2020

Diaphragm seal Engineering

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Introduction

Diaphragm membrane material selection

Usually for Material selection of instruments our basis is Pipe material specs.

It is logical to assume that if our instrument sits on the pipe, we can blindly choose the material that pipe is made up of.

However!! This is not always the cases.

Before we dive into a story that highlights the importance of material selection of diaphragm membrane, let us understand the basics of corrosion allowance.

Basics of Corrosion Allowance

Corrosion Allowance:- In simple words, The extra thickness is added to pipe where corrosion or erosion can occur so that pipe's required thickness is not affected by corrosion.

Let's take a hypothetical Example:-

If a Pipe corrodes at a Rate of 0.02 inches per year you will provide corrosion allowance of maybe 0.5 inch.

That means if in one year the Pipe gets corroded 0.02 inches(0.02 inches per year) then in 25 Years it will get corroded up to 0.5 inches.

So if the pipe required is of 1 inch thickness we will specify 1.5 inches for the above example.(the 0.5 inches compensates for the corrosion during the pipe's lifetime)

A practical story

Now let's explore a project scenario which would make this concept simple to understand

Diaphragm seal material specified in a Diaphragm seal Datasheet was "**Duplex 2205"**

And the pipe material spec for that line stated Duplex 2205 but did NOT mention trim material.

So as the pipe material (Duplex) is compatible with the fluid so the Diaphragm seal material was also selected as Duplex 2205 by requisition engineer

Here's the catch !!!!

Piping guys have pipe with good thickness (also referred as schedule) so that it could compensate for corrosion but we don't have that provision in diaphragm seal.

Most metal diaphragm thickness are in the range of 0.002˝ or 0.004" and mostly upto 0.006" (inches) for design reasons.

And the pipe class had a **CORROSION & EROSION RATE of 0.03 inch/yr** this value looks insignificant but compare this to diaphragm seal's membrane thickness.

i.e in 6 months 0.015 inches would be corroded & eroded and in 3 month 0.0075 inches, so your diaphragm would last for up till maybe a month or more ONLY !!!! (depending on its thickness)

And imagine this, In one of Hydrocracker unit, the corrosion allowance was 0.125"/year so much that ½ inch pipe were not recommended

Imagine our SMALL INNOCENT DIAPHRAGM EXPOSED TO SUCH HARSH FLUID !!!

Conclusion :-

Usually the above being one of the governing factor why we use the **TRIM MATERIAL** mentioned in pipe spec for diaphragm seal application.

Also when the corrosion & erosion rate is very high like 0.125inches/year and above better to be safe and consult with material specialist that whether the trim material is sufficient for diaphragm seal or some other higher/extra thick exotic material must be specified !

Which has happened in few cases!!

so choose wisely!!

Note :-

Usually We encounter the pipe material as Carbon steel and we instrumentation engineer take stainless steel as diaphragm seal material which has high corrosion resistance Hence we are safe.

However when pipe is made of exotic material it is of paramount importance to be sure of the corrosion and erosion rate and thus select the trim material as our diaphragm seal membrane. Like the one highlighted above.

Gold Plating on Diaphragm Seal membrane

When do diaphragm seal membranes require Gold plating?

API RP 551 recommends for the following scenarios:-

1. For a transmitter with temperature ≥43 °C (110 °F) when any hydrogen is present.

2. Wet hydrogen service

3.With Pressure greater than 90 PSIA (5 BARG)

Why to go for gold plating of diaphragm seal?

This is due to phenomenon of Hydrogen permeation.

In simple words hydrogen is very miniscule in size, thus it tends to permeate through the Diaphragm seal membrane.

Hence hydrogen embrittlement weakens it and also enters the fill-fluid of diaphragm seal causing errors.

Why is this criteria of 5 Barg of Pressure ?

Hydrogen in environmental condition exists as H2 molecule, but at high pressure this bond breaks and high pressure causes them to temporarily split.

These small H+ atoms now being so minuscule in size, permeate through the diaphragm membrane.

Once they permeate through other side of the diaphragm seal there isn't such high pressure so these molecules combine and thus remain trapped inside the assembly.

Note:-There is no rule fix value of 5 BARG, Project have been executed with gold plating done for Hydrogen service above 6 BARG. Thus It also depends of client preference however of no guide is available it is recommended to stick to 5 BARG pressure limit.

Gold plating thickness?

As a rule of thumb 40μm thickness is preferred for Diaphragm seal membrane.

Thickness for gold coating of transmitter's membrane in hydrogen service (without diaphragm seal) is usually preferred as 25μm.

Note that there is "no fixed guide" to stick with a particular thickness, for Instance API 551 RP emphasizes more on the quality of coating than just the thickness, sometimes client design preference dictate the thickness of gold plating.(reference API 551 Section 3.6.6 page 16)

Base membrane material for Gold coating?

Stainless Steel is usually the least affected material and is the most preferred with regards to base material.

It is said that Hastelloy C276 material is not be used as base material for gold coating of diaphragm seal but unfortunately such a statement was not found in the few major standards of diaphragm seal like ASME B40 or API 551 RP etc.

Personally, there was a project done with a reputed vendor, Who did provide Gold plating on Hastelloy Base material.

But regardless, I would suggest if such a situation arises then it is advisable to consult with Material engineer before deriving to a conclusion.

API explicitly states that tantalum is very prone to Hydrogen embrittlement and recommends that it should not be used as base material.

Also beware that in worst case scenario if the Gold plating fails, the membrane material will come in contact with process hence it must be given due consideration that it is compatible with process.

Miscellaneous precautions

In a diaphragm seal assembly besides diaphragm membrane there are also other parts that come in contact with process (Wetted parts).Like Flushing ring, **Flushing Flange**, Plugs, Isolation valves, gaskets etc. Due care must be taken during their **selection** as well.

The most preferred choice of material for these wetted parts is stainless steel as it is one of the least affected material with regards to hydrogen embrittlement and is highly recommended in by API RP 511 as well.

Importance of Fill Fluid Section in diaphragm seal assembly

We presume that diaphragm seals provide complete isolation from process so the only wetted part to be needs to be considered for compatibility with process is diaphragm seal membrane.

Such an engineering judgment can lead to an catastrophic accident especially when dealing with hazardous and flammable substance like hydrocarbons or where the environment is highly explosive.

The diaphragm membrane seems invincible but due to **incorrect material selection** or improper understanding of corrosion rate and a variety of other factors, the diaphragm could get eroded/ corroded etc.

When such a scenario occurs the fill fluid inside diaphragm seal would instantly come in contact with the process fluid.

Hence the fill fluid inside diaphragm seal should be compatible with the process.

It is recommended that glycerin or silicone oil (which is a common choice for majority of our application) should not be used with strong oxidizing agents such as oxygen, chlorine, nitric acid or hydrogen-peroxide.

In the presence of such oxidizing agents, potential hazard could result from chemical reaction, ignition, or explosion.

Completely fluorinated or chlorinated fluids, or both, may be more suitable for such applications…….(Reference ASME B40.100-2013 (B40.2) Section 2.8.4)

Also for instance, fill fluids that use hydrocarbon compounds should not be used in oxygen or chlorine service…… (Reference API RP 551 Section

9.2.4 page 199).

For Seals to be used on pharmaceutical or food processing application care should be taken that in worst case scenario if the diaphragm membrane fails, the fill fluid should not contaminate the entire batch or product making it hazardous.

Various standards apply for pharmaceutical or food processing application and must be adhered to by instrument vendor.
Example:- 3A Sanitary standard ……..(ASME B40.100-2013 (B40.2) section 2.8.5)

Special fill fluids are available by vendor for such application like inert oil etc.

Also the fill fluid must be evaluated for it pressure, temperature compatibility.

Conclusively, The Fill fluid of diaphragm seal assembly must be give due importance that it deservers by checking its compatibility with process fluid, environmental conditions, compatibility with pressure and temperature of process.

Otherwise it would be a like a “Time bomb” waiting to react with process fluid or environment and cause significant harm to personal and equipment.

Differential pressure Transmitter installation in Full vacuum

Before we explore the reasons as to why should we follow such an installation.

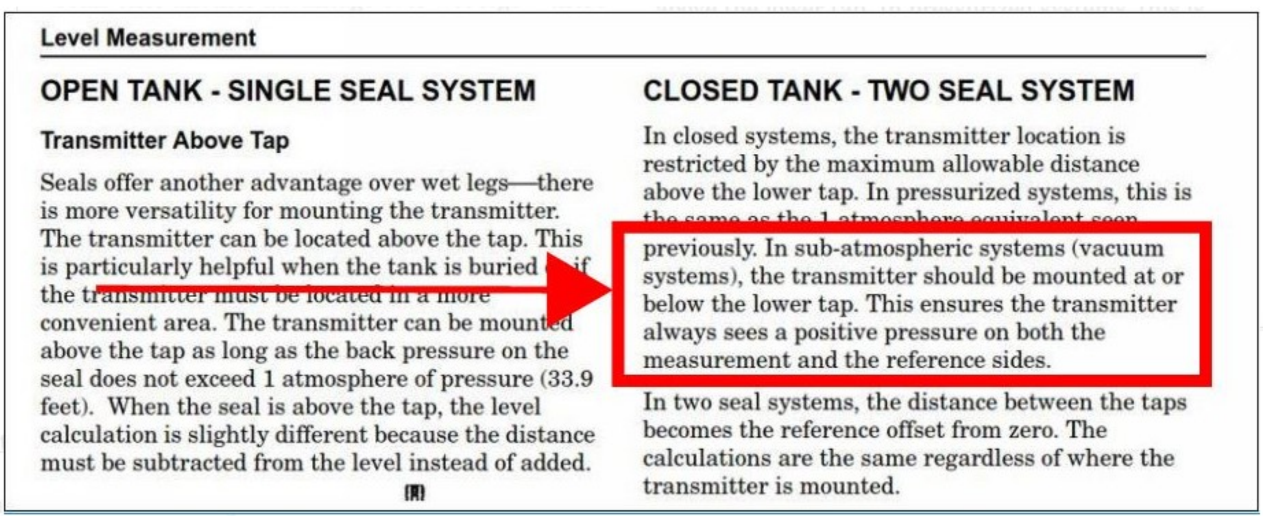
It's important to first provide proof to strengthen its importance and then we can explore the interesting part as to why should we go for such an installation.

The below recommendations are from some world renowned vendors for Full vacuum service.

1.**Vendor :- EMERSON**

Reference document :-
https://www.emerson.com/documents/automation/technical-data-sheet-level-measurement-pressure-rosemount-en-74346.pdf

Below is a extract from above document with regards to vacuum service.



Level Measurement

OPEN TANK - SINGLE SEAL SYSTEM

Transmitter Above Tap

Seals offer another advantage over wet legs—there is more versatility for mounting the transmitter. The transmitter can be located above the tap. This is particularly helpful when the tank is buried or if the transmitter must be located in a more convenient area. The transmitter can be mounted above the tap as long as the back pressure on the seal does not exceed 1 atmosphere of pressure (33.9 feet). When the seal is above the tap, the level calculation is slightly different because the distance must be subtracted from the level instead of added.

CLOSED TANK - TWO SEAL SYSTEM

In closed systems, the transmitter location is restricted by the maximum allowable distance above the lower tap. In pressurized systems, this is the same as the 1 atmosphere equivalent seen previously. In sub-atmospheric systems (vacuum systems), the transmitter should be mounted at or below the lower tap. This ensures the transmitter always sees a positive pressure on both the measurement and the reference sides.

In two seal systems, the distance between the taps becomes the reference offset from zero. The calculations are the same regardless of where the transmitter is mounted.

2.Vendor:- Badotherm

Reference document :-
http://www.badotherm.com/downloads.html

Below is a extract from above document with regards to vacuum service.

The presence of vacuum in process is a very important factor when selecting the Diaphragm Seal fill fluid and mounting the instrument. The relation between the vacuum value and the process temperature should be checked in the vapour pressure curves of the fill fluid to see if the fill fluid is suitable. When mounting the instrument for a vacuum application, the instrument should be placed below the (lowest) Diaphragm Seal to protect the instrument.

3.Vendor:- E&H

Reference document :- Deltabar S PMD75, FMD77, FMD78 catalog, Page 106

Below is a extract from above document with regards to vacuum service.

Mounting instructions

For applications under vacuum, Endress+Hauser recommends mounting the pressure transmitter below the lower diaphragm seal. This prevents a vacuum load of the diaphragm seal caused by the presence of filling oil in the capillaries.

4. Even Standards like **API 551** recommend mounting the transmitter 1 m (3 ft) or lower below the tap.(*Reference:-API 551 Section 9.2.6 page no 200*)

Now the best part, Why so?

As kids what was taught to us?

Water Boils at 100°C.Period!!

But this is not the case always the correct sentence should be “Water boils at 100°C at ATMOSPHERIC PRESSURE”

When we keep reducing the pressure reaching near absolute (full vacuum) the temperature at which liquid boils also decreases.

Water boils at 100°C at Atmospheric pressure but water would start to boils at even 0°C in Full Vacuum.

Similar cases is with the fill fluid like silicone in Diaphragm seal or transmitter.

Hence when we mount the transmitter below the lower tapping there is gravity’s head acting on the fill fluid in transmitter.

Thus even if the instrument is exposed to full vacuum due to gravity’s head the transmitter experiences some positive pressure and thus prevents the fill fluid from Boil and entering the vapor state and also prevent the capsule from seen Full vacuum (absolute zero).

The "Lazy" Diaphragm seal :-
Critical response time of Diaphragm seal assembly

The diaphragm seal must have a response time within PST of the process.

But what is PST (**Process Safety Time)**

IEC 61508:2010 defines **Process Safety Time** (**PST**) as “**Period of time”** between a failure, that has the potential to give rise to a hazardous event, occurring in the EUC [equipment under control] or EUC control system and the **time** by which action has to be completed in the EUC to prevent the hazardous event occurring”

Let us demystify the definition.

In simple words the PST of a given process is the fault-tolerant time of that process, prior to becoming a dangerous condition.

Within this PST the safety system has the opportunity to take necessary action.

Eg:-Closing a valve to prevent overfill or spillage in Tanks.

Why is PST important ?

Within This PST the safety system has the opportunity to take the necessary action to mitigate the hazard and prevent and accident.

Example :- Pressure transmitter senses very high pressure inside tower and opens the valve connected on the vent line to release the excess pressure.

Why is PST is a concern for diaphragm seal assembly ?

There is a delay between the time when diaphragm seal membrane senses pressure and when this is transmitter to the Transmitter.

A variety of factors that affect diaphragm seal response time are:-

1.Size of Flange

2.Capillary length and diameter of capillary tube

3.Fill fluid of diaphragm seal assembly

4.Process temperature and ambient temperature

5.Vacuum condition

Hence if your transmitter is responsible to detect safety critical issue (SIL Transmitter) and if the overall response time of transmitter and entire diaphragm seal assembly is greater that PST then accident is bound to occur.

Even if the issue is detected it will still be of very little use as the process has already reached a dangerous condition.

How to mitigate this issue ?

Evaluate the response time of your diaphragm seal assembly.

All major suppliers have their software that replicate the real time conditions and the response of their diaphragm seal assembly under these conditions.

Note that even though fill fluids having similar names like “Silicone oil”. They are divided into various grades and thus the vendors must be consulted for accurate response time and other characteristics for critical application.

Vendor calculation tools come handy to give a baseline idea whether the diaphragm seal system’s response time is within the PST or not.

A practical example.

Let’s us take case study of the Client SHELL and Vendor Badotherm.

Shell Pernis had been using diaphragm seal pressure transmitter for their safety function.

A typical situation is when temperature in reactor reaches 300-400°C and this point the fill fluid will boil because of low vapor pressure and on top of it the outside temperature is -20°C which would make the viscosity high.

In this situation it is difficult to ascertain what could be the response time of the system.(Incase the fluid is completely in vapor state then obviously an incorrect reading would be shown).

Hence badotherm came up with a tool **"Basecal"** to simulate conditions and assure the response of diaphragm seal system.

A whitepaper published by badotherm explains this concept in detail.

Here’s the link to it.
http://www.badotherm.com/downloads.html

When to check this response time?

This should be carried out for critical systems like Diaphragm seal connected to Safety systems with long capillary lengths or challenging environmental conditions.

Relation between NACE MR0103 & MR0175

When there is Sour Service we opt for NACE.

But what standard of NACE is applicable?

For us usually these are the two standards that we instrumentation department widely used in upstream and downstream sector.

1.NACE MR0175 is for Petroleum and natural gas industries — Materials for use in H2S-containing environments in oil and gas Production

In short this standard serves the UPSTREAM Oil and Gas sector

2.NACE MR0103 is for --Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments (In short Downstream)

In short this standard serves the DOWNSTREAM Oil and Gas sector

The Origin :-

Initially the was only NACE MR0175 standard only then gradually there was a need in the market to have a standard that specifically serves the need of downstream sector.

And thus a new standard was born. Named NACE MR0103 to especially serve the needs of the downstream industry.

Certain new thing like sulphide stress cracking were emphasized that especially trouble the downstream industry

Now the challenge:-

Vendor Catalogs sometime mention compliance to NACE MR0103 or NACE MR0175 only.

So when to accept what?

Overall when going through the difference between the 2 standards in Technical paper Number 04649 2004 NACE International, I have inferred the following:-

Case 1:-Requirement is of NACE MR0103 and vendor provides NACE MR0175

It seems that MR0175 has stringent requirements as compared to MR0103, and it is also somewhat apparent that offshore/upstream has harsher conditions.

So for non-critical factors like Paint system for relief valves if vendor states compliance to NACE MR0175 and we are doing a refinery project, we can accept it even if our requirement is MR0103.

For critical factors like material section it is recommended to discuss with a Corrosion specialist whether it could be accepted depending on your typical project conditions.

Example:-While I was doing a Refinery project for Orifice plate the vendor compiled to NACE MR0175 so after discussing with specialist we inferred that this can be accepted.

For critical parameters it is advised to accept only after consultation with a specialist.

Case 2:-Requirement is of NACE MR0175 and vendor provides NACE MR0103

This is a risky proposition to accept, since offshore/upstream environment generally has harsher conditions.

Here it advised to stick to our requirement of NACE MR0175 and not accept NACE MR0103.

Thanks for reading.

Hope its been of value to you.

PS: This is as per best of my current understanding

What is "Axial" and "radial" diaphragm seal connection?

The basics:-What is the difference between Axial and Radial movement mean?

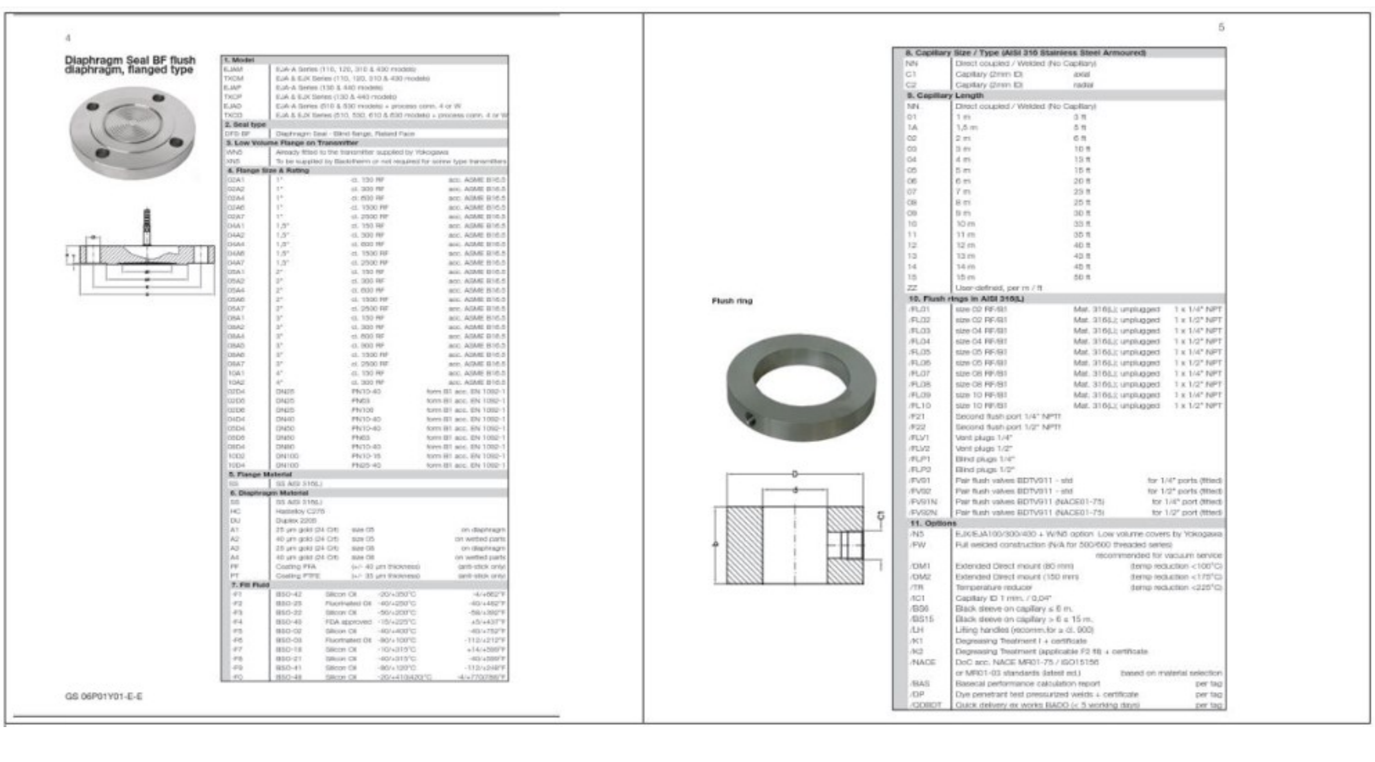
Axial movement
Imagine a circle an you are in the middle of the circle.
Now you start jumping, this is axial movement.

Radial movement
From the center of circle you move to the end of circle.
This is radial movement.
In other words movement along the radius of the circle is called radial movement.

A Practical example:-

Let’s take a case study of the vendor Badotherm

This vendor has a seperate model number code to choose whether we want an axial or radial entry.(Reference :- GS 06P01Y01-E-E 7th Edition)



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Diaphragm Seal BF flush diaphragm, flanged type

1. Model			
EJAM	EJA-A Series (110, 120, 310 & 430 models)		
TXCM	EJA & EJX Series (110, 120, 310 & 430 models)		
EJAP	EJA-A Series (130 & 440 models)		
TXCP	EJA & EJX Series (130 & 440 models)		
EJAD	EJA-A Series (510 & 530 models) + process conn. 4 or W		
TXCD	EJA & EJX Series (510, 530, 610 & 630 models) + process conn. 4 or W		
2. Seal type			
DFS-BF	Diaphragm Seal - Blind flange, Raised Face		
3. Low Volume Flange on Transmitter			
WN5	Already fitted to the transmitter supplied by Yokogawa		
XN5	To be supplied by Badotherm or not required for screw type transmitters		
4. Flange Size & Rating			
02A1	1"	cl. 150 RF	acc. ASME B16.5
02A2	1"	cl. 300 RF	acc. ASME B16.5
02A4	1"	cl. 600 RF	acc. ASME B16.5
02A6	1"	cl. 1500 RF	acc. ASME B16.5
02A7	1"	cl. 2500 RF	acc. ASME B16.5
04A1	1,5"	cl. 150 RF	acc. ASME B16.5
04A2	1,5"	cl. 300 RF	acc. ASME B16.5
04A4	1,5"	cl. 600 RF	acc. ASME B16.5
04A6	1,5"	cl. 1500 RF	acc. ASME B16.5
04A7	1,5"	cl. 2500 RF	acc. ASME B16.5
05A1	2"	cl. 150 RF	acc. ASME B16.5
05A2	2"	cl. 300 RF	acc. ASME B16.5
05A4	2"	cl. 600 RF	acc. ASME B16.5
05A6	2"	cl. 1500 RF	acc. ASME B16.5
05A7	2"	cl. 2500 RF	acc. ASME B16.5
08A1	3"	cl. 150 RF	acc. ASME B16.5
08A2	3"	cl. 300 RF	acc. ASME B16.5
08A4	3"	cl. 600 RF	acc. ASME B16.5
08A5	3"	cl. 900 RF	acc. ASME B16.5
08A6	3"	cl. 1500 RF	acc. ASME B16.5
08A7	3"	cl. 2500 RF	acc. ASME B16.5
10A1	4"	cl. 150 RF	acc. ASME B16.5
10A2	4"	cl. 300 RF	acc. ASME B16.5
02D4	DN25	PN10-40	form B1 acc. EN 1092-1
02D5	DN25	PN63	form B1 acc. EN 1092-1
02D6	DN25	PN100	form B1 acc. EN 1092-1
04D4	DN40	PN10-40	form B1 acc. EN 1092-1
05D4	DN50	PN10-40	form B1 acc. EN 1092-1
05D5	DN50	PN63	form B1 acc. EN 1092-1
08D4	DN80	PN10-40	form B1 acc. EN 1092-1
10D2	DN100	PN10-16	form B1 acc. EN 1092-1
10D4	DN100	PN25-40	form B1 acc. EN 1092-1

GS 06P01Y01-E-E

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Flush ring

8. Capillary Size / Type (AISI 316 Stainless Steel Armoured)			
NN	Direct coupled / Welded (No Capillary)		
C1	Capillary (2mm ID)	axial	
C2	Capillary (2mm ID)	radial	
9. Capillary Length			
NN	Direct coupled / Welded (No Capillary)		
01	1 m	3 ft	
1A	1,5 m	5 ft	
02	2 m	6 ft	
03	3 m	10 ft	
04	4 m	13 ft	
05	5 m	16 ft	
06	6 m	20 ft	
07	7 m	23 ft	
08	8 m	26 ft	
09	9 m	30 ft	
10	10 m	33 ft	
11	11 m	36 ft	
12	12 m	40 ft	
13	13 m	43 ft	
14	14 m	46 ft	
15	15 m	50 ft	
ZZ	User-defined, per m / ft		
10. Flush rings in AISI 316(L)			
/FL01	size 02 RF/B1	Mat. 316(L); unplugged	1 x 1/4" NPT
/FL02	size 02 RF/B1	Mat. 316(L); unplugged	1 x 1/2" NPT
/FL03	size 04 RF/B1	Mat. 316(L); unplugged	1 x 1/4" NPT
/FL04	size 04 RF/B1	Mat. 316(L); unplugged	1 x 1/2" NPT
/FL05	size 05 RF/B1	Mat. 316(L); unplugged	1 x 1/4" NPT
/FL06	size 05 RF/B1	Mat. 316(L); unplugged	1 x 1/2" NPT
/FL07	size 08 RF/B1	Mat. 316(L); unplugged	1 x 1/4" NPT
/FL08	size 08 RF/B1	Mat. 316(L); unplugged	1 x 1/2" NPT

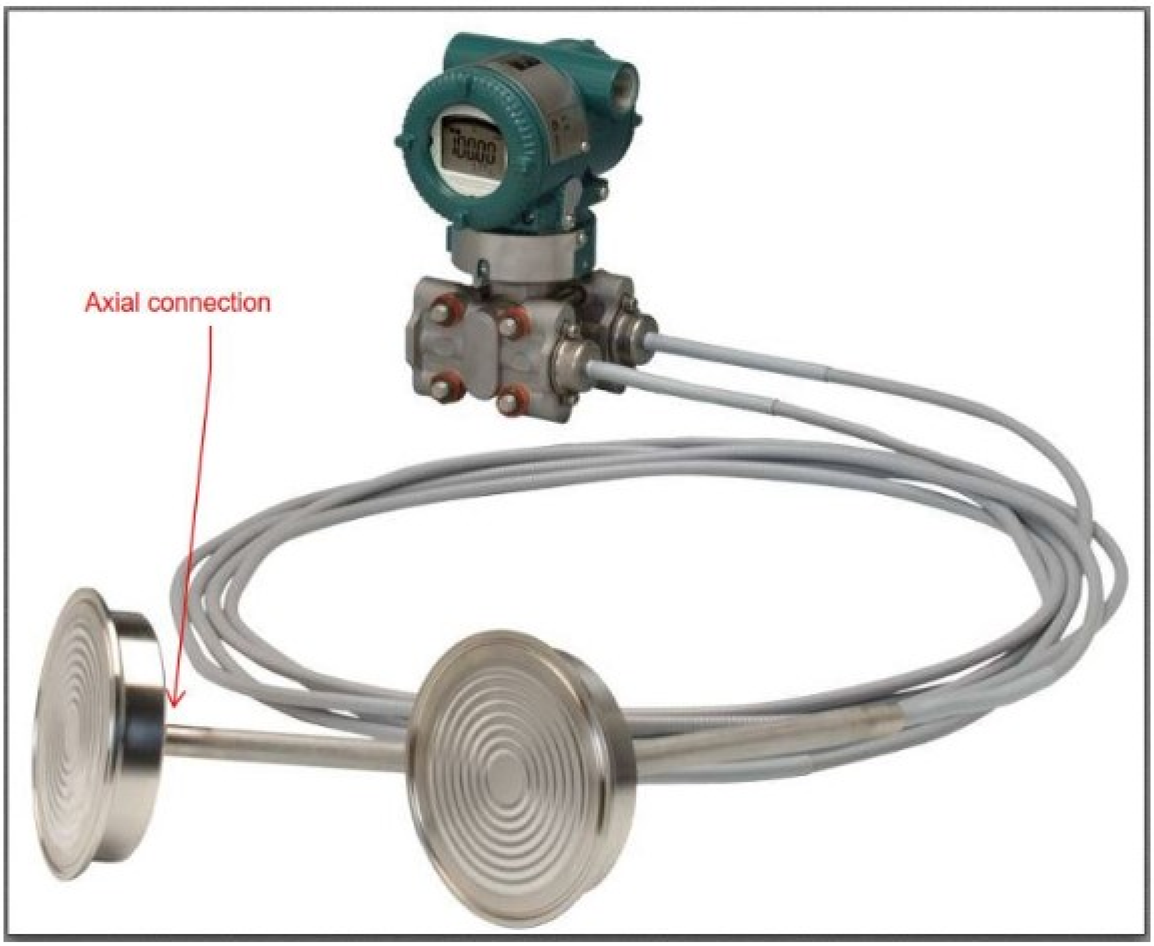
Model code C1/C2

8. Capillary Size / Type (AISI 316 Stainless Steel Armoured)		
NN	Direct coupled / Welded (No Capillary)	
C1	Capillary (2mm ID)	axial
C2	Capillary (2mm ID)	radial

<u>Note:- A majority of vendor by default provide Radial capillary entry.</u>

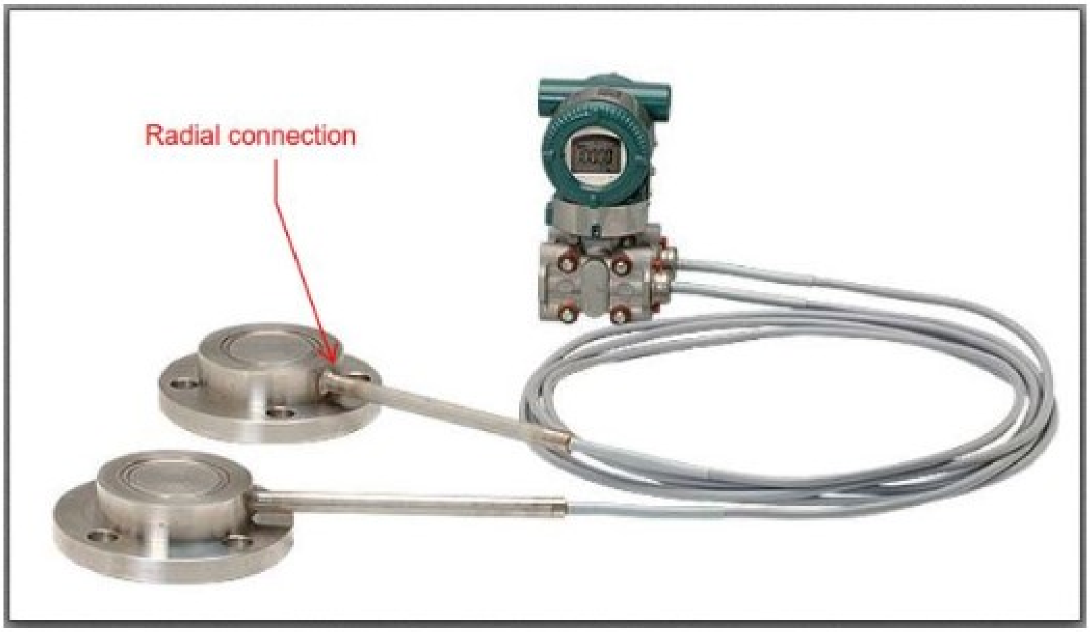
Now the difference can been seen from the picture below.

Axial Connection



Courtesy:-Yokogawa

Radial connection



Courtesy:-Yokogawa

How is this useful ?

Clearance space requirement

Axial diaphragm seal requires clearance space in the X-Y plane.

While the Radial diaphragm seal clearance space in the Y-Z plane.

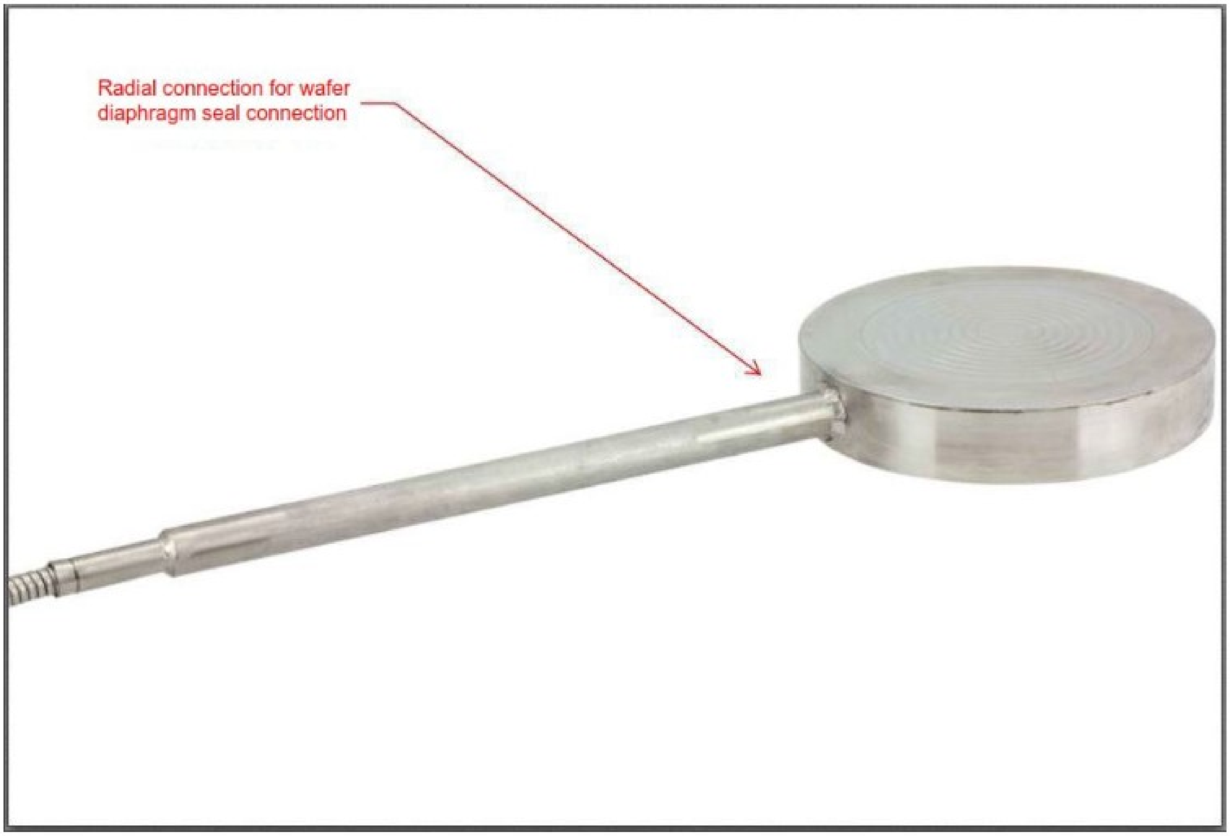
Also the capillary requires bending radius hence as per space consideration the appropriate connection must be selected.

Type of diaphragm seal

The type of diaphragm seal also dictates the connection type.

Example “Pancake” diaphragm seal requires a radial entry diaphragm seal.

Since a pancake diaphragm seal sits between two flanges axial entry is not feasible.



Wafer (Pan-cake) diaphragm seal connection

Thus depending on space consideration and type of diaphragm seal etc appropriate diaphragm seal connection must be used.

In conclusion the freedom of selecting radial and axial diaphragm seal connection depends on the available options with vendor, type of diaphragm seal (Pancake type supports only radial connection), Space considerations etc.

Thanks for reading.

Hope it been of value to you.

PS:This is as per best of my current understanding

Flushing flange and flushing ring are different

Introduction :- Flushing Flange/Ring is used after diaphragm seal to clean the diaphragm seal when viscous fluid could clog near diaphragm membrane. Some other words are calibration ring, flushing ring, drip ring etc

Flushing ring :-

It is like cumber that gets sandwiched between two bread slice .

It gets sandwiched between diaphragm seal flange and process flange

Refer the pic NO BOLTS GO THROUGH the ring !!!!

Flushing flange:-

It is also sits between diaphragm seal flange and process flange BUT the bolts go “through” the flange.

As the bolts can go through the flushing flange so there is better stability etc.

Obviously there is trade of between choosing flushing flange or flushing ring like cost, stability etc.

Or sometimes client design bases/preference dictates when to use flushing flange or ring.

Credits :- The flushing flange pic from Badotherm

Why Instrumentation Engineer must check flange rating?

Usually we copy the Piping department when it comes to flange rating but as always copying without understanding can lead to catastrophic safety hazard

Basics of flange rating:- Where do flange ratings come from?

Well this rating come from the following ASME standards *Note 1

1.ASME B16.5 (if pipe size is less than 24 inches)

2.ASME B16.47(if pipe size is greater than 24 inches)

Every material has a certain limit of pressure and temperature it can withstand so we have the Pressure Temperature tables in this standard

In simple words :-They describe at a particular rating how much Pressure and Temperature it can withstand.

The Higher the rating the more pressure & temperature the flange can withstand.

Enough of theory let's take a practical Example (Understanding How to practically use ASME B16.5)

Lets take a Carbon Steel (A106) flange with rating 300#

I derived from this standard that 300# carbon steel flange can withstand 37.6 Bar of pressure at 350 Deg C.

How to use this Standard ?

Refer a Snippet below from the Standard

Here’s the Catch !!!!

For same 300 Class of flange

The material stainless Steel (SS316L) can withstand 25.1 Bar of pressure at 350 Deg C.

Do you see the difference ?

For same class 300 flange at 350 Deg C, SS316L can only withstand 25.1 Bar while CS A105 can withstand 37.6 Bar !!!!!

But if you compare the corrosion resistance YES ! SS316L is more corrosion resistant than CS A105 as it has very low carbon content .

In one of my projects Hydrocracker unit which had High Pressure &Temperature majority of SS flanges did not fit in the PT rating hence higher Flange rating had to be used and the same had to be informed to piping that even they have to do the same !!
(So that both flanges are of same dimensions)

So be safe, keep you plant/Project Safe and always check PT ratings in ASME B16.5/16.47 !!!

I hope this article has been helpful

Note 1:- There is also DIN piping standard called 1092-1. In this the flange ratings are mentioned in PN rating. Like PN 10 etc

Certification:- CMTR VS PMI with a practical example

f Grade A in milkshake.

But in order to be sure that the milkshake vendor uses Grade A sugar and not the cheap sugar you do two things

STEP 1 :- You ask the Vendor to submit the Detail bill (like material certificate) of sugar purchased from wholesaler (D-MART etc) to ensure vendor has bought Grade A sugar .

Now :- When you receive 1000 tons of milkshake there could be a chance that vendor bought the Grade A sugar from D-MART but did not use it in you milkshake and used some cheap quality

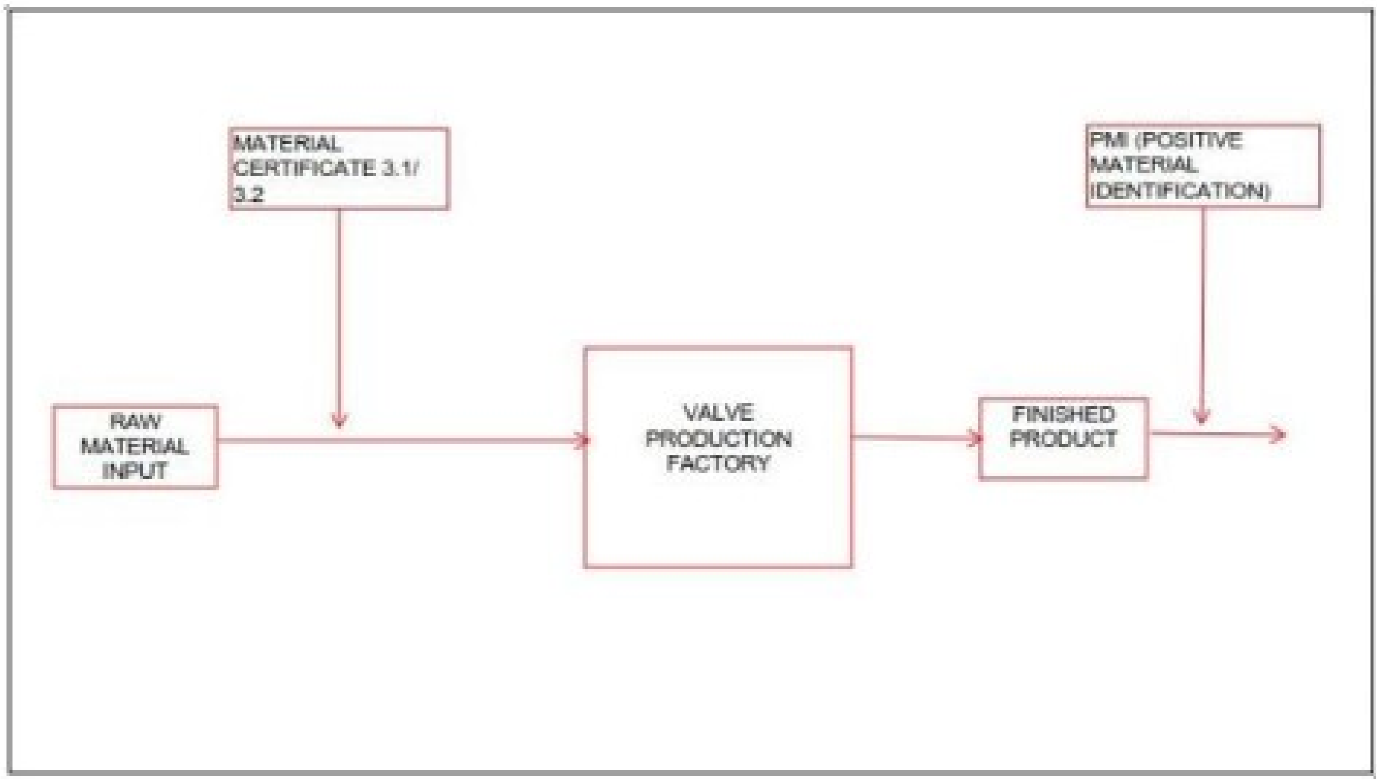
STEP 2 :- So you run a test (like PMI) in milkshake sample or entire lot to know whether grade A sugar was put in it or not .

Same is with PMI the PMI could be done on few tags or entire lot of tags (Also referred as 100% of Tags) or 10% of tags etc depending on criticality etc.
Example in one of my project for Bolts only 10% of the lot would undergo PMI was finalized and agreed by client so cost could be minimized .

Practical "Valve" example

Suppose we want 100 Valve's of Grade A so when the vendor buys the Material from the supplier the supplier produces a Certificate called material certificate 3.1 and after the Valve is manufactured to ensure that the same material is used and no mixing has taken place PMI test is done.

In Short Material certificate is for Material Quality of Raw material and PMI is for the finished product .



Material certificate is further divided

Material Certificate 3.1:- This in brief means :-This certificate given by the manufactures own representative who was not involved in manufacturing process himself

Material Certificate 3.2 :- Here a 3rd party (independent inspection authority) is involved which checks the material and the certificate is provided

Its is also sometimes referred as CMTR :- Certified Material test Report

Thanks for reading!!!

Credits :- Thanks a lot to Satish Sohani for explaining this concept to me !

PS: This is as per best of my understanding !

Interesting lesson :- "How Simple O-Ring caused NASA's shuttle to blast"

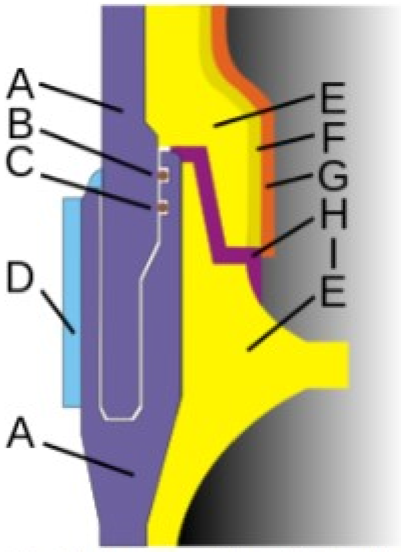
The "Technical" Story :-

Below you can see Violet Part which is the Steel wall

The Gray part is Fixed Propellant.

In simple words these make the shuttle motor

Now B is Primary O-Ring ,And C is Secondary O-Ring.



Simplified cross section of the joints between rocket segments SRB; outside to left.
Legend:
A – steel wall 0.5 inches (12.7 mm) thick
B – base O-ring gasket,
C – backup O-ring gasket,
D – Strengthening-Cover band,

These O-Ring form a seal and don't allow hot gases to come out. From that purple portion !

No alt text provided for this image

Interesting thing is for all previous launch this same construction worked but this time something different happened.

What always happened was called “Ballooning”.

In Simple words, At high temperatures (2,760 °C) , the metal parts of the casing bent away from each other, opening a gap through which hot gases—above 2,760 °C leaked

This happen for all rocket launch So why didn’t other rockets blast ???

This had occurred in previous launches, but each time this happened, The primary O-ring had shifted out of its groove and formed a seal.

Although the SRB (the above picture) was not designed to function this way, it appeared to work well enough, and Morton-Thiokol (The contractor) changed the design specs to accommodate this process, known as extrusion.

Everything went good for many launchs then ………………….One Fine Day was the launch of NASA's Challenger.

What happened this time was after 17 sec of launch the Space shuttle exploded and it was into thousands of pieces, Like it didn't exist!!!!!

During this Launch a crucial factor was cold weather

The Night Before the launch, Temperature had dropped down to -8°C

The next morning Ice had accumulated and team of people cleared it .

Now there is something called as "Glass Transition temperature"

"Glass Transition temperature"

When an O-ring is cooled below its Tg (glass transition temperature), it loses its elasticity and becomes brittle.

Interesting Question is What happens when you are near Tg ?

When an O-ring is cooled near, but not beyond, its Tg, the cold O-ring, once compressed, will take longer than normal to return to its original shape.

And as we know O-rings (and all other seals) work by creating positive pressure against a surface thereby preventing leaks and This was famously demonstrated physics professor Richard Feynman, when he placed a small O-ring into ice-cold water, and subsequently showed its loss of flexibility before an investigative committee that this was the caused that at crucial need the O-ring could not seal at the right time !

Also Note the O-Ring used for Space shuttle is FKM Vitton.

This is a widely used O-ring in our Petroleum & chemical industry too !!!!

With Little more Engineering Knowledge we can save lives of people at plant and Billions of dollars!!!

So what are the Technical lessons we can learn ?

DON'T ONLY CHECK UPPER TEMPERATURE LIMIT.

We usually only check the Upper Temperature limit of O-Rings and Gaskets

Like for Example for PTFE the upper temperature is 260 °C.

But there is also the Lower temperature that must be checked .

This is sometimes called "Glass Transition temperature" or "Brittleness Temperature" or "Lower Temperature limit"

Below is a screen shot from ISO 23936-1:2009

Table 5 gives the characteristic properties of the unfilled polymers, together with the related standards.

Table 5 — Characteristic properties of selected unfilled polymers

Type	Property				
	Melting point (DSC) °C	Vicat B softening temperature (50 K/h) °C	Maximum operating temperature °C	Brittleness temperature °C	Impact strength at −30 °C (Charpy) MPa
	Standard				
	ISO 11357-1 to ISO 11357-6	ISO 306	—	ASTM D746	ISO 179-1
PPS	280	220	200	−50	No break
PEEK	335	259	250	−65	No break
PTFE	325	300	260	−200	No break
PAI	275	260	200	−65	No break

Yellow highlighted is “Brittleness Temperature” for PTFE

Yes PTFE has a very low Brittleness Temperature but not all materials !!

Also as we learn from this accident is don’t keep lingering around this glass transition temperature

when an O-ring is cooled near, but not beyond, its Tg, the cold O-ring, once compressed, will take longer than normal to return to its original shape.

CHEMICAL COMPATIBILITY

Few Examples of What must not be used for a particular service

Polyether-etherketones (PEEK)

Hydrogen sulfide can attack PEEK, specifically in the presence of amines and elemental sulfur and at high partial pressures and temperatures in the range of 200 °C

Limited chemical resistance exists also against halogenated hydrocarbons (O-Ring selection standard ISO 23936-1:2009 Page 10)

Now,My Personal Favorite the O-Ring used above in NASA’s Shuttle Motor FKM Vitton

FKM Vitton

This is an amazing O-ring material acceptable to many services but still there are few service where it is not compatible

FKM is not acceptable for Amines or hot water and steam ………..(API RP 551…..PAGE 15)

And STEAM is used in Majority of plants !!!

We cannot predict how a Elastomer will fail some swell, some dissolve, and some take a compression set.

Explosive Decompression (ED) can occur when an elastomer absorbs process vapor and the pressure is abruptly released.

A seal can become damaged as a result and will be unable to hold pressure afterwards

Polytetrafluoro-ethylene (PTFE)

The temperature limit is 260 °C. At this temperature, the mechanical properties are very poor due to creep. Stress corrosion cracking has not been observed with PTFE.

No media used in oil and gas production, including functional chemicals (detergents, surfactants, emulsifiers, demulsifies and corrosion inhibitors), have been reported to attack PTFE up to the temperature limit.

………………(O-Ring selection standard ISO 23936-1:2009 Page 11)

But Obviously the standard does not hold any responsibility of compatibility but it gives us a good guide line in selection.

Hence stay safe and refer Standards :-

1) ISO 23936, Non-metallic Elastomers for Oil and Gas Production

2) EN 682, Non-metallic Elastomers for Oil and Gas Production,

Also consult with manufacture in case you find something that needs further clarification !!!

Also, During initial start up of plant it is better to not start activity at extreme cold and hot temperatures!!

Thanks for Reading !!!

Hope this was helpful, Even if in a small way !

- Introduction

- **Diaphragm seal membrane selection with respect to corrosion allowance 1**
- **Gold plating of diaphragm seal 2**
- **Fill fluid precaution in diaphragm seal 3**
- **Gasket selection of diaphragm seal (NASA's accident case study) 4**
- **Flange selection of diaphragm seal 5**
- **Flushing ring or flushing flange 6**
- **PST concern in engineering diaphragm seal assembly 7**
- **Axial and radial diaphragm seal 8**
- **Vacuum condition installation (Included full vacuum condition) 9**
- **NACE requirement (since diaphragm seal are used in challenging environment) 10**
- ITP for diaphragm seal assembly **(PMI Vs CMTR Certificate difference) 11**
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- Fill fluid vaporization
- Design requirements (strut, cut-out, Cover against heat, axial radial bending radius clearance space)
- Diaphragm seal in Cryogenic applications ??(LATER REVISION 2)

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