



Component Specification for the Liquid Fuel Pressure Sensor

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 specification establishes the requirements for a liquid fuel pressure sensor used in conjunction with a Fuel Pump Power Module (FPPM) or Fuel Tank Zone Module (FTZM) and Fuel Pump Module (FPM) to control the liquid fuel pressure delivered to the engine fuel rail. Pressure regulation shall be accomplished by controlling fuel pump speed while monitoring FPM output pressure via a pressure sensor.

1.2 Applicability. The sensor defined in this document provides liquid fuel pressure data that is utilized by the FPPM/FTZM for fuel pump control.

1.3 Remarks. This document provides the standard technical requirements for the Liquid Fuel Pressure Sensor. This document must only be used when invoked by a program-specific technical specification. References to the program-specific technical specification are included in this document where program-specific requirements are expected to exist.

Note: The program-specific technical specification may include additional program-specific requirements that are not referenced in this document and may supercede any requirements included in this document. In the case of any conflicts between this document and the program-specific technical specification, the program-specific technical specification takes precedence.

2 References

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

2.1 External Standards/Specifications.

ISO 1431-1	ISO 6149-3	SAE J1739	SAE J2886
ISO 6149-1	ISO 16750-5		

2.2 GM Standards/Specifications.

9985784	GMW3172	GMW15311	GMW16444
GMW3059	GMW3191	GMW15571	GMW16600
GMW3091	GMW14754	GMW15760	GMW16776
GMW3097	GMW14872	GMW15850	GMW17081
GMW3103	GMW15272	GMW15986	GMW17560

2.3 Additional References.

2.3.1 Fuels.

GMPT-4-002	GMPT-5-036	GMPT-6-022
GMPT-4-008	GMPT-6-005-B	GMPT-6-025-A
GMPT-5-005/020	GMPT-6-019	GMPT-6-030

2.3.2 Additional References

- CG1752 Hydrocarbon Permeation Measurement Process
- CG2019 Liquid Pressure Sensor Validation Cross Reference Index (VCRI)
- CG2308 Process Control and Documentation for Injection Molded Parts

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- CG3043 Supplement to GMW3172 Component Environmental Test Plan Template
- GM1927 Advanced Product Quality Planning
- GM1927-03 Supplier Quality Statement of Requirements
- GM 8774 Platform to Powertrain Electrical Interface Specification: Enhanced Evaporative Emissions and Fuel Subsystem
- United States Council for Automotive Research (USCAR) Drawing 120-S-003-1-Z02 (Connector Key A)
- USCAR Drawing 150-S-003-1-Z01 (Connector Key A)

3 Requirements

3.1 Component Definition. The absolute pressure sensor shall transmit a voltage ratio proportional to the measured absolute pressure and the 5 V reference voltage. The pressure sensor shall interface to the fuel delivery system through a threaded female port (metal) or male barbed endform (plastic) in the fuel delivery line between the fuel tank and the engine fuel rail. The interface to the wiring shall be through a three (3)-wire connector to the FPPM/FTZM or Engine Control Module (ECM).

3.1.1 Appearance. Not applicable.

3.1.2 Content.

3.1.2.1 Physical Content. The sensor typically includes the following:

- Pressure measuring device.
- Electrical connector interface.
- Means of mounting/retaining the sensor.
- Material selection and design to reduce fuel permeation of fuel to the atmosphere.
- Sealing surface for the mounting interface.

3.1.2.2 Functional Content. The liquid fuel pressure sensor shall translate the pressure that is read through a port in the liquid fuel delivery line into a percentage of the reference voltage. The sensor shall operate with fuel delivery pressure from 0 kPa to 1000 kPa. The mounting position/orientation should have no influence on the electrical characteristic or tolerance of the sensor output. The signal voltage shall not drop below 5% of the reference voltage or exceed 95% of the reference voltage during all operating conditions. The controller shall determine that there is a failure if it reads voltage outside this range.

3.1.3 Ambient Environment. The ambient environmental conditions that the pressure sensor may encounter during its life are defined in this section.

3.1.3.1 Operating Environment. The fuel pressure sensor shall withstand all operating environment extremes, as shown in Table 1, and suffer no permanent damage. The fuel pressure sensor shall exhibit acceptable performance (per this document), once the operating conditions return to normal.

Table 1: Operating Environment

Parameter	Value
Normal Operating Ambient Temperature	-40 °C to 90 °C
Fuel Pressure	0 kPa to 1000 kPa
Relative Humidity	1% to 100%
Barometric Pressure	55 kPa to 105 kPa
Grade	≤ 30%
Altitude	-150 m to 4600 m
Wind	≤ 100 km/h (vehicle at rest)
Precipitation	≤ 4.6 cm/minute

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3.1.3.2 Non-Operating Pressure and Temperature. The sensor shall meet all operating performance requirements, without loss of function or degradation of service life, under the operating environment defined in 3.1.3.1 after exposure to the following non-operating conditions:

- Transport by airplane at altitudes up to 13 700 m.
- Free air temperature of -48 °C to 93 °C.

3.1.3.3 Fuels. The liquid fuel pressure sensor shall be designed for both gasoline and diesel fuel applications. The fuels and/or fuel characteristics that shall be successfully accommodated by the sensor are identified in this section.

3.1.3.3.1 Test Fuels. The fuel pressure sensor shall be compatible with the fuel compositions that it will see in use and shall be tested for durability in the test fuels listed in Tables 2 and 3. Test fuels shall be purchased from an approved supplier. Refer to 3.2.1.11.2 for fuel exposure testing.

Table 2: Durability Fuels

Designation	General Description
GMPT-4-002	E85 - General Purpose
GMPT-6-030	Fuel C with 15% methanol
GMPT-5-020	Ultra Low Sulfur B20 Biodiesel
GMPT-5-036	Soy based deposit forming and peroxide B20 Biodiesel
GMPT-6-019	Oxidized Gasoline
GMPT-6-022	Corrosive E22-Tier 2

Table 3: Permeation Fuels

Designation	General Description
GMPT-6-025-A	CE10, Fuel C with Ethanol

3.1.3.4 Corrosives - Chloride Exposure. The typical corrosive agents and concentrations relevant to lower-body/underbody exposure are outlined in this section.

3.1.3.4.1 Calcium chloride (CaCl₂) exposure with concentration 50% aqueous solution (by weight) shall be considered. Refer applicability of materials to test, test procedure and requirements in GMW16600.

3.1.3.4.2 Zinc chloride exposure with 50% aqueous solution (by weight) shall be considered. Refer applicability of materials to test, test procedure and requirements in GMW16600.

3.1.4 Interfaces.

3.1.4.1 External to Vehicle to Component.

3.1.4.1.1 Minimize Permeation. The sensor and mounting interface seal(s) shall be designed to minimize escape of fuel vapor to the atmosphere. Refer to 3.2.1.9 for test procedure and requirements.

3.1.4.1.2 Electrical Supply Voltage. See Table 4 for details on supply voltage. Refer to GM8774 for sensor interface schematics to FPPM/FTZM or ECM.

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Table 4: Sensor Supply Reference

Parameter	Value
Supply voltage nominal	5.0 V $\pm$ 0.1 V
Supply current maximum	10 mA
Maximum supply to ground capacitance	10 μ F

3.1.4.1.3 Reference Voltage Protection. The FPPM/FTZM or ECM shall provide a transient protected reference voltage of 5.0 V $\pm$ 0.1 V and ground to the sensor. The sensor supply to ground capacitance shall be 10 μ F maximum. At this supply voltage, the current drain shall be less than 10 mA. See Appendix A, Figure A1, for recommended load circuits. The maximum supply voltage limit of the sensor shall be -0.3 V to 7.0 V.

3.1.4.2 Component/Subsystem Interface Requirements.

3.1.4.2.1 Pressure Sensor Location. Only Spark-Ignited Direct Injection (SIDI) or Direct Injection (DI) gasoline/ethanol engines or diesel engines with Electronic Return Fuel System (ERFS) require the pressure sensor. In diesel applications, the sensor shall be packaged downstream of the diesel fuel filter and the T connection used for hydrocarbon injection line.

3.1.4.2.2 Temperature around the Sensor. The sensor shall be mounted in a location that does not violate the temperature exposure range listed in 3.1.3.1.

3.1.4.2.3 Crashworthiness. The sensor shall not create any leak that causes the fuel system to fail crashworthiness requirements, as outlined in GMW15311.

3.1.4.2.3.1 The sensor shall be designed to prevent leakage if the electrical connector housing is damaged.

3.1.4.2.4 Sensor to Fuel Line Interface. The sensor shall comply with GMW15986 for fuel line interface requirements. Additional interface requirements are defined in 3.1.4.2.4.1 through 3.1.4.2.4.4.

3.1.4.2.4.1 Sensor Mounting Orientation. The sensor port shall be mounted to promote drainage with the axis of the pressure port within 5 degrees and 85 degrees of vertical.

3.1.4.2.4.2 Threaded Sensor Interface. The pressure sensor shall be installed to a male threaded port in the steel section of the fuel feed line. The sensor shall have M10 x 1 internal threads, conforming to ISO 6149-1. The mating threads on the fuel line adaptor shall conform to ISO 6149-3. Size of the hole in fuel line at the adaptor shall be minimum of 2 mm (after all tolerance).

3.1.4.2.4.3 Inline Sensor Interface. The pressure sensor ends that connect to fuel hose shall be designed as outlined in barbed end drawing 10093203. Any deviations shall be justified by meeting permeation requirements from 3.2.1.9 and durability requirements from 3.2.1.8.2.

3.1.4.2.4.4 Inline Sensor Mounting. The first mode natural frequency shall be $\geq$ 30 Hz at the sensor in installed position.

Note: It is the responsibility of the fuel bundle supplier to comprehend this requirement. If the first mode natural frequency is less than 30 Hz at the sensor in installed position, then the sensor/hose shall be secured to fuel lines using clip(s).

3.1.4.2.5 Sensor Electrical Connector Interface. The sensor electrical connection system shall meet the requirements listed in GMW3191. Chassis side connector to sensor connector interface requirements are tested as outlined in 3.2.1.12.6. The sensor pins shall be configured as shown in Figure 1. Durability tests shall be performed with a representative wiring harness/electrical connector installed to the sensor. Refer program specific Interface Control Document (ICD) for GM connector part number details.

3.1.4.2.5.1 Threaded Sensor Connector. The electrical connector shall conform to the USCAR 1.5 mm, 3-way, sealed connector dimensional and terminal standards. Refer USCAR Drawing 150-S-003-1-Z01 (Connector Key A).

3.1.4.2.5.2 Inline Sensor Connector. The electrical connector shall conform to the USCAR 1.2 mm, 3-way, sealed connector dimensional and terminal standards. Refer USCAR Drawing 120-S-003-1-Z02 (Connector Key A).

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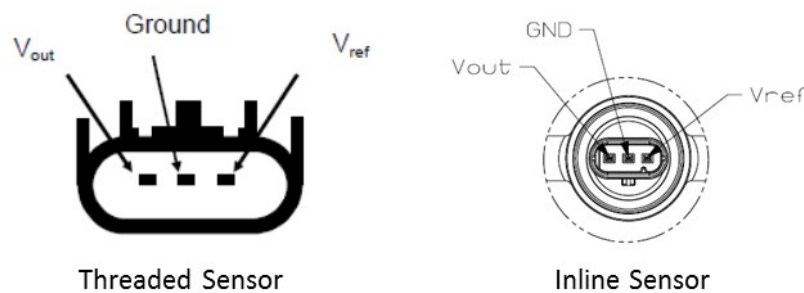


Figure 1: Sensor Pin Configuration

3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 Operating Pressure Range. The normal operating pressure for the sensor shall be between 100 kPa and 500 kPa. Excursions to 1000 kPa can be expected under certain operating conditions. Maximum pressure range that the sensor shall be able to work is between 0 kPa and 1000 kPa. Refer to 3.2.1.2 for transfer function and test details.

3.2.1.2 Analog Signal Output Proportional to Pressure. The pressure sensor shall provide an analog signal output proportional to pressure input and ratiometric to the reference voltage. Further requirements are defined in 3.2.1.2.1 through 3.2.1.2.5. Tests to verify specifications and functionality of the sensor are done at the beginning and end of each leg as outlined in Appendix C, Figures C1 through C4.

3.2.1.2.1 Transfer Function.

$$V_{out} = V_{ref} (K1 \times P + K2)$$

Where:

V_{out} = Output Voltage

V_{ref} = Supply Voltage

K1 = Slope or Gain Constant

K2 = Offset Constant

P = Input Pressure (kPa) (absolute)

The input pressure range, slope, and offset are device specific. Values can be found in Appendix C, Figure C5.

3.2.1.2.2 Calibration Points.

- Low Pressure Calibration Point: 350 kPa $\pm$ 3.75 kPa (absolute)
- High Pressure Calibration Point: 500 kPa $\pm$ 6 kPa (absolute)

3.2.1.2.3 Output Voltage Operating Range. The pressure sensor shall have an output voltage range between $10\% \times V_{ref}$ and $90\% \times V_{ref}$. Any reading above $95\% \times V_{ref}$ or below $5\% \times V_{ref}$ shall be considered beyond normal operating range and can be recorded as an electrical failure in the sensor. With V_{ref} equal to 5.0 V, the nominal output voltage of the sensor is 4.5 V to 0.5 V for the pressure range of 843.6 kPa to 56.3 kPa. If the supply voltage (V_{ref}) falls outside the operating range ($5.0 \text{ V} \pm 0.1 \text{ V}$), the sensor output voltage (V_{out}) may not remain within the error limit, but shall return to the normal operation upon restoration of the supply voltage.

3.2.1.2.4 Sensor Response to Pressure Change. The pressure sensor shall operate at any altitude with 0.0% shift due to altitude or change in barometric pressure or seasonal variation.

3.2.1.2.5 Sensor Error.

3.2.1.2.5.1 The error shall not exceed $\pm 3\%$ of the Reference Voltage for temperatures ranging from -40°C to 20°C .

3.2.1.2.5.2 The error shall not exceed $\pm 2\%$ of the Reference Voltage for temperatures ranging from 20°C to 90°C .

Note: These requirements include error due to temperature, hysteresis, repeatability, altitude, and life.

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3.2.1.3 Sensor Response to Pressure Changes. The pressure sensor shall reach 90% of its final voltage within 10 ms after applying a full pressure step input within the range defined in 3.2.1.1 and with the reference voltage as per Table 4. The output response of the sensor shall operate to average the system pressure over the response time and not as point response for each output level.

3.2.1.4 Sensor Output Noise. The pressure sensor output noise shall not exceed ± 10 mV at 1 kHz or greater, subtracting the supply and measurement variation. Refer to 3.2.1.12.5 for test details.

3.2.1.5 Over Voltage Protection. Sensor shall meet over voltage protection per the latest released GMW3172 requirement. Refer to Appendix C, Figures C2 for test flow.

3.2.1.6 Reverse Voltage Protection. The pressure sensor shall survive a reverse voltage, per the latest released GMW3172 requirement. Refer to Appendix C, Figures C2 for test flow.

3.2.1.7 Short Circuit Protection. The pressure sensor shall survive a short from any pin to ground per the latest released GMW3172 requirement. Refer to Appendix C, Figures C2 for test flow.

3.2.1.8 Sensor Mounting Durability.

3.2.1.8.1 Threaded Sensor Mounting Durability.

3.2.1.8.1.1 Torque to Seal. When installation torque of 15 N·m +5 N·m is applied to the hexport, the sensor shall not exhibit leak more than the required leak specified in 3.2.1.10.2.

3.2.1.8.1.2 Torque to Fail. The sensor shall not have cracks or thread deformation until a torque of 30 N·m applied to the hexport of the sensor.

3.2.1.8.2 Inline Sensor Mounting Durability.

3.2.1.8.2.1 Fitting Pull-off. The barbed endform on the sensor shall not crack, break or create leak until a force of 450 N. Refer to test method in GMW17560.

3.2.1.8.2.2 Pressure, Temperature and Vibration Cycling. When tested as outlined in GMW17560 with the pressure, temperature and vibration cycling, the sensor assembly shall meet performance requirements and shall not have any leak. Also, the sensor shall meet burst requirements from 3.2.1.10.7.

3.2.1.9 Fuel/Vapor Permeation. The sensor assembly and mounting interface shall minimize escape of fuel vapor to the atmosphere. When tested per GMW16776 and CG1752, the sensor assembly, including any seals used in mounting, shall not exceed the equilibrium hydrocarbon permeation/leakage value of 2.2 mg/day using GMPT-6-025-A (CE 10) test fuel.

3.2.1.10 Sensor Durability with Pressure.

3.2.1.10.1 Sensor Helium Leak Test on Production Line. When tested at minimum 1000 kPa pressure using helium, leak rate from the sensor shall not exceed $5.0 \text{ std cc/sec} \times 10^{-6} \text{ std cc/sec}$.

3.2.1.10.2 Sensor Air Leak Test. The sensor assembly as mounted, shall not leak more than 0.1 cc/minute at 800 kPa in 30 s, when tested at temperatures of -40 °C, 22 °C and 90 °C, using air. If the leak rate at -40 °C is greater than the specified amount, run one of the following options listed:

- A suitable correlation study comparing test fuel and air volumetric leak rates shall be performed and approved by GM. This study shall show a leak rate in air does not cause a corresponding leak using test fuel. The correlation study shall be documented in the final test report provided to GM.
- The sensor assembly, as mounted, shall not show any evidence of external leakage at 800 kPa $\pm$ 25 kPa after stabilization at -40 °C $\pm$ 3 °C using GMPT-4-008 (E25) test fuel.

3.2.1.10.3 Sensor Liquid Leak. The sensor assembly, as mounted, shall not show signs of leak at 1131 kPa $\pm$ 35 kPa after stabilization with GMPT-6-005-B (E25) test at 22 °C $\pm$ 3 °C.

3.2.1.10.4 Robustness to Pressure. With sensor(s) mounted in a production representative manner, apply 1000 kPa pressure at the sensing port for 30 minutes at 22 °C $\pm$ 3 °C, using GMPT-4-008 (E25) test fuel or GMW16444 Automatic Transmission Fluid (ATF) (or equivalent). During this test, the sensor shall not leak or shall not show functionality issues.

3.2.1.10.5 Over Pressurization. With sensor mounted in a production representative manner and subjected to a pressure of 2000 kPa for 30 s at 90 °C using GMW16444 ATF (or equivalent), the sensor shall not show signs of leak. The sensor does not need to operate after this test.

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