

# Pressure Sensors Built to Withstand the Abuse of Hydrogen Applications

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**T**he US government's announcement to fund development of alternative fuels to reduce dependency on foreign oil has resulted in a flurry of activity in the area of hydrogen. As an environmentally friendly element, hydrogen shows great potential to be the next fuel of the future. The generation and storage of hydrogen, however, poses new challenges in the types of pressure sensors that can be used safely and accurately in these new applications.

Hydrogen salvage and distribution systems are currently in development to handle this fuel efficiently. Dependent upon size, these tanks can experience pressures ranging from 1,000 to 12,500 psi. To maintain critical levels of pressure and safety, pressure sensors are employed for continuous monitoring. The pressure sensors are installed directly on the outlet valve, close to the tank.

When selecting pressure sensors for these hydrogen applications, it is important to ensure material compatibility and resistance against two major forms of corrosion: hydrogen permeation and embrittlement.

As the simplest and smallest atom element, hydrogen itself is not corrosive. However, when hydrogen atoms split into a hydrogen ion (two H<sup>+</sup> atoms), it can penetrate through thin metal diaphragms.

Pressure transducers employing thin isolation diaphragms with fluid fill (as shown in diagram 1) are prone to hydrogen permeation. Hydrogen ions will penetrate the diaphragm and be trapped in the fill

fluid, producing hydrogen bubbles. These bubbles will cause zero and span readings to change, degrading the transducer performance. Over time, the build-up of hydrogen will cause outward expansion of the isolation diaphragm, leading to cracks and sensor failure through loss of fill fluid.

Hydrogen permeability occurs in both pure and non-pure hydrogen applications involving high pressure-temperature in pure hydrogen applications; galvanic reaction such as seawater; and steam at high temperatures. To reduce or eliminate hydrogen permeation in thin diaphragms, American Sensor Technologies offers its pressure sensors with a one-piece, thick diaphragm design, free of internal O-rings, welds or fill fluids.

The unique one-piece bulkhead design keeps hazardous media out, eliminating the chance of hydrogen permeation and eventual sensor failure. Diagram two shows a cross-section of a typical AST pressure transducer for hydrogen service, highlighting the one-piece thick diaphragm design.

In addition to hydrogen permeation, long-term exposure to hydrogen can also cause embrittlement that reduces the mechanical properties of metal, leading to transducer failure. Factors for hydrogen embrittlement are environmental, caused by internal absorption and chemical reaction in the presence of hydrogen ions. Susceptibility of embrittlement increases with tensile stress and the ultimate strength of the

pressure sensor metal as a function of hydrogen purity levels.

To reduce or eliminate embrittlement, material selection, together with thickness, surface finish, weld free joints and conservative design stresses, must be considered when choosing a pressure transducer for hydrogen applications. Metals such as 410 stainless steel, 1040 steel, 17-4 and 17-7 stainless steels and Inconel 718 are ideal for a host of different applications but should be avoided for pressure sensors as these metals are extremely embrittled in hydrogen. Metals such as 310 and 316 stainless steel, however, offer negligible embrittlement.

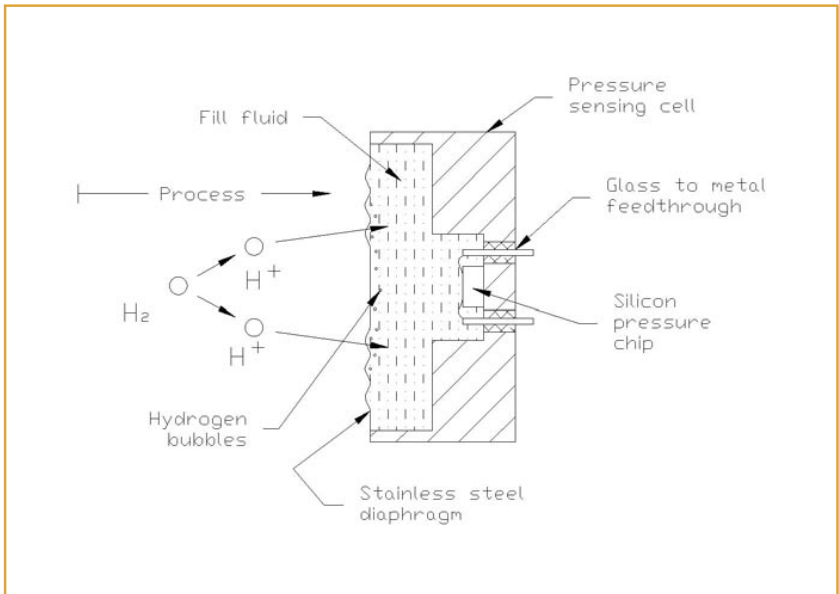
For hydrogen applications, AST pressure transducers employ wetted parts made from 316 L stainless steel, which promote long life and resistance to media corrosion. This high strength stainless steel construction also promotes good over-range and burst protection.

The Company also utilizes its own-patented Krystal Bond™ Technology to further enhance sensor performance by reducing long-term drift to just 0.25% per year, which is much tighter than epoxy-based strain gauge systems. Krystal Bond Technology utilizes an inorganic bond, free from glue line failure and outgassings, as typically found in organic-based systems.

Krystal Bond Technology also provides for a high electrical isolation up to 1000V, a high degree of compensation and the ability to adhere to different diaphragm material, which allows a wide range of media to be easily handled.

While any AST pressure transducer can be constructed with properties that make it suitable for use in hydrogen applications, the company features three pressure family, each employing three one-piece thick diaphragm 316L diaphragms, that address specific performance specifications, installations and cost parameters. These include:

- The AST 4000 offers a variety of connections for flexibility in mechanical and electrical interfaces. Within the AST 4000 family is the low cost Model AST 4100 for use in confined spaces as well as panel-mountable Model AST4200 pressure sensor.
- AST4300 offers high accuracy of  $< \pm 0.25\%$  BFSL at 25°C (77° F) and is approved to UL 1604 (CSA 213), Class1 Div. 2, Groups A, B, C and D for use in hazardous location areas.
- AST Explosionproof 4600 Series is approved to CSA 30 (UL 1203) Class 1, Div. 1, Explosionproof, Groups A, B, C and D, and can withstand the high vibration and temperature extremes. **FPJ**



**TOP:** AST4600 Series Explosionproof Pressure Sensors are CSA-approved to withstand high vibration and temperature extremes, as well as exposure to hydrogen.

**ABOVE:** Diagram One: Typical oil-filled pressure sensors and transducers employ thin isolation diaphragms that are prone to hydrogen permeation.

**LEFT:** Diagram Two: This cross-sectional of a typical AST pressure sensor highlights its one-piece thick diaphragm design that keeps hazardous media from penetrating the sensor diaphragm.

For more information on American Sensor Technologies, please visit their web site at [www.astensors.com](http://www.astensors.com).