Article by:
Michael Thomas
Senior Product Leader - Druck

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Design considerations for choosing a hydrogen pressure sensor

What is a hydrogen pressure sensor and what is its primary function?

- Pressure is a vital parameter in hydrogen systems for safety, efficiency and compliance.

Simply put pressure sensors convert the application of a pressurised media into an electrical signal enabling the pressure value to be measured. Pressure sensors perform critical functions within the hydrogen industry to measure pressure readings across a range of applications, from electrolysis to filling stations. Pressure is a vital parameter in hydrogen systems for safety, efficiency and compliance.

What are they key components of the pressure sensor?

- The design of the pressure sensing element dictates the performance.

The outer casing is the first surface to interact with the installation environment and has to protect the sensor during use, transportation and set up. Using a sturdy, resistant material for outer casing is not a luxury, but a requirement. Druck's hydrogen rated pressure sensors are built using a 316L stainless-steel housing to provide longevity and protection from the elements even in a harsh environment.

The outer casing houses the pressure sensing element. The sensing component of a pressure sensor varies with the manufacturer's design; traditional technologies include thin film, bonded foil strain gauge or oil filled silicon strain gauge. The design of the pressure sensing element dictates the performance, including accuracy, stability and precision of the sensor. Each design has its merits but for the best stability and accuracy with minimal thermal effects oil-filled silicon strain gauge is the superior technology.

How does the pressure sensor work?

Oil filled silicon strain gauge pressure sensors consist of a silicon die sensing element mounted in an oil-filled metal housing and isolated from the media with a thin resilient metallic diaphragm. Pressure sensors convert the deflection of the sensing element due to the application of pressure into an electrical signal. This electrical signal is then processed either using analogue methods to give a voltage or current signal or using digital processing and provide an output in a recognised digital protocol.

What are the key performance criteria for the hydrogen pressure sensors?

- Maintaining performance over time requires a highly stable pressure sensor.

A pressure sensor for use in a hydrogen application needs to perform in harsh outdoor environments potentially with wild swings in temperature. The media is often at high pressure and the hydrogen media may contain significant levels of impurity. Maintaining performance over time requires a highly stable pressure sensor, providing long reliable service, without drifting or suffering embrittlement.

Hydrogen embrittlement is the degrading process of metals when exposed to hydrogen gas, causing them to weaken in structure, and result in collapse. The process of hydrogen embrittlement can go unnoticed until the point of failure, resulting in decreased operation efficiencies, and increased potential of catastrophic gas leaks, or dangerous explosions.

Another issue to consider is hydrogen permeation. Following physical and chemical absorption on a surface, hydrogen gas normally disassociates into hydrogen atoms and follows a steady-state diffusional transport though materials that supports a pressure difference. Over time, not only will the performance of sensor be affected if hydrogen permeates though the isolation diaphragm, but the diaphragm will also distend during a pressure drop due to formation of hydrogen gas bubbles.

Why are hydrogen pressure sensors important for the hydrogen industry?

With the global shift towards hydrogen as a viable energy vector, production, storing, transporting and utilising hydrogen in gaseous form requires careful management of the operating pressures. Increasing pressure in operations can increase efficiencies improving the viability of hydrogen as a fuel. This trend increases the burden on the instrumentation to provide accurate and reliable data to optimise processes and ensure safety in operation. Hydrogen capable pressure sensors, as with many industrial instrumentation applications, are a necessity for operators to invest in.

What safety measures should be considered when using a pressure sensor in the hydrogen environment?

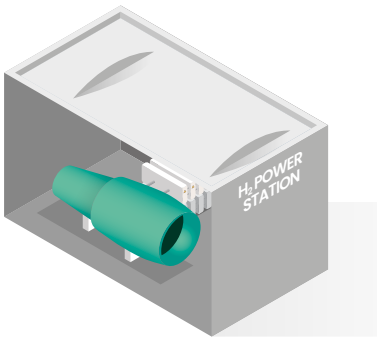
- Each hydrogen application demands different specific requirements are met for safe operations.

Clearly safe operation is a necessity as with any hazardous or flammable media, however clear and strict requirements are only apparent in some sectors of the hydrogen landscape. Each hydrogen application demands different specific requirements are met for safe operations. Certain key factors need to be considered in all applications.

Safe and reliable sealing on pressure connections, whilst some elastomeric seals are rated for hydrogen use, at high pressures it's safer to use proven metal-to-metal seal connectors.

Additionally, dependent on application, system designers need to consider if there is potentially a hazardous area, and the correctly certified product needs to be installed for the region. Hydrogen is classified as a Group C gas under the IECeX scheme (NFPA – Class I Div 1 or 2, Group B), however as hazardous area certification schemes vary by region, the correct scheme needs to be applied and product carrying the appropriate certification needs to be utilised.

System designers need to understand the pressure parameters, uncertainty factor, temperature, and accuracy requirement for the application. Carefully reading the product datasheet and understanding the true performance across the desired ranges must be the first step. Working with the pressure sensor supplier is also advised. Working with Druck as a partner in hydrogen will mean you have 50+ years of pressure expertise to aid you in choosing a hydrogen rated pressure sensor ideal for your application.



What different pressure sensing technologies are available on the market?

- There is significant demand for stable and reliable pressure sensors.

Over recent years, pressure sensors have been released and utilised for hydrogen pressure measurement applications. With increasing reports of inefficiencies and failures of existing pressure sensing solutions, there is significant demand for stable and reliable pressure sensors, designed for use in the hydrogen market. Solutions including thin-film technology, whilst initially seem to perform under hydrogen exposure, have tendencies for the metallic diaphragm to suffer embrittlement leading to drift. The impact of drift impacts the output of the pressure sensor. With reduced confidence in pressure readings, operators are at risk of reduced efficiencies and safety concerns.

When considering pressure sensors for hydrogen applications, it is wise to understand how the supplier has mitigated for the effects of hydrogen and if the product has been thoroughly tested prior to specification and use.

Why are the Druck hydrogen sensors superior?

The high-performance barrier coating and carefully selected substrate material used in the isolation diaphragm for the Druck hydrogen rated sensor products; the UNIK5000H and the RPS/DPS8000H minimises the impact of hydrogen permeation and extends the life of the pressure sensor, offering class leading long term stability and use in harsh applications.

- The UNIK5000H and the RPS/DPS8000H minimises the impact of hydrogen permeation.

The UNIK5000H builds on the existing, and widely trusted, UNIK5000 configurable pressure sensor to develop Hydrogen compatibility. Utilising the high-performance diaphragm barrier coating each UNIK5000H is a customisable pressure sensing solution, but with the short lead times and competitive pricing you would expect from standard products. The UNIK5000H is ideal for hydrogen-based applications including fuel cell testing, filling stations and pipelines.

In addition to the unique barrier coating substrate, the RPS/DPS8000H product line utilises Druck's resonant silicon technology, TERPS (Trench Etched Resonant Pressure Sensing) Technology, and the quality, reliability and flexibility of the market leading RPS/DPS8000 Series to offer a truly unique solution for high accuracy and high stability pressure measurement in a hydrogen rich media. The RPS/DPS8000H is designed to offer class leading performance in hydrogen-based applications including gas turbines, fuel cell tests and gas analysis equipment.

Hydrogen compatible pressure module

Druck only manufactures oil filled silicon strain gauge pressure modules using Druck hydrogen rated pressure sensors that are engineered with a high performance, barrier coated diaphragm, designed specifically for pressure sensing within the harsh hydrogen gas application. This promotes reliability and long-term usage in the hydrogen landscape.

All Druck hydrogen compatible sensors use 316L stainless steel wetted components which is universally accepted to provide the best resistance to hydrogen embrittlement. Giving customers peace of mind for many years of safe operation.

Druck DPS8000H

Druck UNIK5000H

Are there any challenges or considerations when using hydrogen pressure sensors?

- Before purchasing a pressure sensor, consider the most up-to-date live hydrogen standard.

When choosing a pressure sensor for a hydrogen application, close attention to the datasheet specification is required. Suppliers of pressure sensors often quote typical long-term drift specification in perfect conditions; in real usage the operator may see these exceeded by some margin. We have seen that the maximum drift specification of alternative hydrogen pressure sensors is quoted at lower temperature ranges; meaning that the "true" performance in a typical hydrogen application will be worse than expected.

Understanding the relevant hydrogen certification for the application is essential before purchasing a hydrogen pressure sensor. Existing pressure sensing options quote compliance to the automotive EC79 requirement; this has been made obsolete since 2022. The replacement UN ECE R134 specification must be met for the full system including pressure sensors used in the hydrogen automotive application. Before purchasing a pressure sensor, consider the most up-to-date live hydrogen standard.

Not all hydrogen pressure sensing applications have the same requirements; from pressure ranges to electrical outputs and connectors, the hydrogen pressure sensor requirements can differ. Consider choosing a reliable hydrogen rated pressure sensor that has configurable options available, whilst not compromising on performance or specifications.

The author of this paper is **Michael Thomas**. Michael is Senior Product Leader for industrial sensors at Druck, a Baker Hughes business with proven experience supporting customers across industries, including hydrogen, environmental monitoring and motorsport.

Please do not hesitate to contact Michael and our team of pressure experts if you have any inquiries or need additional assistance with your application.

For all enquiries please visit **Druck.com/Contact** or find out more at **Druck.com/Hydrogen**.