



## Specification for Fuel Tank 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 fuel tank pressure sensor to be used in conjunction with the Evaporative Diagnostics. The functions, performance, design constraints, and validation required for the component are defined in this document for both vented (regular gasoline/ethanol vehicle) and sealed fuel systems (e.g., Plug-in Hybrid Electric Vehicle (PHEV)) unless it is specifically called out to be different. In addition, this document is meant to supplement the requirements listed in GMW15311, the Fuel Subsystem Technical Specification.

**1.2 Applicability.** The sensor defined in this document provides pressure data that is utilized by the Evaporative Diagnostics.

**1.3 Remarks.** This document provides the standard technical requirements for the Fuel Tank Pressure Sensor (also known as Vapor Pressure Sensor (VPS)). 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  | SAE J1739 | SAE J2886 |
| ISO 16750-5 | SAE J2587 |           |

#### 2.2 GM Standards/Specifications.

|         |          |          |          |
|---------|----------|----------|----------|
| GMW3059 | GMW3172  | GMW14800 | GMW15850 |
| GMW3091 | GMW3191  | GMW15311 | GMW16600 |
| GMW3097 | GMW14234 | GMW15571 | GMW16776 |
| GMW3103 | GMW14754 | GMW15760 | GMW17081 |

#### 2.3 Additional References.

- CG1752, Hydrocarbon Permeation Measurement Process
- CG2014, Fuel Tank Pressure Sensor Component Technical Specification (CTS) Validation Cross Reference Index (VCRI)
- CG2308, Process Control and Documentation for Injection Molded Parts
- CG3043, Supplement to GMW3172 Component Environmental Test Plan
- GM Drawing 10093203
- United States Council for Automotive Research (USCAR) Drawing 120-S-003-1-A01 (Connector Key B)

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- USCAR Drawing 150-S-003-1-Z01 (Connector Key A)

### 3 Requirements

**3.1 Component Definition.** The Onboard Diagnostics II (OBD II) compliant Fuel Tank Pressure Sensor measures fuel tank vapor space pressure then translates the information to an electrical output for Evaporative Diagnostics. The pressure sensor assembly generates an analog signal output proportional to a pressure input and ratiometric to the reference voltage (see Figure 1).

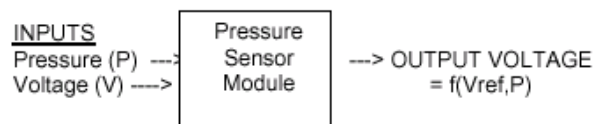


**Figure 1: Pressure Sensor Module Input/Output**

**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/design to reduce fuel permeation from the fuel tank to the atmosphere.
- Seal for the mounting interface.

**3.1.2.2 Functional Content.** The sensor provides the following functions:

- Measure gauge pressure in the fuel tank vapor space.
- Generate an analog signal output proportional to a pressure input and ratiometric to the reference voltage.
- Minimize escape of fuel/vapor from the mounting interface to the atmosphere.

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

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

**Table 1: Operating Environment**

|                                      |                              |
|--------------------------------------|------------------------------|
| Normal Operating Ambient Temperature | 0 °C to 90 °C                |
| 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              |

**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:

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- 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 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 3.2.1.8.2 for fuel exposure testing.

**Table 2: Durability Fuels**

| Fuel Formulation | Fuel Label | Fuel Description                         |
|------------------|------------|------------------------------------------|
| GMPT-6-002       | E22        | Corrosive E-22                           |
| GMPT-4-008       | E25        | General Purpose E-25                     |
| GMPT-4-015       | M15        | General Purpose Validation Fuel          |
| GMPT-6-018       | Peroxide   | 108 ppm peroxide in a specified gasoline |
| GMPT-4-002       | E-85       | General Purpose - Summer E85             |

**Table 3: Permeation Fuels**

| Fuel Name    | Fuel 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 (CaCl<sub>2</sub>) 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 3.2.1.3 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 Fuel Tank Zone Module (FTZM) or Engine Control Module (ECM).

**Table 4: Sensor Supply Reference**

| Parameter                            | Value          |
|--------------------------------------|----------------|
| Supply Voltage Nominal               | 5.0 V ± 0.25 V |
| Supply Current Maximum               | 13 mA          |
| Maximum supply to ground capacitance | 10 µF          |

**3.1.4.1.3 Reference Voltage Protection.** The FTZM or ECM shall provide a transient protected reference voltage of 5.0 V ± 0.25 V and ground to the sensor. The sensor supply to ground capacitance shall be 10 µF

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maximum. At this supply voltage, the current drain shall be < 13 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.** Vehicles sold in North America, Korea and China (with China 6 emission standards) only require the tank pressure sensor. For mounting location of the VPS, refer program specific Statement of Requirements (SOR) documents of fuel tank assembly or Fuel Pump Module (FPM).

**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 of this document.

**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.

**3.1.4.2.4 Sensor Mounting Requirements.** There are two (2) types of mounting methods for VPS. The following requirements apply for both mounting methods. Individual mounting interface requirements are defined in 3.1.4.2.4.1 and 3.1.4.2.4.2.

- The sensor shall be mounted such that the axis of the pressure port is within  $\pm 40$  degrees from vertical to promote fuel drainage (if the sensor port is exposed to fuel).
- Provisions shall be made to prevent blockage of the sensor atmospheric port by environmental contamination (e.g., water, snow, mud, ice and dust).
- The sensor mounting design shall be robust to rough handling and loads exerted on the wiring harness without damage to the sensor/mounting interfaces.
- The sensor mounting interface and seal(s) shall be designed to minimize escape of fuel tank vapor to the atmosphere.

**3.1.4.2.4.1 Sensor Mounting Directly on Tank or the Flange of FPM.** The pressure sensor/seal assembly shall be designed to be mounted through a hole described in Figure 2.

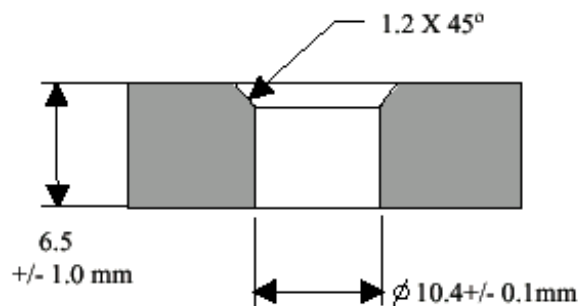


Figure 2: Sensor Mounting Hole

**3.1.4.2.4.2 Sensor Mounting in Fuel Vapor Hose.** The pressure sensor barbed ends that connect to the vapor hose shall be designed as outlined in drawing 10093203 (size 5/8"). Any deviations shall be justified by meeting permeation requirements from 3.2.1.3 and pressure cycling durability requirements from 3.2.1.6 and 3.2.1.7.

**3.1.4.2.5 Cap to Protect the Air Reference Port.** In some vehicles, the sensor air reference port may have to be protected with a separate cap to prevent water blocking the port. GM program engineers, who ultimately have the responsibility to integrate the sensor in GM vehicles, need to evaluate water entry points to the air reference port of the sensor to decide the need for protection of the sensor using external cap. Refer to 3.2.1.9.3.1 and 3.2.1.9.3.2 for performance tests.

**Note:** It is the responsibility of the integrated supplier of fuel tank or FPM to install the cap as outlined in the program specific SOR documents.

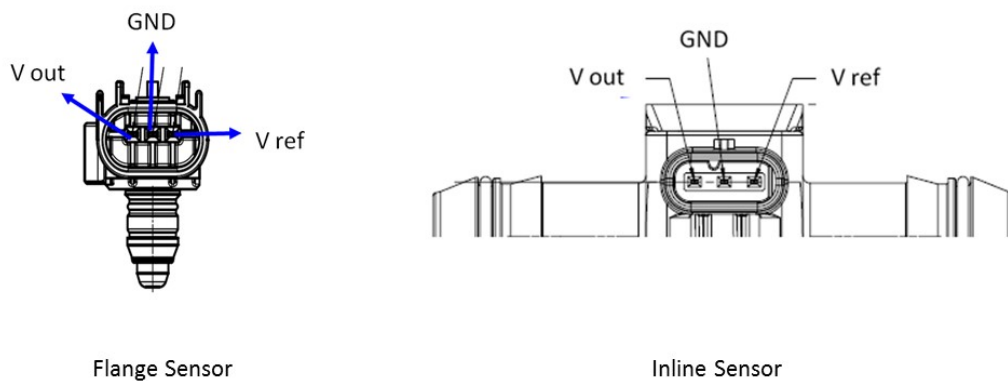
**3.1.4.2.6 Sensor Electrical Connector Interface.** The sensor electrical connection system shall meet the requirements listed in GMW3191. Chassis side connector to sensor connector interface requirements are tested as outlined in 3.2.1.9.6. The sensor pins shall be configured as shown in Figure 3. 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.

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Note: GND = Ground

Figure 3: Sensor Pin Configuration

**3.1.4.2.6.1 Flange Mounted 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 B).

**3.1.4.2.6.2 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 B).

### 3.2 Product Characteristics.

#### 3.2.1 Performance Requirements.

##### 3.2.1.1 Operating Pressure Range.

**3.2.1.1.1 Pressure Range for Vented Fuel Systems.** Pressure range for the sensor shall be from -3.73 kPa to 1.24 kPa gauge.

**3.2.1.1.2 Pressure Range for Sealed Fuel Systems.** Pressure range for the sensor shall be from -3.75 kPa to 3.5 kPa gauge.

**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 3.2.1.2.7. 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.** Transfer function is the equation that relates the output voltage to the input pressure and supply voltage. The electrical output of the sensor assembly is determined by the following 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

$P$  = Differential Pressure, where the differential pressure is defined as:

$$P_{\text{differential}} = P_{\text{fuel tank}} - P_{\text{atmosphere}}$$

The input pressure range, slope, and offset are device specific.

**3.2.1.2.1.1 Output Voltage Operating Range for Vented Fuel System.** For vented system, Appendix A, Figure A2 shows the output voltage vs pressure range of the sensor. The pressure sensor shall have an output voltage range between 4.5 V ( $90\% \times V_{ref}$ ) to 0.5 V ( $10\% \times V_{ref}$ ) for the differential pressure range of -3.73 kPa to

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1.24 kPa ( $V_{ref}$  equal to 5.0 V). The maximum output voltage of the sensor, regardless of the pressure applied to the port, shall be  $< 95\%$  of  $V_{ref}$ . The minimum output voltage of the sensor, regardless of the pressure applied to the port, shall be  $> 5\%$  of  $V_{ref}$ . If the supply voltage ( $V_{ref}$ ) falls outside the operating range ( $5.0 \text{ V} \pm 0.25 \text{ V}$ ), 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.

**3.2.1.2.1.2 Output Voltage Operating Range for Sealed Fuel System.** For sealed system, Appendix A, Figure A4 shows the output voltage vs pressure range of the sensor. The pressure sensor shall have an output voltage range between 4.5 V ( $90\% \times V_{ref}$ ) to 0.5 V ( $10\% \times V_{ref}$ ) for the differential pressure range of -3.75 kPa to 3.5 kPa ( $V_{ref}$  equal to 5.0 V). The maximum output voltage of the sensor, regardless of the pressure applied to the port, shall be  $< 95\%$  of  $V_{ref}$ . The minimum output voltage of the sensor, regardless of the pressure applied to the port, shall be  $> 5\%$  of  $V_{ref}$ . If the supply voltage ( $V_{ref}$ ) falls outside the operating range ( $5.0 \text{ V} \pm 0.25 \text{ V}$ ), 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.

**3.2.1.2.2 Sensor Output Impedance.** The source of impedance of the sensor output voltage shall be  $\leq 50 \Omega$  relative to the ground connection during normal operation. Under an open ground fault condition, the source impedance of the sensor output shall be  $\leq 9000 \Omega$  relative to the reference voltage connection.

**3.2.1.2.3 Sensor Response to Pressure Change.** The sensor assembly response time shall not exceed 5 ms. Response time is defined as the time required for the output ( $V_{out}$ ) to change from an initial value, to 90% of the new steady state value following a step change in pressure input for the entire operating range of the sensor. The sensor assembly shall be capable of driving minimum load impedance of 30 000  $\Omega$ .

**3.2.1.2.4 Absolute Pressure Error Limit.**

**3.2.1.2.4.1 Absolute Pressure Error Limit for Vented System Sensor.** The absolute pressure error limit (accuracy) specifies the maximum absolute pressure measurement error during test and adjustment of the sensor within the operating temperature range defined in 3.1.3.1. It encompasses all error-contributing factors, such as stability, repeatability, hysteresis, and interchangeability. The pressure error limits for the VPS are given in Appendix A, Figure A3.

$$\text{Voltage Error Limit} = V_{ref} \times K1 \times E_p$$

Where:

$V_{ref}$  = Supply Voltage

$K1$  = Slope

$E_p$  = Pressure Error Limit

**3.2.1.2.4.2 Absolute Pressure Error Limit for Sealed System Sensor.** The absolute pressure error limit (accuracy) specifies the maximum absolute pressure measurement error during test and adjustment of the sensor within the operating temperature range defined in 3.1.3.1. It encompasses all error-contributing factors, such as stability, repeatability, hysteresis, and interchangeability. The pressure error limits for the VPS are given in Appendix A, Figure A5.

**3.2.1.2.5 Sensor Response to Power.** At atmospheric pressure, the sensor assembly shall stabilize within 3% of the output voltage within 30 ms after  $V_{ref}$  is applied to the sensor.

**3.2.1.2.6 Sensor Output Characteristics in Extreme Temperature.** The supplier shall provide sensor performance characteristics in the temperature ranges of  $-40^\circ\text{C}$  to  $0^\circ\text{C}$  and  $80^\circ\text{C}$  to  $90^\circ\text{C}$ . The sensor shall meet all performance requirements in the normal operating temperature range ( $0^\circ\text{C}$  to  $80^\circ\text{C}$ ), without loss of function or degradation, after the sensor is exposed to the extreme operating temperatures.

**3.2.1.3 Fuel/Vapor Permeation.** The sensor assembly and mounting interface shall minimize escape of fuel vapor to the atmosphere. As measured in procedure 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.

**3.2.1.4 Sensor Assembly Retention.**

**3.2.1.4.1 Retention of the Flange Mounted Sensor and Cap.**

**3.2.1.4.1.1** The sensor shall remain seated when 350 kPa pressure is applied to the sensor for 30 s, with the sensor mounted in maximum diameter tolerance hole (see Figure 2). The sensor is not required to function after this high pressure exposure test. Acceptance criteria for leak is 2 cc/minute.

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**Note:** After the 350 kPa test, increment the pressure and hold for 30 s in steps of 100 kPa until 1050 kPa. Report the results.

**3.2.1.4.1.2** The pull-off force shall be 112 N minimum when the sensor is mounted in maximum diameter tolerance hole (see Figure 2).

**3.2.1.4.1.3** The sensor shall be designed to meet ergonomic force requirement of  $\leq 45$  N for installation. Refer to GMW14234 for further guidelines.

**3.2.1.4.1.4** The cap, designed to protect the air reference port, shall meet ergonomic force requirement of  $\leq 45$  N for installation. Refer GMW14234 for further guidelines.

**3.2.1.4.1.5** The pull-off force for the cap (designed to protect the air reference port) shall be 80 N minimum when the cap is pulled vertically upwards.

**3.2.1.4.1.6** The cap, designed to protect the air reference port, shall not crack until 50 N minimum when the force is applied vertically downward, at 50 mm/minute, at the center of the cap surface.

**3.2.1.4.1.7** When the electrical connector is subjected to 50 N load minimum, at 50 mm/minute, the sensor mounting shall not experience any leak. Apply force at the connector locking tab in all directions.

**3.2.1.4.2 Retention of the Inline Sensor.** The barbed endform on the sensor shall not crack, break or create leak until a force of 450 N.

### **3.2.1.5 Sensor Leakage.**

**3.2.1.5.1 Sensor over Pressure Integrity.** The sensor shall remain leak free and in the installed position, after 350 kPa pressure is applied within 30 ms to the sensor. The sensor is not required to function after this pressure test.

**3.2.1.5.2 Sensor Leak Tightness.** The sensor assembly as installed shall maintain process capability for a maximum allowable leak not more than a 15 micron or equivalent channel. The leak test shall be conducted as outlined in SAE J2587.

**3.2.1.5.3 Liquid Leakage.** This requirement is applicable for the flange sensor only. The sensor shall not leak liquid when the sensor is mounted in maximum and minimum tolerance hole (see Figure 2) and pressure applied from 0 kPa to 11.2 kPa at test temperatures of  $-40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ,  $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  and  $65\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ . Perform the leak test at 90 degree and 180 degree angles of rotation after the test fixture and test fuel stabilized at the temperature of interest for 4 h. During the temperature stabilization period, there shall be no pressure applied to pressure port of the sensor. GMPT-6-001 (Stoddard solvent) may be used at 65 °C and GMPT-4-008 (E25) shall be used at the other temperatures.

**3.2.1.5.4 Cold Roll Leak Integrity.** This requirement is applicable for the flange sensor only. The VPS shall withstand exposure and pass criteria per GMW14800. The test shall be conducted using production representative FPM flange (both steel and plastic versions) and fuel tank mounted adaptor. No machined substitute parts are to be used for the test.

### **3.2.1.6 Robustness to Power, Pressure, Temperature.**

**3.2.1.6.1 Power, Pressure, Temperature (PPT) Robustness.** With the sensor mounted in a production representative manner, test as outlined in the following bullets using air. Performance tests may be conducted at appropriate intervals. The sensor shall be cycled for a minimum of 450 temperature cycles with the PPT conditions outlined. Sensor output shall be monitored during this test. The sensor shall not experience any performance issues or leak during the test.

**3.2.1.6.1.1 Power.** 5.0 VDC, 3 minutes On, 3 minutes Off, continuous cycle.

**3.2.1.6.1.2 Pressure.** -10 kPa to 20 kPa at 0.2 Hz cycling speed, each pressure extreme applied 30% of the cycle time.

**3.2.1.6.1.3 Temperature cycle.**  $-40\text{ }^{\circ}\text{C}$  to  $90\text{ }^{\circ}\text{C}$  with transition rate of  $5\text{ }^{\circ}\text{C/minute}$  and 15 minute dwell time at temperature extremes.

**3.2.1.6.2 Robustness to Pressure.** The sensor shall meet functional requirements listed in 3.2.1.2, after 68 kPa air pressure, at room temperature, is applied to the pressure port of the sensor for 30 minutes.

**3.2.1.7 Pressure Cycling.** The sensor shall meet functional requirements listed in 3.2.1.2, when the sensor is tested in production representative mounting at  $80\text{ }^{\circ}\text{C}$  with  $5\text{ V} \pm 0.25\text{ V}$  applied and the pressure cycled as follows:

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