

Hydrogen Permeation

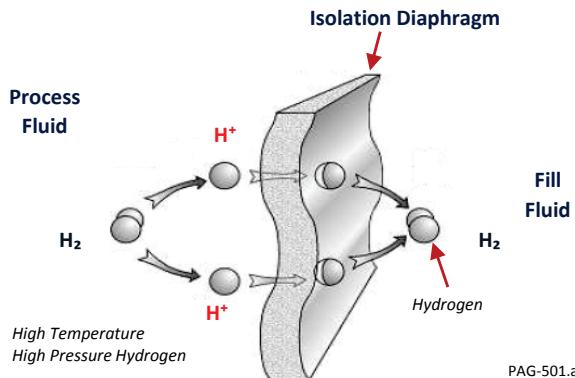
- Industry: Various
- Product: EJA-E Series and EJX-A Series Pressure Transmitters

• Introduction

Hydrogen is the simplest and smallest atomic element. Water, acids, bases, and the immense family of organic compounds all contain hydrogen. Even though hydrogen is not corrosive, it can cause problems for pressure transmitters through Hydrogen Permeation.

• Hydrogen Permeation

Hydrogen Permeation is the penetration of hydrogen ions through the thin metal isolation diaphragms of a pressure transmitter. Over time, this penetration will cause errors in measurement. Hydrogen is normally found in nature in a diatomic state (a H₂ molecule). In this diatomic state, hydrogen cannot penetrate the thin (0.002 inch to 0.003 inch thick) isolation diaphragms because the H₂ molecule does not have enough energy, due to its size, to push through the lattice structure of the metal isolation diaphragm. However, if the hydrogen molecule splits into two hydrogen ions (H⁺), then, due to its reduced size, the H⁺ ion can draw enough energy from the process to push its way through the metal lattice structure.



Once on the other side of the isolation diaphragm, the H⁺ ion will reform H₂ molecules with other H⁺ ions that have also passed through. The H₂ molecules become trapped inside the fill fluid of the transmitter because they are once again too large to pass back through the isolation diaphragm. Gradually, the H₂ molecules will dissolve into the fill fluid. Over time the fill fluid will become saturated and a hydrogen bubble will form.

This hydrogen bubble will cause zero and span shifts, degrading the performance of the pressure transmitter.

In extreme cases, the hydrogen bubble can build up enough volume to force the isolation diaphragm to expand outward causing cracking of the isolation diaphragm. This phenomenon is known as "Jiffy-Pop". These cracks will lead to leakage of the fill fluid into the process and the complete failure of the pressure transmitter.

• Examples of Problem Processes

A pure hydrogen service is an obvious application in which hydrogen permeation could be present. However, hydrogen permeation can occur where hydrogen is not in its pure form.

Example #1

In a pure hydrogen service, hydrogen permeation is caused by kinetic energy. When the process is at high temperature or at high pressure, hydrogen molecules collide with each other releasing kinetic energy. This kinetic energy breaks the bonds of the hydrogen molecules, yielding hydrogen ions.



Example #2

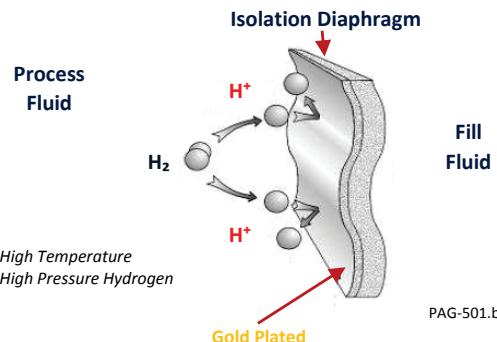
Hydrogen permeation can be caused by galvanic energy. Galvanic energy is an electrolytic reaction between two dissimilar metals. For example, processes with sea water (a weak electrolyte) and zinc-plated impulse piping will generate galvanic energy through corrosion. This galvanic energy breaks the bonds of the molecules containing hydrogen (in this case, water) yielding hydrogen ions.



• Industry Solutions

Picking the correct isolation diaphragm material can reduce the rate of hydrogen permeation. Historically, *stainless steel* has been the material of choice for general permeation protection. Although, nickel based materials like Hastelloy C-276 and Monel offer greater corrosion protection than stainless steel, they are avoided due to their "loose" lattice structure.

For critical applications, *gold-plated stainless steel* diaphragms yield the best resistance to permeation. The gold plating adds a very thin layer of gold. This thin layer has a very tight lattice structure.



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▪ Yokogawa Solutions

Yokogawa offers two solutions to improve the permeation resistance of our pressure transmitters.

- > Passivated Hastelloy C-276 diaphragm (*Yokogawa Exclusive*)
- > Gold-plated Diaphragm (*Industry Standard*)

> Passivated Hastelloy C-276 Diaphragm

On the Yokogawa, EJA-E Series and EJX-A series; we offer as our standard material a passivated Hastelloy C-276 diaphragm with the balance of the wetted parts being 316 stainless steel. The passivation adds a thin layer of CR-oxide to the diaphragm surface. This layer introduces a tighter lattice structure. This gives our Hastelloy C-276 diaphragm the equivalent permeation resistance as 316 Stainless Steel; but, it still retains the superior corrosion resistance of the Hastelloy. This combination of corrosion and permeation resistance leads to the Yokogawa transmitter having a much longer service life than our competitors units with stainless steel diaphragms.

The Passivated Hastelloy C-276 Diaphragm is available as Wetted Parts Material code "S" on all EJA-E and EJX-A series pressure transmitters. It is not available on those Yokogawa transmitters that have remote seals (EJA118E, EJA210E, EJA438E, EJX118A, EJX210A or EJX438A).

Refer to the General Specification sheet of the specific transmitter for complete details.

> Gold-plated Diaphragm

Yokogawa also offers the industry standard of gold-plating the transmitter diaphragm or the remote seal diaphragm. This option offers 5x the permeation resistance of the passivated Hastelloy diaphragm.

The Gold is plated to a thickness of 0.000118 inch.

For Yokogawa's transmitters with remote seals, the gold is plated on the fill fluid side of the remote seal diaphragm. This prevents the gold from being damaged during handling or installation.

For the standard transmitters, the gold is plated on the process side of the diaphragm. In this case, the gold is protected from damage during handling and installation by the cover flanges of the transmitter.

The Gold-plated diaphragm is available on all EJA-E and EJX-A series transmitters (including those with remote seals) as option code /A1.

Refer to the General Specification sheet of the specific transmitter for complete details.

▪ Conclusion

Identifying processes that will have hydrogen permeation problems is critical to ordering the correct wetted materials. The selection of suitable material is the responsibility of the customer.

Yokogawa offers two separate solutions for the issue; however, if the customer has any doubt, use the gold-plated diaphragm option.

General Guideline for Diaphragm Material Selection

Process Fluid	Piping Material			
	Zinc Plated	Brass	Iron	Stainless Steel
Pure Water	S	S	S	S
Boiler Feeding Water	S	S	S	S
Tap Water	S	S	S	S
Well Water (w/o Sea Water)	Δ	S	S	S
Water for Industrial Use	Δ	Δ	S	S
Waste Water (w/o Sea Water)	Δ	Δ	Δ	S
Sea Water	/A1	/A1	/A1	S

S Passivated Hastelloy C-276 can be used

/A1 Gold-plated Diaphragm recommended

Δ Depends on process conditions



Note: This is a general guideline for diaphragm material selection where hydrogen permeation may occur. Every application is different; therefore, material should be selected carefully to suit the individual application. The selection of suitable wetted material is the responsibility of the customer.

