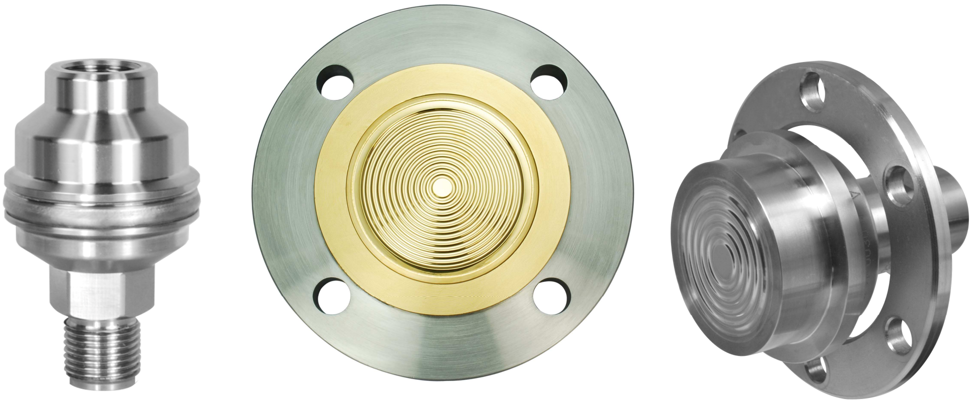
GENERAL INFORMATION ABOUT DIAPHRAGM SEALS



INTRODUCTION

Modern chemical processing and process manufacturing procedures demand ever greater accuracy and reliability from their pressure measuring instruments. In order to minimise costs, both reject levels and production downtime must be kept to an absolute minimum. In some applications where there are chemical or hygiene considerations, it is necessary to isolate the pressure measuring instrument usually a gauge or a transmitter from the process medium.

This isolation is achieved by using a pressure-sensitive diaphragm made from a material resistant to the process medium enclosed in a system fitted to the base of the instrument. The space between the diaphragm and the measuring element in the instrument has to be evacuated under a vacuum and filled with a suitable fill fluid and sealed. The process pressure exerts a force on the outside face of the diaphragm. As the diaphragm flexes under this force it pushes inwards and attempts to compress the fill fluid within the instrument.

This fill fluid is designed to withstand compression so that the movement is channelled directly into the measuring element producing a resultant reading on the gauge.

The entire operation of the diaphragm seal system is based on Pascal's Principle which states that a pressure exerted on a fluid is transmitted undiminished through that fluid and in every direction.

For this process to work the displacement force of the diaphragm must exceed the force required to move the measuring element in the instrument itself. In practice this means that the smaller the force required to move the measuring element the easier it is to construct an accurate seal system.

APPLICATION

Knowing in which situations to install a diaphragm seal rather than a standard instrument is critical to maintaining the integrity of the process. A diaphragm is usually required under the following circumstances.

- The process medium is corrosive, and would chemically attack the working parts of a standard pressure gauge or transmitter.
- The process medium is viscous or contains solid particles, either of which could result in the gauge's pressure inlet becoming blocked and preventing any pressure from reaching the measuring element.
- The process medium is prone to solidifying over time (e.g. it may freeze as the temperature drops, or it may set as it dries, or it may be subject to polymerization), in which case a standard gauge's internal moving parts could be rendered immobile.
- The process medium is so corrosive that even pressure elements made from exotic materials such as Monel or Hastelloy do not provide adequate protection. The only solution is to apply a special coating to the base material to prevent corrosion. Application of these special coatings to the internal movement of a standard pressure gauge or transmitter would be impossible, but a diaphragm seal fits the bill perfectly.
- It is important to eliminate the formation of bacteria on or in the process connection in applications where hygiene is of paramount importance such as in the food and beverage industries.

POTENTIAL PROBLEMS WHEN SELECTING A DIAPHRAGM SEAL

Avoiding common mistakes will improve your chances of successfully selecting and installing a diaphragm seal.

- Diaphragm displacement is incompatible with the required displacement volume of the instrument's measuring element. The diaphragm is too small or too stiff to allow for natural thermal expansion of the fill fluid, leading to zero shifts and false pressure readings.
- The process or ambient temperatures exceed the acceptable service range of the fill fluid.
- In differential pressure applications, very small differential readings may not be possible owing to the amount of force required to drive the diaphragm and the measuring element.
- Also in differential pressure applications, if a system has grossly imbalanced volumes on either side of the instrument this may lead to unacceptable zero shifting owing to thermal expansion or contraction.
- The fill fluid inertia (static head pressure) is greater than the force required to move the measuring element.
- The length and internal diameter of capillary in combination with the fill fluid viscosity create resistance, driving up system response time to unacceptable levels.
- The process temperature can influence the ambient temperature close to the process. If the instrument is positioned too close to the process this may lead to unacceptable reading errors.
- Care should be taken when specifying a seal system for measuring a vacuum or high vacuum pressure. While they perform normally for most standard vacuum applications, as the pressure moves closer to a perfect vacuum, acceptable accuracy levels become more difficult to achieve. This is due to the fact that most fill fluids contain microscopic amounts of air or trapped gases, which tend to expand significantly as a pressure of absolute zero is reached.

FUNCTIONAL CHARACTERISTICS

Accuracy: at 20°C ±0,5% … 1% according to the chemical seal . Those values must be added to the accuracy class of the indicating instrument. The accuracy of vacuum however cannot be guaranteed beyond -0,85 bar in the standard executions. This is due to the fact that most filling fluids contain microscopic amounts of air or trapped gases, which tend to expand significantly as a pressure of absolute zero is approached. This expansion effects the measuring element in the instrument.

Process fluid temperature: minimum -80°C, max +399°C, according to the type of filling fluid used and of the material of diaphragm and of the process connection.

DIAPHRAGM MATERIAL

The diaphragm is an elastic measuring element. It can be manufactured out of different materials, and if required it can be provided with various protection foils or coatings so that a suitable version can be supplied for almost any kind of medium.

DIAPHRAGM TIGHTNESS

After the diaphragm is welded to the chemical seal we conduct a helium leak test to ensure there are no microscopic holes. We later repeat this process on the complete sealed system

SURFACE QUALITY

The surface quality of the diaphragm and wetted parts is very important for the efficiency of CIP (Cleaning in place) processes. Scratches, dead spots, microscopic pinholes should be avoided in order to prevent contamination by undesirable substances such as product residues, micro organisms and cleaning and disinfecting residues. Typically a good surface clean ability can be achieved with an average roughness value or Ra $\leq$ 0.8µm for smooth surfaces and Ra $\leq$ 1.6µm near welds. No improvement in cleaning ability can be expected below Ra $\leq$ 0.4µm.

INFLUENCE OF TEMPERATURE

The complete pressure sensing system, made with the diaphragm seal (with or without capillary) and the pressure instrument, is filled with a fill fluid at a specific temperature (generally +20 ±2°C) called reference temperature. A increase or decrease in ambient temperature or of the process fluid make a proportional variation on the fill fluid volume. Consequently this has an effect on the internal pressure of the closed sensing system and adds an error of zero on the instrument. To minimize such error, it is necessary to compensate for the volume variation caused by temperature. Low diameter diaphragms may compensate only a small variation of volume (see fig. 1). It is suggested to use, accordingly with the process conditions, chemical seals with diaphragms of the biggest possible diameter. Furthermore when the process temperature exceeds +150°C but lower than 250°C, it is necessary to install the instrument with a cooling tower to avoid the effects of the thermal transmission between diaphragm seal and instrument. Above 250°C a capillary line should be used. The device has been engineered to protect the instrument from high process temperatures. So it reduces the temperature inside the instrument to a value close to the ambient temperature value.

The fill fluid used is very important for the temperature application range of the chemical seal. The minimum and maximum temperatures of the process medium and environment must be considered when choosing. Additionally the fill fluid must be compatible with the medium especially for media such as oxygen or for applications in the food industry. This is very important in case the diaphragm is ruptured e.g. via particles in the medium and as a result the fill fluid is able to drip from the rupture into the medium.

Max. Cleaning Temperature CIP/SIP

+150 °C (+302 °F). For the complete pressure measuring system consisting of a pressure gauge (100mm dial) and chemical seal fitted and filled with Food / Sanitary fill fluid.

Liquid type	Min / Max Operating temperature
Low Temperature	-45 / +160°C
High Temperature	-40 / +399°C
High Temperature / Vacuum	-10 / +315°C
Oxygen service	-45 / +250°C
Food / Sanitary FDA	-40 / +150°C

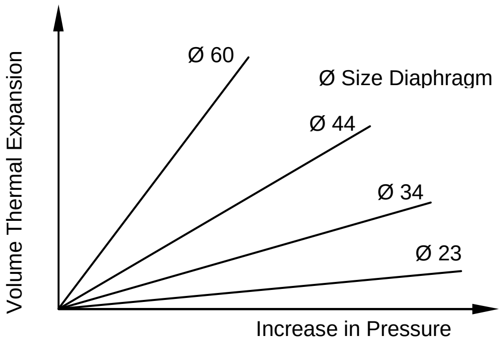


Fig.1

In summary temperature influences can be minimised by:

- Using a suitable fill fluid
- Diaphragm diameter as big as possible
- Volume inside the instrument as small as possible
- Keeping the instrument apart from the temperature effects by means of a cooling tower or capillary between the seal and pressure measuring instrument.

INSTRUMENTS WITH CAPILLARY

The use of the capillary allows the reading of the instrument from remote and limits the effects of the process temperature (above 250°C) on the accuracy of the instrument. A capillary length of 500mm is normally enough the keep the temperature of the instrument close to the ambient temperature value.

The length of the capillary must be as short as possible, and is advised not to exceed 6 meters because the temperature variation on the capillary length may influence the accuracy and response time (see Fig. 2).

Pressure instruments with a capillary require them to be suitable for a wall or panel mount. The difference of height (see fig.3) between pressure instrument and the diaphragm seal (Fig.3) adds an increase of the total error due to the hydrostatic effects on the fill fluid within the sensing element and consequently influences the pressure reading on the instrument. Often referred to as head pressure. If such difference is known, it must be highlighted on the order. Otherwise instrument zeroing on the spot is required.

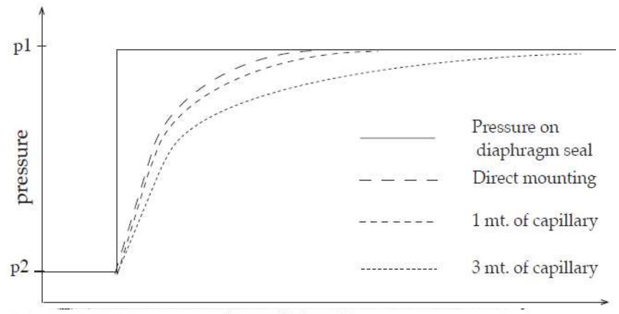


Fig.2

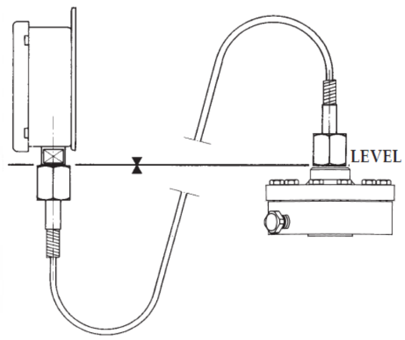


Fig.3

DIAPHRAGM SEALS FITTED TO MANUFACTURER'S INSTRUMENTS

Diaphragm seals can be fitted to most models from our ranges of gauges, transmitters, or pressure switches depending on the nature of your process context. We can also develop custom seals for unique applications and attach our diaphragm seals to other manufacturer's pressure measuring instruments**.**