

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.

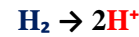
Hydrogen Permeation

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 state, hydrogen cannot penetrate the thin (0.001 inch to 0.002 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 this lattice structure.

permeation can occur in applications where hydrogen is not in its pure form.

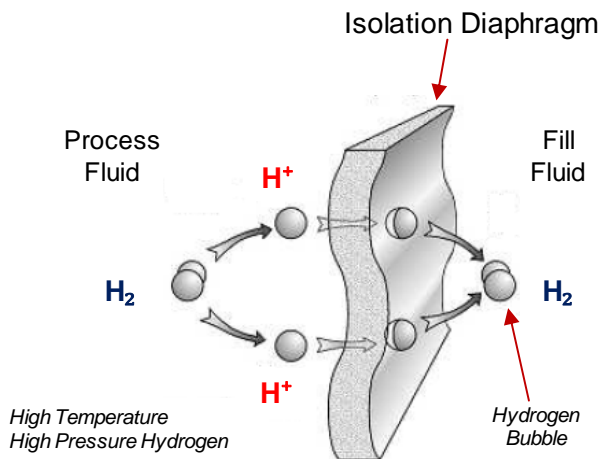
Example #1

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 example, water), yielding hydrogen ions.



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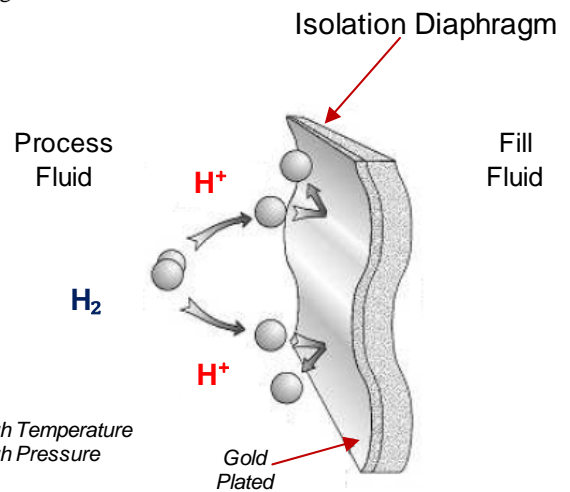
Once on the other side of the isolation diaphragm, the H⁺ ion will reform H₂ molecules with other H⁺ ions that have also passed through. The H₂ molecules become trapped inside the fill fluid of the transmitter because they are once again too large to pass back through the isolation diaphragm. Gradually,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

Solutions

Picking the correct isolation diaphragm material can reduce the rate of hydrogen permeation. The tighter the lattice structure of the material, the more resistance there is to 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 were 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 thin layer of very tight lattice structure to the stainless steel diaphragm. This is the tightest lattice structure a transmitter diaphragm can have.



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Examples of Problem Processes

A pure hydrogen service is an obvious application in which hydrogen permeation could be present. However, hydrogen

Yokogawa Solutions

Yokogawa offers several options to improve the corrosion and permeation resistance of our pressure transmitters.

Yokogawa Solution #1

EJA and EJX series pressure transmitters come *standard* the Hastelloy C-276 diaphragm with a Cr-oxide passivated layer.

("S" material code) This passivated layer adds a tight lattice structure to the diaphragm. The passivated Hastelloy C-276 gives similar permeation resistance as stainless steel; but, outperforms stainless steel due to its better corrosion resistance, yielding longer service life.

Yokogawa Solution #2

The permeation resistance of a gold-plated diaphragm is more than 5 times better than the permeation resistance of passivated Hastelloy C-276. The EJA and EJX series pressure transmitters offer gold-plated options on both the transmitter diaphragm and the remote seal diaphragms.

The transmitters offer gold-plated Hastelloy C-276 isolation diaphragms (Option code /A1). Since the diaphragm is internal and therefore protected from the potential of physical damage, the gold is plated onto the process side of the isolation diaphragm.

The remote seals offer gold-plated 316 Stainless Steel or gold-plated Hastelloy C-276. (Option code /A1) Since the remote seal isolation diaphragm is exposed, the gold is plated on the fill fluid side of the diaphragm.

Conclusion

Appropriate material selection of the transmitter's isolation diaphragms is the important key in protecting a transmitter from hydrogen permeation. *The selection of the material is the customer's responsibility.* If there is any doubt about the level of risk of hydrogen permeation in a process, select Yokogawa's Solution #2 (Gold-plated diaphragm).

	Isolation Diaphragm			
	Passivated Hastelloy C-276	Gold-Plated Hastelloy C-276	Gold-Plated 316 SST (Remote Seal)	Gold-Plated Hastelloy C-276 (Remote Seal)
EJA110A	✓	✓		
EJA118A			✓	✓
EJA130A	✓	✓		
EJA430A	✓	✓		
EJA438A			✓	✓
EJA310A	✓	✓		
EJA510A	✓	✓		
EJA530A	✓	✓		
EJX110A	✓	✓		
EJX118A			✓	✓
EJX130A	✓	✓		
EJX430A	✓	✓		
EJX438A			✓	✓
EJX310A	✓	✓		
EJX510A	✓	✓		
EJX530A	✓	✓		

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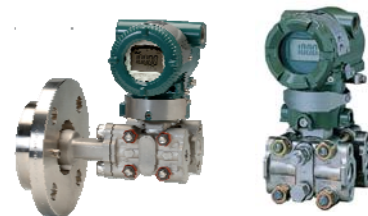
Process Fluid	Material Piping			
	Zinc-Plated	Brass	Iron	Stainless Steel
Pure Water	S	S	S	S
Boiler Feeding Water	S	S	S	S
Tap Water	S	S	S	S
Well Water (without Sea Water)	Δ	S	S	S
Water for Industrial Use	Δ	Δ	S	S
Waste Water (without Sea Water)	Δ	Δ	Δ	S
Sea Water	/A1	/A1	/A1	S

S: Passivated Hastelloy C-276 can be used

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Δ: Depends on process conditions

/A1: Gold-plated Diaphragm recommended



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