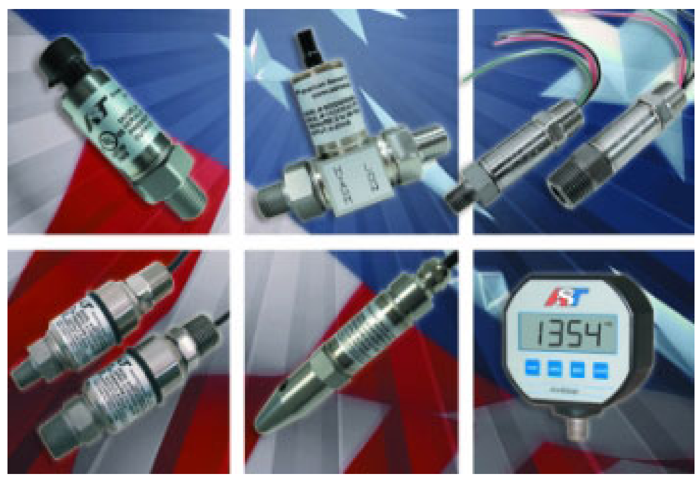
Design Essentials: How to select a pressure sensor for a specific application

By Karmjit Sidhu, VP, Business Development American Sensor Technologies



There are over 200 pressure sensor suppliers around the world, offering products from a few dollars to thousands of dollars. A purchaser or engineer unfamiliar with pressure sensors can become overwhelmed with the price range, quality, and options. The first step is to understand the application from the media being measured to the desired electrical output for indication or control. The following is a guide through a variety of options to make a prudent decision.

Media

Media is the most important item when selecting a pressure sensor for an application. Most sensor suppliers only sell sensors that are rated for benign environments such as clean, dry air. The next tier of suppliers will sell products that will handle mild environments through to difficult/corrosive environments. Clean water, steam, some forms of hydraulic oils, and Freon can be considered mild environments. Difficult media tends to be corrosive liquids and gases such as hydrogen sulfide, hydrochloric acid, bleach, bromides, waste water, and hydrogen. Wrongful selection of a pressure sensor can lead to catastrophic failure and serious injury. When unsure, ask the pressure sensor manufacturer to provide a chemical compatibility chart with their products. In fluidic systems, such as water and hydraulics, one must understand how the water hammer and pressure transients effect the pressure sensor.

Environment

The conditions under which the pressure sensor operates must be defined clearly such as temperature range, indoor/outdoor usage, shock, vibration, electrical interference, and hazardous areas (oil and gas applications). If the pressure sensor is installed in a hazardous area, the class type and group type must be known in order for the product to comply with NEC or CEC codes in North America. When using sensors outdoors, the sensors may be sealed or vented depending on the pressure range. For example, pressure ranges of 100 psig (7 bar) or below that are used for gauge pressure measurements will change their output (zero offset value) if sealed under barometric conditions. The error may be up to 2 psi (0.138 bar). This error may be acceptable if the objective is a gross measurement with the benefit of preventing the electronics from moisture, humidity, rain, ice, or system wash down. This has to be reviewed as part of the system performance. If the 2-psi error is unacceptable, the sensor needs to be vented in such a way that it will provide precise information under adverse conditions. Ensuring that the sensor is in a low humidity environment or that the vent tube has a desiccant filter will assist in full operation with gauge pressure measurements.

Another important parameter is knowing the ambient and media temperatures. For example, the ambient temperature of steam measurements may be 100°F — however, the steam temperature may reach 275°F within the system. If the sensor is not compensated correctly or the temperature is not reduced before it reaches the diaphragm, it will change its value drastically.

Sensor package

A sensor package dictates the space envelope and types of environmental protection needed for an application. The size of these packages can range from 0.25 in. in diameter and length to 10 in. in diameter by 12 in. in length. Fig 1. shows typical sensor packages, about 1 in. in diameter and 2 in. in length, with welded housing, molded connector, and cable for use in typical industrial environments. This package, with a 304 stainless steel housing and glass-filled plastic connector, can be used over a wide range of temperatures, shock, vibration, and Electro Magnetic Interference (EMI).

Fig. 1. Typical sensor configurations with an integral connector (left) and cable (right).

Within the sensor package, the pressure-sensing element technology, electronics, and EMC protection are combined to complete the sensor package. Fig. 2 shows a typical exploded view of a sensor package with all the key components to make a sensor.

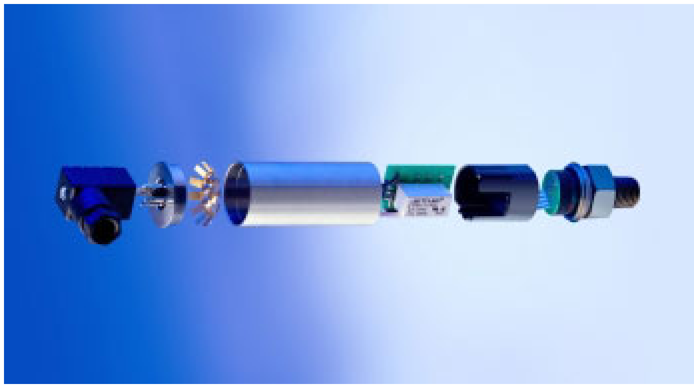


Fig. 2. Exploded view of sensor package.

Some of the sensing technologies require oil-filled cavities, welded diaphragms, or internal O-rings to seal against the media. Very few technologies, such as the Krystal Bond Technology, offer a full hermetic seal against the media. Fig. 3 shows two common sensing technologies that have been used for years, as well as Krystal Bond technology utilizing a one-piece design.

Fig.3. Oil-filled sensors (left), thin-film welded sensor element (middle), and Krystal Bond technology one-piece design (right).

Mechanical interface

The vast majority of pressure sensors are supplied with some form of a thread as the process connection, while few specialty applications require an O-ring seal, tube stub for a welding, or crimped front end. In North America, NPT (National Pipe Threads) threads are very common for low to medium pressures up to 5,000 psi (350 bar). NPT threads are tapered in nature and require some form of Teflon tape or putty to seal the thread to a piece of equipment. Installation torque must not exceed 25 ft-lb or else the threads will be damaged and will not seal against the media. UNF (Unified Fine) threads, as well as metric parallel threads, sealed with a face elastomer O-ring, can be used from low to high pressures up to 15,000 psi (1,000 bar). Above 15,000 psi, metal-to-metal seals should be employed in place of elastomer-based O-rings.

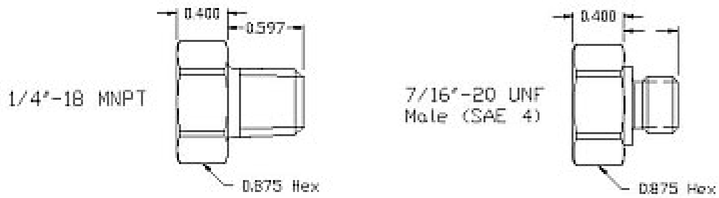


Fig. 4. Shows various thread configurations; NPT (left) and 7/16-20 UNF (right).

Electrical interface

Electrical interface allows the user to connect the sensor output to the system via connectors or cables. Depending on the output signal chosen, connectors and cables can be selected depending upon the environmental conditions.

Connectors certainly add benefits to pressure sensor installation. If the sensor needs to be removed from the system for re-calibration or system maintenance, the connector can be unplugged and the sensor un-threaded. The sensor and the cable harness can also be installed independently. Depending on the number of bends, length, and manufacturing procedure, the use of a pressure sensor with cable wired to a controller can be a costly mistake.

Most of the time, the connectors are an integral part of the pressure sensor. However, high-vibration environments, such as heavy-duty construction equipment, require an inline connector (a connector at the end of a length of wire) to reduce stress on the back-end of the sensor. Inline connectors also reduce the loading on the connector pins, increasing the life of the sensor significantly. Fig. 5 shows different forms of connector configurations. When selecting a cable option, the outer jacket material and inner conductor insulators must be selected to match the application. For example, if the sensor is to be used on an outdoor application from -40°F to 160°F (-40°C to 70°C), the jacket of the cable must meet the temperature rating and carry UV resistance in order to avoid cracking.

Fig 5. Mini DIN 43650C connector (left), 6-pin metal connector (middle), and inline connector (right).

Electrical input/outputs

Electrical input/outputs are normally dictated by the customer for seamless integration into the controller. The input is excitation or supply voltage. Typical industrial pressure sensors operate from 10 V to 32 V, unregulated supply. Pressure sensors operating from this supply will have internal regulators to provide a stabilized input to the electronic circuitry under varying supply voltages. The output of industrial sensors can have high-level voltage outputs such as 1 VDC to 5 VDC, 0 VDC to 5 VDC, 0 VDC to 1 VDC. Typical distances for transmitting these high-level voltages are between a few inches and 30 ft. Beyond this, the output signal will lose its amplitude and accuracy due to resistance of the cable. Also, a zero-based output signal (i.e., 0 V to 5 V) does not offer constant feedback at zero pressure. Unfortunately, the controller is unaware if the system is at operating at zero pressure or if there is a problem with the pressure sensor. The 1-V to 5-V option offers a live zero for constant feedback into the controller. The disadvantage of the 1-V to 5-V option is that it offers one less volt of span; a 1-V to 6-V option is gaining popularity in the industrial market because it has the live zero with a 5-V span.

A 4-mA to 20-mA, two-wire loop-powered output, also known as a pressure transmitter, is very popular for long distances. This allows sensors to have cable lengths up to 1 mile (1.5 km) as long as the supply voltage is high enough to compensate with voltage drop due to cable resistance. The two-wire system is immune to electrical noise in comparison to the voltage output. Other outputs can be ratiometric outputs such as 0.5 V to 4.5 V from a 5-V supply. This is commonly used in off-road and wireless systems where low power consumption is needed.

Finally, frequency output is gaining popularity due to its ability to communicate directly with a micro-controller without the need of external analog-to-digital (ADC) converter.

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