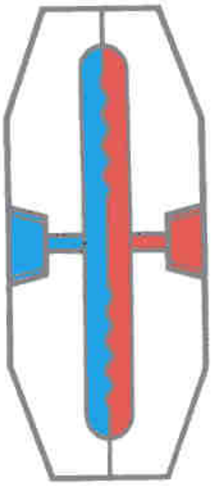
PRESSURE SOLUTIONS

P104: Chemical Seals

In P101, we discussed pressure measurement in general. We determined that the sensor design might need to be compatible with dirty, viscous, corrosive, hot or pulsating fluids.

Bourdon tube instruments are difficult to protect from corrosive, viscous or dirty fluids.

Even though diaphragm designs are more suited for design to meet these criteria, economics may mitigate in favour of a limited set of configurations.



The chemical seal, or diaphragm seal, in many cases, provides an answer. The chemical seal consists of a flexible diaphragm sandwiched between an instrument connection and a process connection. The space between the instrument and the diaphragm is solid-filled with a suitable liquid, usually inserted under vacuum. The reason for this is to exclude air, which will compress under pressure, providing a virtually incompressible fill, which will limit the displacement of the diaphragm to the elastic distortion of the instrument.

The diaphragm is usually corrugated, to increase its flexibility in the axial direction, and thus provide maximum displacement.

Because the diaphragm does not need good spring characteristics, the list of available materials is limited mainly by commercial availability. Being a diaphragm, open, un-blockable connections are possible.

A chemical seal would not be used solely for pulsation or temperature protection, but when required for other reasons, can provide those functions.

Corrosion Protection:
Corrosion attacks everything, but in some materials the rate of attack is very slow. Our diaphragms are typically 75µ (0,075mm) thick. This means that very little corrosion can be allowed. In the NACE handbook, the best category is "less than 50µ per year". That would give us about 18 months at worst.

Often, people will use pipeline material as a rule of thumb. If it's carried in a stainless steel pipeline, then stainless steel must be OK, right?
Maybe, but a pipeline can have a corrosion allowance built into the wall thickness, and a diaphragm can't.
We can use the pipeline material when choosing a process connection material, though, since we have plenty of meat available for a corrosion allowance.

It is difficult to get good corrosion figures, and we find the NACE handbook is best. It is not a total solution, because corrosion can be accelerated or inhibited by impurities, and in the main, the NACE book deals with relatively pure chemicals.

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Corrosion rates for a given material against a given corrosive, depend on both temperature and concentration. The universal rule for temperature is that more activity takes place at higher temperatures. The rule on concentration is not so clear. Usually higher concentrations corrode more, but not always. Sulphuric acid is a case in point, where dilute sulphuric acid is generally more corrosive than concentrated sulphuric acid.

The first thing to realise is that there is no universal material. We tend to realise that in atmospheric conditions, mild steel rusts, copper and brass tarnish, aluminium and stainless steel stay bright, and gold resists everything except aqua regia.

Now gold will dissolve in a cyanide solution, but steel won't.
Gold will dissolve in aqua regia but tantalum won't.
Tantalum will dissolve in caustic soda, but stainless steel won't.
Brass will dissolve in hydrogen peroxide but aluminium won't.
Plastics will dissolve in organic solvents but not inorganic acids.
The list is endless.

What about PTFE? PTFE and its fluorocarbon cousins have marvellous corrosion resistance, BUT they do have temperature limitations, AND they tend to creep under the effects of temperature and pressure, causing mechanical problems. In addition, PTFE is a sintered material rather than a plastic, and is slightly porous.

Stainless steel is the most common material used in corrosive applications, but is not universal. In any case, most instrument sensors are made from 316 stainless steel, so they don't need any help from a chemical seal to resist corrosion.

Al-metal seal designs are best mechanically. Plastics may be used with care at moderate temperatures and pressures. Use customer's input as a guideline, but do check it out against some other reference. Remember that customer's previous supplier might not have had the material choice to properly solve his problem. We have the widest choice on the market.

Note that because of our use of investment castings, we can produce virtually any material for the process connection. Our standard screwed connection materials are:

- 316 stainless steel, most often requested.
- Alloy 20: ideal for dilute sulphuric acid
- Aluminium Bronze: ideal for brine or dilute sulphuric acid
- Hastelloy B: ideal for hydrochloric acid
- Hastelloy C: Ideal for chlorine
- Monel: Ideal for HF

We usually carry the following diaphragm materials, shown in order of cost, but if the quantity permits, we can often obtain many other materials such as cupro-nickel, Hastelloy B2 etc.

- 316 Stainless steel for general purpose use.
- Titanium: ideal for organic acids and chlorine
- Hastelloy C: ideal for many oxidising acids
- Inconel 600: good on chlorides which attack 316ss
- Monel for some seawater and fluorine applications
- Silver for some difficult applications
- Tantalum, for most difficult applications

Blockage:
A bourdon tube pressure gauge has a long narrow inlet that is easily blocked. This problem can easily be solved by using a chemical seal. Even using a ½" screwed connection means that we can have a 15mm bore instead of the 3 – 5mm inlet common in screwed instrument connections. In the Blanes design, our usual active diaphragm diameter is 63mm, so we can make open flange connections with no restriction from DN50 upwards. The rule is, the dirtier or thicker the fluid, the larger the inlet. In extreme cases, we can make extended diaphragm designs which present a diaphragm flush with a tank or pipeline wall, with no deadspace which can block.
Inline designs are available which present a clear bore and thus no possibility of blockage.

Temperature:
Where a chemical seal is required by conditions above, temperature reduction can be achieved by using either a cooling tower, or a length of capillary.

Pulsation:
This can be reduced by using a restrictor or capillary, coupled with a more viscous filling oil.

Seal Designs:
There are various designs available, all with their strengths and weaknesses.

Plastic Design:
We do have an all-plastic design, not often used, for when weight is critical, and where temperatures and pressures are low, typically up to 1 000 kPa at 100ºC depending on materials used. This is a screw-together design with O-Ring seals, and is often used with small diameter or plastic cased gauges.

CW Range:
The compact welded range is an all-welded design, which can only be re-furbished by the factory. It is limited to screwed connections from ¼" up to ½". This design can only use metal components. This is our cheapest mainstream range.

SC Range:
This is our standard range. The main components are investment cast, allowing us great flexibility in materials, and making the use of exotic alloys affordable. This is a clamped design of great flexibility, allowing us to provide any process connection from ½" upwards, screwed or flanged, metal or plastic, with any combination of diaphragm and connection material. All metal versions use a metal-to-metal seal, eliminating soft seals and allowing temperatures up to 300ºC. Versions incorporating plastics use soft seals and are usually limited to 100ºC. It is rated to a maximum of 10 MPa. If there is a weakness, it is that fill is lost if the unit is completely dismantled, because the diaphragm is not welded to the top housing. However, there is a cleanout variant which overcomes this. This design is field-repairable.

LC Range:
This is a version of the SC Range using a 90mm diaphragm for low pressure or large displacement applications, usually flanged 80mm or larger.

HW Range:
This is the HP version of the standard range, which uses an instrument housing with a welded diaphragm protected by a diaphragm bed. Top and bottom parts are sealed with a PTFE joint ring, and held together with stainless steel cap screws. This design is rated to 60 MPa.

FW Range:
This range is used where a flush diaphragm is required. This range includes the standard hygienic designs, e.g. DIN 11851 as well as flanged designs. Many custom offerings are possible.

FWX Range:
This range incorporates an extended diaphragm for where tank nozzle blockage is a problem. These are custom built around 63, 74 or 90mm diaphragms, but other sizes are possible.

IL & Donut Range:
The In-line design provides unimpeded through-flow where blockage is likely in a pipeline, as with thick slurries. These custom-built designs use an abrasion resistant liner as an isolating barrier. These require dismantling of the pipeline to remove, with the attendant requirement to have a replacement available, so SC designs are always preferred where there is a reasonable chance they will work. These in-line designs usually incorporate an adhesive-secured liner.

Pneumatic Seal:
We have a special design using air as the transmission medium. There are applications where the measuring point is too far above the tapping point for conventional oil-filled capillary seals. This is limited to low-pressure ambient-temperature applications.