) shall not change more than 20% comparing pretest to posttest Compression Cycling Durability (3.2.1.10), Vibration Resistance (3.2.1.15), and Standard Fuel Resistance (3.2.1.80).

3.2.1.9 Compression/Extension Travel Resistance. The FPM shall not bind or stick when compressed or extended at any point within the FPM required installation height range. Binding or sticking is defined as a localized change in compression force rate (change in load vs. distance slope) when compressing or extending at a speed of 10 mm/s, measured at a rate of 20 Hz. Measurement load applied at a point equidistant between guide rods. Travel resistance shall be measured before and after Compression Cycling Durability (3.2.1.10), Vibration Resistance (3.2.1.15), and Standard Fuel Resistance (3.2.1.80).

3.2.1.10 Compression Cycling Durability. FPM shall withstand exposure to 15 357 cycles of extension/contraction from fully extended to fully compressed heights, following Hardware Conditioning (3.2.1.5). FPMs shall be pressurized to 95% regulator or relief pressure using GMPT-6-001 at 22 °C. FPM shall be compressed at a rate of 1 Hz and allowed to expand unconstrained. Test samples should represent worst case manufacturing variation and clearances, per Operational Clearances (3.2.1.7). A performance assessment based on comparing pretest and posttests functional measurements is defined in Appendix C, Table C1.

3.2.1.11 Low Energy Mechanical Shock. The FPM installed in a fuel tank installation representative test fixture shall withstand low energy 245.2 m/s² mechanical shock applied in less than 30 ms without performance degradation or damage when tested per GMW17488. A performance assessment based on comparing pretest and posttests is defined in Appendix C, Table C1. Visual inspection shall be focused on structural and fuel delivery elements. Float arm may be removed from test samples.

3.2.1.12 High Energy Mechanical Shock. The FPM in a fuel tank installation representative test fixture shall withstand high energy mechanical shock without compromise to flange assembly leak integrity (includes sealing components such as Fill Limit Venting Valve (FLVV), Grade Vent Valve (GVV), Vapor Pressure Sensor (VPS) and interfaces). Install fuel pump module into fixture compressing module to PDT determined expanded height (reference 3.2.1.1). Lower module contact surface should be flat and free of obstructions, which would inhibit movement of the lower module. Apply initial load lower than that expected to cause separation in less than 30 ms in one direction. Repeat, progressively increasing load in repeatable and quantifiable increments until lower

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module is mechanically separated. Some lightweight systems, such as transfer modules, may require added mass to separate. Mass attachment shall be repeatable, quantifiable, and documented in test report. Repeat test with new hardware for remaining directions to complete a total of 4 directions (from front, rear, left, right). Breakaway analysis shall be completed prior to tooling and testing to ensure adequate difference in maximum principal stress levels comparing targeted crack initiation zones to surrounding areas. A performance assessment based on comparing pretest and posttests is defined in Appendix C, Table C1.

3.2.1.13 Thermal Cycle. The FPM shall withstand 20 thermal cycles powered to 13.5 Vdc (or maximum Revolutions Per Minute (RPM) at 13.5 Vdc for EC pump applications), and 400 kPa in GMPT-6-001 (gasoline applications) or GMPT-5-014 (diesel applications), per Table 4, following Hardware Conditioning (3.2.1.5). Soldered electrical components shall withstand thermal cycle requirements defined in GMW3172. A performance assessment based on comparing pretest and posttests functional measurements is defined in Appendix C, Table C1.

Table 4: Thermal Cycle Schedule

Step	Duration	Temperature	Fuel Pump Condition
1	Within 2 h maximum	Warm to +70 °C	Cycle 3 s on/3 s off
2	2 h	At +70 °C	Cycle 3 s on/3 s off
3	Within 2 h maximum	Cool to -40 °C	Off
4	2 h	At -40 °C	Off
Repeat Steps 1 thru 4 to total 20 cycles			

3.2.1.14 Thermal Shock. The FPM shall be subjected to 20 thermal shock cycles unpowered in air, per Table 5. Soldered electrical components shall withstand thermal shock cycle requirements defined in GMW3172. A performance assessment based on comparing pretest and posttests functional measurements is defined in Appendix C, Table C1 and is performed using GMPT-6-001.

Table 5: Thermal Shock Schedule

Step	Duration	Temperature
1	Within 30 s maximum	Warm to +70 °C
2	1 h	At +70 °C
3	Within 30 s maximum	Cool to -40 °C
4	1 h	At -40 °C
Repeat Steps 1 thru 4 to total 20 cycles		

3.2.1.15 Vibration Resistance. The first frequency response to modal excitation shall be greater than 50 Hz. The fuel pump module shall withstand random vibration testing per GMW15570 Table A1 and Table 6. Test parts shall include flange external mating connector. Resistance measurements shall be continuously collected for all circuits. Fuel pump circuit shall be shunted across inner pump terminals within end cap assembly. Fuel level sensor circuit shall be shunted across resistor card to bypass dynamic contact interface, but include card terminal interface. Electrical circuit resistance shall be inspected. There shall be no open circuit or circuit resistance shifts exceeding 15 mΩ throughout the duration of the test. A performance assessment based on comparing pretest and posttests functional measurements is defined in Appendix C, Table C1.

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Table 6: Vibration Resistance Schedule – BOF Applications

Application	Test Duration
Global Standard 240 000 km (150 000 mi)	115 h/each axis
Heavy Duty Applications 320 000 km (200 000 mi)	154 h/each axis

3.2.1.16 Shipping Damage Resistance. The FPM shall be robust to the ASTM D4169 schedules E (Vehicle Vibration), F (Loose Load Vibration), and G (Simulated Rail Switching). A performance assessment based on comparing pretest and posttests functional measurements is defined in Appendix C, Table C1.

3.2.1.17 Noise and Vibration. When tested per GMW15982, following Hardware Conditioning (3.2.1.5) and a 2 h break-in at nominal input voltage and pressure, tested “as new”, and following durability as defined in Appendix C, Table C1, the FPM shall meet the following requirements:

- Minimum ten (10) fuel pump modules shall be selected to represent range of hardware anticipated in production population. Modules supplied to include best and worst case parts based upon noise performance. Selection criteria to be reviewed and subject to GM approval.
- Provide noise performance distribution, indicating performance of selected test hardware with the population.
- Provide process control plan, including fuel pump vibration acceptance criteria, to ensure capability to maintain production performance equivalent to test samples.
- Provide noise vs. temperature performance comparing GMW15982 test conditions and 40 °C.
- FPMs shall be evaluated in intended application fuels. E85 and E100 FPMs shall also be evaluated in E85 and E100, respectively, in addition to base fuel conditions. Alternative test fluids may be used where sound measurements are conducted to accommodate laboratory safety protocol, but require qualification and correlation to actual application fuels.

Note: Temperature shall not adversely affect noise and vibration performance.

3.2.1.17.1 Sound Pressure Level vs. RPM Sweep. A Weighted Sound Pressure Level (SPL) (i.e., dB(A)) and critical orders shall be determined via Fast Fourier Transform (FFT) vs. RPM sweep analysis measured per GMW15982. Reference Figure 7.

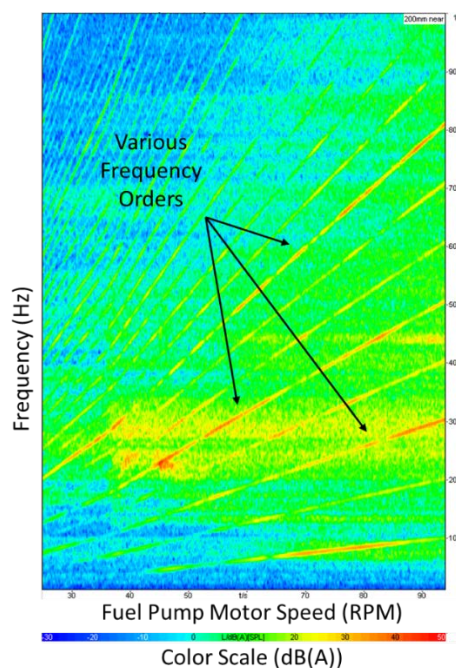


Figure 7: FFT vs. RPM Sweep

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3.2.1.17.2 Overall Noise Level and Variation. Overall noise shall be determined per GMW15982. A nominal overall noise level vs. fuel pump motor speed at idle conditions shall be determined using best fit linear regression, resulting in a line defined as $y = mx + b$. Overall noise level shall not exceed $y = 0.0022x + 42$ throughout the idle rpm range (ERFS nominal idle rpm range -200 rpm + 1500 rpm) for gasoline applications and shall not exceed $y = 0.0032x + 40$ throughout the idle rpm range (ERFS nominal idle RPM range -200 rpm $\pm$ 1500 rpm [5 V to 7 V for DC ERFS] 3) for diesel applications. For MRFS applications the voltage range is 10 Vdc to 15 Vdc for testing purposes. Overall noise variation shall not exceed ± 3 dB(A) (reference Figure 8).

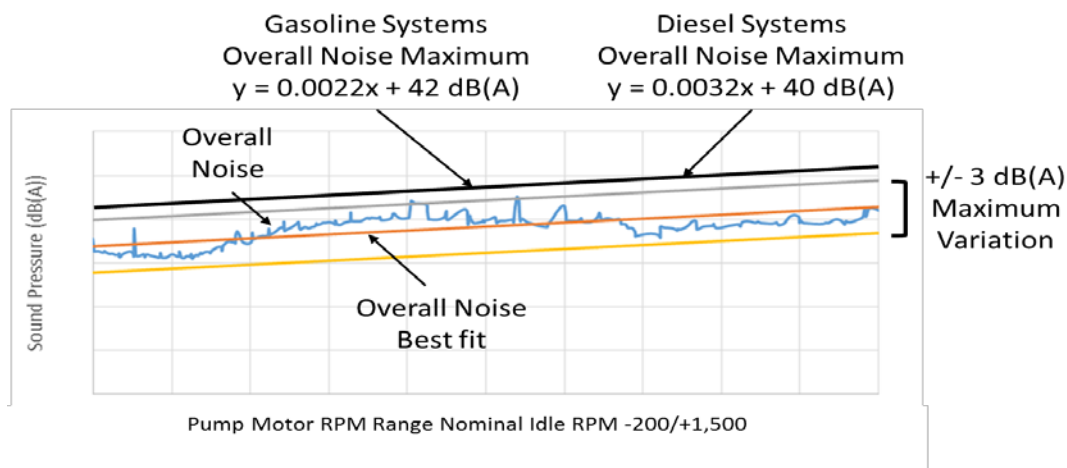


Figure 8: Overall SPL vs. RPM

3.2.1.17.3 Emergence. Noise levels of critical orders determined from FFT vs. RPM sweep shall be plotted against overall noise level (reference Figure 9). Overall noise level (best fit), overall noise level (actual), and overall noise level minus 12 dB(A) shall be included. No individual order noise level shall exceed the level determined by overall noise level minus 12 dB(A).

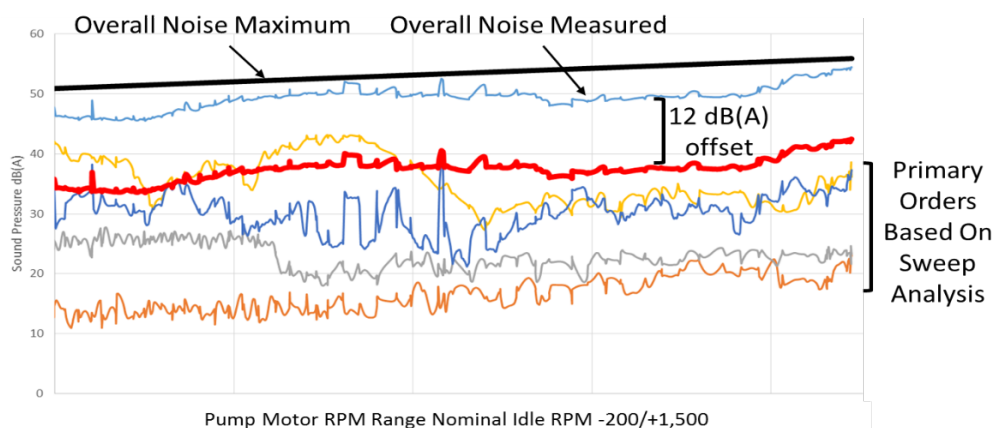


Figure 9: Individual Order SPL vs. RPM

3.2.1.17.4 Subjective Rating. There shall be no objectionable noises including, but not limited to, ticks, howls, chirps, squeals, etc. When installed in the vehicle, the FPM should have a subjective rating of 8 or higher per GMW14264. Subjective testing shall be completed using application intended fuels and alternative test fluid for comparison.

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3.2.1.18 Compression Cycling Noise. The FPM noise rating shall be 7 or better when evaluated per GMW14264 when expanded and contracted throughout the complete installation height range, following Hardware Conditioning (3.2.1.5) using GMPT-6-030. FPM flange shall be held stationary and assembly compressed at a rate of 1 Hz by pressing against module bottom surface and allowed to expand unconstrained. Analysis of materials, stresses, and bearing surfaces (especially on plastic to plastic interfaces), which may affect noise performance shall be completed prior to tooling and testing.

3.2.1.19 Flange Over Pressure Leak Integrity. FPM flange assembly shall withstand 350 kPa(g) pressure applied within 30 ms to the tank-internal side of the flange without compromise to leak integrity. Flange shall be fixed using fuel tank interface defined in 3.1.4.2 (or equivalent). May be run as flange assembly only. Bottom side electrical connector must be present (if applicable). Top side electrical connector must not be present. Ports are to be capped (top side) with sealed quick connects. Functional VPS is to be included (if applicable). If parts fail, rerun test using high-speed video to show crack initiation. Flange dimensional study shall be completed on hardware prior to testing.

3.2.1.20 Flange Cold Roll Leak Integrity. The FPM shall withstand exposure and pass criteria per GMW14800, as received (for development analysis) and following Hardware Conditioning (3.2.1.5) (validation). Flange assembly material and dimension study of relevant dimensions shall be completed prior to testing. If flange features an FLVV and/or GVV, test shall be repeated with non-functioning, sealed valves without disturbing the valve interface to determine contribution of these components.

3.2.1.21 Flange Leak Tightness. For leaks to the atmosphere, process capability shall be maintained to ensure each fuel pump module meets the maximum allowable leak rate equivalent to a 15 μ m diameter opening as measured by a helium or equivalent method at room temperature. The leak test shall be conducted per the "Leak Tightness Attachment I" of SAE J2587. Flanges shall include all overmolded (i.e., terminals) and press-fit (i.e., guide rods) components. Virtual Leak Diameters (VLD) determination method allows for supplier flexibility in determining the best leak test process for the subassembly/component. The length of the virtual leak path shall be related to the most likely leak path, but shall be no less than 1.0 mm. Flange dimensional study shall be completed on test hardware prior to testing.

3.2.1.22 Flange Vapor Emissions. On gasoline applications, flange assembly permeation shall not exceed the following limits defined in Table 7 when tested per CG1752 using CE10 fuel (GMPT-6-025). Flange dimensional study shall be completed on test hardware prior to testing.

Table 7: Flange Vapor Emissions Limits

Flange Construction, Content	Permeation
Plastic, Integral Connector, No VPS	5 mg/day HC
Steel, Inserted Connector, No VPS	
Plastic, Integral Connector, With VPS	10 mg/day HC
Steel, Inserted Connector, With VPS	

Note: HC = Hydrocarbon

3.2.1.23 Port Design. Plastic port geometry shall be optimized to minimize stress at a given load, applied at the end of, and perpendicular to, the port, as defined in Table 8. Plastic exterior port and flange geometry shall be of a common material and single piece construction. If applicable, port conductivity features to comply with Electrostatic Discharge (ESD) requirements shall be managed from the interior surface of the flange and not influence interface mechanical strength or durability performance (reference 3.2.1.25 thru 3.2.1.27). See program document(s) for specific requirements.

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Table 8: Maximum Stress, Plastic Ports

Port Size	Maximum Stress/Force Applied
8 mm ($\frac{5}{16}$ in)	0.70 MPa/N
10 mm ($\frac{3}{8}$ in)	0.44 MPa/N
13 mm ($\frac{1}{2}$ in)	0.44 MPa/N
16 mm ($\frac{5}{8}$ in)	0.44 MPa/N

3.2.1.24 Port Leak Integrity. FPM ports and interface shall withstand 1500 kPa(g) internal pressure applied at a rate of 100 kPa/s without compromise to leak integrity.

3.2.1.25 Port Strength, Short Term. FPM ports shall withstand loads defined in Table 9 without compromise to leak integrity when stressed to failure, per SAE J2044 with the load applied 10 mm from end of port. Load applied using ITT 824572 (straight 8 mm ($\frac{5}{16}$ in) port) or using ITT 815513 (straight 10 mm ($\frac{3}{8}$ in) port). Applied load shall be continuously increased until failure.

Table 9: Port Strength Requirements

Parameter	Plastic Port	Steel Port
Side load, 10 mm ($\frac{3}{8}$ in) port	266 N	Load to bend 90 degrees (> 400 N)
Side load, 8 mm ($\frac{5}{16}$ in) port	167 N	Load to bend 90 degrees (> 400 N)
Extension (connector pull off)	450 N	450 N
Compression (flange in)	1200 N	1200 N
Load apply rate	50 mm/minute	20 mm/s

3.2.1.26 Port Strength, Long Term. Long term robustness capability shall be demonstrated via creep/rupture vs. time analysis. Finite Element Analysis (FEA) shall be used to determine principal stress direction and critical geometries from which long term creep assessment can be performed. Hardware shall be tested per Table 10 to develop long term trends, which can be used to predict life robustness and correlate to short term tests that may be used for audit purposes. Load applied at the end of the port using ITT 824572 (7.9 mm port) or using ITT 815513 (9.3 mm). Ports larger than 10 mm (9.3 mm) shall be evaluated using FEA and compared against 10 mm (9.3 mm) FEA and test results to ensure equal to or higher performance.

Table 10: Port Strength Test Parameters and Pass Criteria

Condition	Fuel	Minimum Duration To Failure – 10 mm ($\frac{3}{8}$ in) (end test)	Minimum Duration To Failure – 8 mm ($\frac{5}{16}$ in) (end test)
60 N load, 60 °C	M15 (GMPT-6-030)	750 h (1200 h)	n/a
50 N load, 60 °C	M15 (GMPT-6-030)	1500 h (2500 h)	n/a
37.5 N load, 60 °C	M15 (GMPT-6-030)	n/a	750 h (1200 h)
31 N load, 60 °C	M15 (GMPT-6-030)	n/a	1500 h (2500 h)

Note: n/a = Not applicable

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