APPLICATION NOTE

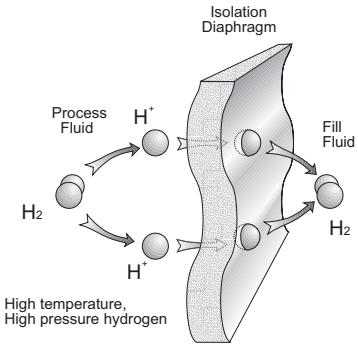
Hydrogen Permeation

INTRODUCTION

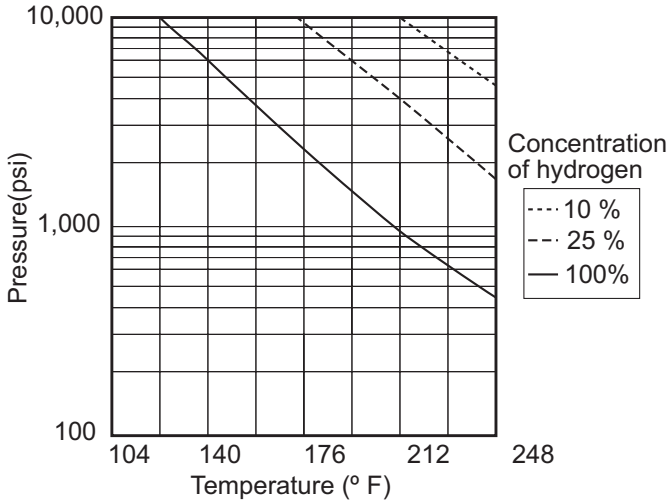
Hydrogen is the simplest and smallest atom element. Water, acids, bases, and the immense family of organic compounds all contain hydrogen. Even though hydrogen is not considered corrosive, it can cause problems with pressure transmitters if the application is not properly examined.

Hydrogen atoms can penetrate thin metal isolation diaphragms of a pressure transmitter and cause errors in measurement. A typical pressure transmitter diaphragm only measures 0.001 to 0.002 inches (0.025 to 0.050 mm) thick.

Hydrogen is normally found in a diatomic state, H_2 molecules, composed of two hydrogen atoms. In a diatomic state, molecules will not penetrate thin metal isolation diaphragms. However, if the hydrogen splits into hydrogen ions, two H^+ atoms, it can penetrate isolation diaphragms because H^+ ions are smaller than the space between molecules of the isolation diaphragm metal.

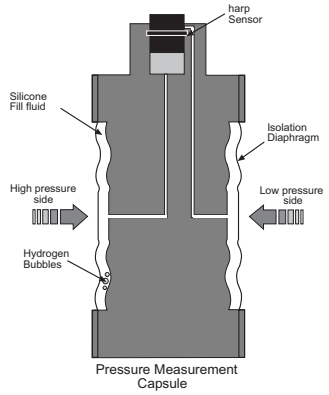


After passing through isolation diaphragms, H^+ ions can transform into H_2 molecules which become trapped inside the transmitter. Gradually H_2 will dissolve into the transmitter's silicone fill fluid and



over time silicone fill fluid will become saturated and a hydrogen bubble will appear.

Bubbles of hydrogen will cause zero and span shifts degrading performance of the transmitter. As hydrogen builds up, it causes outward expansion ("jiffy-pop") of the isolation diaphragms leading to cracks and transmitter failure through the loss of fill fluid.



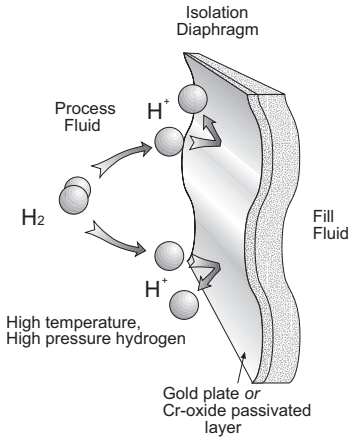
APPLICATION

Where to Watch for H_2 Permeation? Pure hydrogen applications are the obvious applications concerning hydrogen permeation. However, hydrogen permeation can occur in applications where hydrogen is not in its pure form. Hydrogen can randomly become dissociated from molecules into ions in many ways. Below are several different ways this can occur.

1. Changes can occur at high temperature or high pressures. In a pure hydrogen environment, hydrogen molecules collide with each other and bonds are broken.
2. A galvanic reaction will cause dissociation. Processes like sea water, a weak electrolyte, and Zinc-plated impulse piping will cause corrosion and generate hydrogen ions.
3. Steam at high temperatures can cause corrosion of metal diaphragms and hydrogen ions can be generated.

Diaphragm Protection
Diaphragm material will have an effect on the rate of permeation because molecular lattice space is different in each material. Historically, stainless steel has been the diaphragm material of choice.

In the past, nickel based metals, like Hastelloy C and Monel, were avoided and Tantalum was not even considered. Although expensive, the gold-plated stainless steel diaphragms were thought to offer the best protection because a thin layer (0.00012 inches (3 µm) thick) would virtually eliminate permeation.



New and Improved Offering
Yokogawa is introducing a new passive coating to the standard Hastelloy C diaphragms offered on DPharp transmitters. Passivated Hastelloy C diaphragms give a similar permeation rate to stainless steel, and outperform stainless steel due to better corrosion resistance leading to longer service life. For severe hydrogen service Yokogawa also offers gold-plating of Hastelloy C, refer to the / A1 model code option (see table 1).

Several factors should be taken into consideration when choosing between passivated Hastelloy C and gold-plated Hastelloy C. Potential transmitter down time and application experience are two critical factors. The following graph shows which hydrogen applications should be considered for gold-plated diaphragms.

The type of piping used will affect diaphragm selection. Appropriate diaphragm material can be selected from table 2.

SOLUTION

DPharp EJA series transmitters come standard with Hastelloy C diaphragms providing excellent corrosion resistant material at a similar price to stainless steel.

Yokogawa's new standardized passivated Hastelloy C diaphragm provides better corrosion resistance and permeation protection. The benefit of corrosion and permeation resistance allows a lower cost of ownership. Passivated Hastelloy C diaphragms are included on EJA110A and 130A differential pressure, EJA430A and 440A gauge pressure, EJA310A absolute pressure transmitters as standard.

Gold-plating is specified with a /A1 model code option. Refer to General Specifications for details of /A1 model code availability.

	Stainless Steel	Hastelloy C	Pass. Hastelloy C	Gold-plated
Corrosion Resistance	C	B	B	B
Permeation Resistance	B	D	B	A
Mechanical Strength	C	B	B	B
Cost	B	C	C	D

Best A>B>C>D Worst

Table 1

	Material of piping			
Process Fluid	Zinc -plate	Brass	Iron	SS
Pure water	❍	❍	❍	❍
Boiler feeding water	❍	❍	❍	❍
Tap water	❍	❍	❍	❍
Well water (without sea water)	Δ	❍	❍	❍
Water for Industrial use	Δ	Δ	❍	❍
Waste water (without sea water)	Δ	Δ	Δ	❍
Sea water	/A1	/A1	/A1	❍

❍: Passivated Hastelloy C Diaphragm can be used
/A1:Gold-plated Diaphragm recommended
Δ: Depends on conditions

Table 2