



# PRESSURE SENSORS FOR LAUNCH VEHICLES

Requirements for Pressure  
Sensors with a Comprehensive  
Checklist

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FACT SHEET



## Pressure Sensors in Launch Vehicles

Pressure sensors play a crucial role in aerospace engineering, particularly in launch vehicles. They enable precise monitoring and control of systems that are essential for the safe launch, operation, and even reusability of rockets. This document provides a concise overview of the key requirements and challenges in selecting and utilizing pressure sensors in this demanding environment.

### Characteristics of Launch Vehicles

#### Multistage Design

Each stage carries fuel and an engine, which is detached after depletion to reduce weight

#### High-Performance Propulsion

Typically powered by chemical rocket engines (liquid or solid propellants), with an increasing focus on reusable systems

#### Variable Payload Capacities

Depending on the mission, they can transport small satellites or large space station components

### What is a Launch Vehicle?

Launch vehicles are rockets designed to transport payloads such as satellites, space probes, or crewed spacecraft from Earth into space. They typically consist of multiple stages, which are ignited and discarded sequentially to efficiently deliver the payload into the desired orbit or an interplanetary trajectory.

### The Importance of Pressure Sensors in Launch Vehicles

Launch vehicles are exposed to extreme environmental conditions, particularly significant temperature fluctuations. During launch, temperatures can rise dramatically due to aerodynamic heating, while in the vacuum of space, extremely low temperatures prevail. This places high demands on pressure sensors, as they must operate reliably and accurately under these conditions.

Pressure sensors play a crucial role in various areas:

- Monitoring fuel and oxidizer pressure to ensure stable combustion
- Regulating thrust for optimal rocket control
- Detecting critical pressure changes to prevent malfunctions
- Enhancing reusability through continuous system monitoring

For reusable launch vehicles, precise and reliable pressure measurement is especially critical to ensure a safe landing and enable reuse.



## Requirements for Pressure Sensors

### Extreme Conditions

Pressure sensors in space applications must withstand extreme temperatures, high accelerations, and vibrations. Typical challenges include:

- Fluctuating temperatures: Ranging from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- High mechanical stress during launch and landing
- Operation in vacuum-like environments

### Precision and Stability

For rocket control, highly precise measurements are essential. Key factors include:

- Low long-term drift to ensure consistent accuracy over time
- High repeatability for reliable data acquisition
- Minimal temperature influence on measurement accuracy

### Resistance to Extreme Temperatures

Pressure sensors in launch vehicles are exposed to extreme temperature fluctuations – from freezing conditions in orbit to intense heat near the propulsion system.

The key measures to ensure functionality include:

- Material selection: High-strength metals such as stainless steel or titanium to minimize thermal expansion
- Electronics protection: Hermetic sealing to shield against thermal stress
- Temperature compensation: Reducing measurement errors caused by temperature variations

# Checklist

## How to select the right sensor

<p>Pressure Range</p>	<ul style="list-style-type: none"> <li>• Sensors have to be designed for the expected pressure levels (e.g., from vacuum to several hundred bar)</li> <li>• A safety margin should be considered for unexpected pressure spikes</li> </ul>	
<p>Overload Protection</p>	<ul style="list-style-type: none"> <li>• Proof Pressure: The sensor must operate reliably at up to 400% of the operating pressure</li> <li>• Burst Pressure: The sensor should withstand up to 10 times the operating pressure without failure</li> </ul>	
<p>Signal &amp; Interface</p>	<ul style="list-style-type: none"> <li>• Analog signals (e.g., 0-5 V or 4-20 mA) for simple and robust integration</li> <li>• Digital protocols (e.g., RS485/Modbus, HART) for high-precision data transmission and advanced diagnostics</li> <li>• Selection of the appropriate interface based on system requirements and environmental conditions</li> </ul>	
<p>Mounting Requirements</p>	<ul style="list-style-type: none"> <li>• Direct process connections without adapters to prevent measurement errors</li> <li>• Compatible seals (e.g., metallic seals for high-pressure or high-temperature applications)</li> <li>• Sufficient space for accessibility and maintenance</li> </ul>	
<p>Temperature Resistance and Range</p>	<ul style="list-style-type: none"> <li>• Consideration of the full operating temperature range (launch phase, stratosphere, cryogenic fuels if applicable)</li> <li>• Calibration and accuracy must be ensured even under extreme temperature fluctuations (e.g., from -200°C to +200°C, depending on the application)</li> </ul>	

<p>Vibration and Shock Resistance</p>	<p>Certification for high vibration frequencies and accelerations typical of rocket launches Resistance to sudden shocks (e.g., staging events, booster separation)</p>	
<p>Accuracy and Long-Term Stability</p>	<p>Defined accuracy classes (e.g., <math>\pm 0.1\%</math> FS, <math>\pm 0.25\%</math> FS) Understanding and documenting drift behavior over the sensor's lifetime Planning regular recalibration intervals</p>	
<p>Material and Corrosion Resistance</p>	<p>Suitable housing and diaphragm materials (e.g., stainless steel, titanium) for high pressures and potentially aggressive media (e.g., LOX, kerosene) Surface treatments, sealing materials, and corrosion protection adapted to the operating environment</p>	
<p>Calibration and Testing</p>	<p>Regular factory and field calibration to ensure measurement accuracy Documented testing procedures (e.g., pressure reference test stands, certification) Traceability of measurements to international standards (e.g., ISO/IEC 17025)</p>	
<p>Redundancy and Fail-Safe Reliability</p>	<p>Regular factory and field calibration to ensure measurement accuracy Documented testing procedures (e.g., pressure reference test stands, certification) Traceability of measurements to international standards (e.g., ISO/IEC 17025)</p>	
<p>Certifications and Standards</p>	<p>Redundant sensor configurations are often required in safety-critical applications (e.g., n+1 redundancy) Real-time monitoring of individual sensors (diagnostic functions) to quickly detect failures Integration into fail-safe concepts (e.g., signal evaluation through separate systems)</p>	

Data Processing and Real-Time Capability	<ul style="list-style-type: none"><li>• Sensor sampling rate must match the dynamics of pressure changes (e.g., high sampling rates during launch)</li><li>• Real-time data processing and transmission for flight control (e.g., guidance and telemetry)</li></ul>	
Weight and Space Requirements	<ul style="list-style-type: none"><li>• Minimal weight is essential in launch vehicles – choose lightweight and compact sensors</li><li>• Optimize mounting locations to ensure short wiring paths and reduce signal interference</li></ul>	
Supplier Selection and Quality Management	<ul style="list-style-type: none"><li>• Long-term availability of spare parts and maintenance (replacements, repairs)</li><li>• Quality assurance and traceability of all components (batch tracking, serialization)</li><li>• Manufacturer’s experience in the aerospace industry</li></ul>	
Documentation and Traceability	<ul style="list-style-type: none"><li>• Complete technical documentation, including material certificates, test reports, and calibration certificates</li><li>• Clear identification (serial number, production batch) for full traceability</li></ul>	

## Conclusion

Pressure sensors are essential components for launch vehicles and must withstand extreme conditions. Careful selection, considering temperature resistance, signal processing, and mechanical durability, is crucial for mission success. Only through the use of robust and precise sensors can launch vehicles be operated safely and efficiently.

## About STS Sensors

With more than 30 years of expertise, we deliver swiss-made pressure sensors renowned for their reliability and accuracy, trusted across diverse industries. 2,500+ ATM.1ST sensors installed globally, trusted for reliability, accuracy, and robustness in critical applications.