Isolation seals protect transmitters while faithfully conveying pressure signals. They enhance the measurement of not only pressure and vacuum, but also of derived variables, including flowrate, level and density. Because of their measurement flexibility, electronic differential pressure (DP) transmitters are widespread throughout industrial and municipal processes.

Although the typical DP transmitter has a metallic isolation diaphragm to help protect it from exposure to the media being measured, many difficult applications make this protection ineffective. In such cases, the measuring system must include some way to keep the measured fluid from directly contacting the transmitter, while nevertheless responding quickly and accurately to changes in the measured variable.

**Isolation seals**

One practical method of protecting the transmitter from the process fluid is the use of isolation seals - also known as chemical seals and remote seals, Figure 1. Remote seals permit the transmitter to be located up to 80 feet from the point of measurement.

An isolation seal has two main components:

- a flexible seal diaphragm that is exposed to the measured fluid and reflects its pressure
- a liquid-filled capillary. The capillary connects to the transmitter body and its liquid hydraulically transmits the pressure to one of the two primary diaphragms in the transmitter.

Depending upon the measured variable, the connection is to either the “High” or “Low” pressure side of the DP pressure transmitter. Flow measurement, for example, requires two separate seal systems, each connected to one of the DP transmitter’s inlets.

An important construction feature of a sealed system is that it prevent in-leakage of air or other ambient gases. This is especially vital for operation under vacuum conditions, which magnify the effects of even a tiny air or gas bubble. The use of all-welded construction at key points helps to assure reliable performance over a wide range of temperatures and absolute pressures.

Instead of being remote, the seal system can be close-coupled to the transmitter, Figure 2. When feasible, close coupling has the advantage of being especially responsive to pressure changes and less subject to effects of ambient temperature changes.

**Why use an isolation seal?**

Applications suggesting the use of isolating seals include:

- The process fluid is highly corrosive. Seal diaphragms come in a wider choice of corrosion-resistant materials than do the isolating diaphragms of ordinary transmitters.
The measured fluid contains particulates or is viscous, so as to foul the impulse lines leading to the transmitter in a conventional installation.

- The process fluid exceeds the maximum recommended temperature for the transmitter.
- The measured liquid can solidify in impulse lines and the transmitter body.
- The transmitter must be located away from the process to be more accessible for maintenance.
- The measured fluid is too hazardous to allow conventional field calibration and service at the point of measurement.
- An interface-level or density measurement is involved. These applications require a signal-transfer fluid of equal and constant specific gravity on both the Low and High connections to the transmitter body.

**Capillary fluid and diameter**

The choice of fill fluid for a seal system can affect the safety of certain processes, as well as the accuracy and response time of the measurement. What’s more, if a fault condition causes the fill fluid to leak, a poorly chosen fluid could affect the quality of the process stream being measured.

Four considerations apply when choosing the fill fluid:

1. **Temperature**—The operating-temperature ranges for a fill fluid depend on the measured pressure. A given grade of silicone oil, for example, can operate at -130 to +176°F under vacuum conditions, but instead at -130 to +356°F when the pressure is above 15 psia. A fluid exposed to temperatures outside its recommended range may solidify or vaporize. The effect of temperature on performance can be markedly lessened by sealing the system under full vacuum, minimizing the presence of entrained air or other gases. The thermal expansion of air is 1,000 times greater than that of a typical silicone fill fluid; thus, an air bubble of only 0.032-inch diameter can cause, in terms of pressure, a system error greater than 1 inch of water per 100°F.

2. **Expansion coefficient**—The various fill fluids in use have different coefficients of thermal expansion. Wide fluctuations in ambient temperature can cause the fill fluid to expand or contract significantly. This effect becomes particularly important when capillaries for both the High and Low connections are involved and their lengths differ or they are exposed to different ambient temperatures. The smaller the expansion coefficient, the less the measurement will be affected.

3. **Compatibility with measured fluid**—Because the seal diaphragm is usually thin, there is always the chance that it could be damaged and the fill fluid could leak into the measured medium. This possibility should particularly be considered if contamination of the measured fluid is covered by government regulations (as with foods processing) or is otherwise of great concern.

4. **Viscosity**—The fill fluid’s viscosity can significantly influence the response time of the measurement. The less viscous the fluid, the faster the response. Remember also that if the temperature around the capillary decreases, the viscosity increases. Kinematic viscosities of fill fluids range widely— from 4 cSt for silicone oil to 1,130 cSt for glycerin, both at 68°F (glycerin is usable down to the extremely low temperature of -462°F.)

**Response time**

Before the capillary fill fluid can hydraulically convey to the transmitter a change in the pressure of the measured medium against the seal diaphragm, a finite amount of time must elapse. Often overlooked, this response time can significantly affect the performance of the seal system and measurement.

The major design considerations with respect to response time are the capillary diameter and length as well as the viscosity of the fill fluid. The smaller the diameter, the longer the response time. The typical diameter of the capillary is 2 mm. In applications where response time is important, consider a larger diameter. As for capillary length, it is often dictated by installation needs, but response times are improved by keeping the capillary as short as feasible.

Although low fill-fluid viscosity favors a fast response, a low viscosity may not be consistent with the requirements for thermal expansion and operating temperature range. The tradeoff varies on a case-by-case basis.

**Fluctuating temperature effects**

A common problem with using isolating seals is the inaccuracies that can result from fluctuating temperature conditions. Each change of ambient temperature around each seal capillary will expand or contract the fill fluid by an amount dictated by the fluid’s thermal...
expansion coefficient.

The system designer has three options to minimize the error caused by temperature effects:

- Reduce capillary diameter to decrease the volume of fill fluid (at the price of increasing the response time).
- Choose a fluid with lower expansion coefficient (subject to viscosity and temperature-range limitations).
- Specify a relatively large diameter for the seal diaphragm. The comparative stiffness of small diaphragms tends to magnify errors related to temperature fluctuations.

Installing a seal system

Proper installation of the DP transmitter and its isolation seal system depends basically on the variable being measured. In general, flow and gage-pressure applications allow the most flexibility. Conversely, when the process vessel operates under vacuum, a liquid-level measurement entails restrictions on the relative elevations of the transmitter and the seals. For measurements of absolute pressure, there are similar restrictions when the lower range value is less than 1 atm.

Basically, transmitters linked to isolation seals respond not only to process pressures, but also the head pressure caused by the liquid column in the seal system itself. The latter is a function of transmitter and seal locations. Dealing with this complication depends on the type of measurement being made.

With most installations for measuring flow, gage-pressure or absolute-pressure, the head-pressure effect is minor and can be canceled out by a zero adjustment in the transmitter. When measuring liquid levels, however, head pressures can have a bigger effect on calibration because of a substantial difference between the elevations of the high- and low-side seals.

Measuring pressures

A gage-pressure transmitter with a remote seal can be used for measurement on either a process pipe or a tank. Figures 3 and 4 show gage-pressure installations on pipe, respectively for pressure service and vacuum service. The seal diaphragm should be on the top or, as shown, the side of the pipe, to keep sediment from collecting on the seal diaphragm.

Pressure service: When the low end of the operating-pressure range is above 1 atm (0 psig), the transmitter can be placed in any convenient location -- at the same level as the remote seal diaphragm, above or below it, Figure 3.

Vacuum service: When the operating-pressure range includes pressures below atmospheric, the transmitter must be below the elevation of the seal element, Figure 4. This ensures that the pressure in the transmitter body is always above 0 psig. The recommended minimum vertical distance between transmitter datum line and seal datum line is 1 ft (0.3 m).

For absolute-pressure measurements, the installations are the same as those for gage pressures. If the absolute-pressure operating range has a minimum above 1 atm, the transmitter can be in any convenient location.
But if the pressure range goes below 1 atm, follow the recommendations for vacuum service.

Flow Measurement

Differential-pressure transmitters with two isolation seals can measure flowrates in horizontal or vertical lines. Figure 5 shows a horizontal installation, the transmitter connected across the differential-producing (wedge) flow element. The upstream seal links to the transmitter high side (“HP”), the downstream one to the low side (“LP”).

Whether the pipe horizontal or vertical, the transmitter can be placed in any convenient location (except in vacuum applications, where it must be below the datum line of the lower seal). For accurate measurement of liquid flow, the flow restriction must be in a pipe section that is always full.

In a horizontal setup, as shown, the seal elements are at the same elevations, so head pressure of capillary fill-liquids are the same on the high and low sides of the transmitter. Accordingly, the transmitter calibrations can be zeroed out. If the process fluid contains suspended solids, the seal elements should be at the top of the pipe, to avoid collection of solids on the seal diaphragms.

In a vertical setup, the elevation difference between the seals induces a differential head pressure (even with no flow). When the pipe is full at no flow, the initial differential depends on the distance between the two seals, and the difference in density between the process liquid and the fill liquid. A zero adjustment in the transmitter can compensate for this condition.

Liquid-level measurement

A DP transmitter with either one or two isolating seals can measure liquid level whether the tank is open or closed, and, in the latter case, whether it is operating under positive pressure or vacuum. For closed tanks,
given the choices of using one or two seals, and dry-leg or wet-leg connections, the installation options multiply.

Open tank, one isolation seal used:: The seal element must be at or near the bottom of the tank (Figure 6) so that its datum line is at or below the minimum process-fluid level. As shown, the seal connects to the high side of the transmitter, with the low side vented to atmosphere. The transmitter can be located either above (as shown) or below the seal element. The head effect can be corrected accordingly by the zero adjustment.

Closed tank, two isolation seals with pressure service:: When two seals are used, Figure 7, the lower one, located at or below the minimum level, is connected to the high side of the transmitter, with the low side vented to atmosphere. The other isolation seal must be at or above the maximum level and connected to the transmitter low side. This arrangement cancels out the effect of vessel pressure, and the instrument measures only liquid level.

When measuring liquid level in pressurized vessels, the transmitter can be located between the seals, as shown in Figure 7, or it can be either above or below both seals. The preferred location is midway between the two seal elements; as a rule, this location provides the most side of the transmitter and the tank’s vapor space above the maximum liquid level. If the process vapor is not readily condensible, or if the compensating leg is at a higher temperature than the tank interior, a dry leg can be used, Figure 8. A condensate trap at the bottom of the leg minimizes the chance of condensate collecting in the transmitter body.

If the process vapor is condensible, a wet leg should be used; the leg is filled with a suitable liquid of higher specific gravity, to maintain a constant pressure on the low side of the transmitter. This arrangement avoids the problem of process vapor condensing and collecting in the compensating leg, which would lead to serious measurement error. An alternative is to locate the transmitter near the tank top, Figure 9, so that condensate drains back into the tank.

Closed tank, service involving vacuum: When a transmitter is used on a closed tank in which the operating pressure range extends below atmospheric, the instrument must be below the high seal datum line, regardless of whether one or two seals are being used. The recommended minimum distance between the primary datum line for the transmitter and the high seal datum line is 1 ft. Seal-element locations for vacuum service are the same as for pressure service.

Interface level measurement

Using two seal systems, the interface level between two liquids in a process vessel can be measured with a DP transmitter. The high-side seal element is located near the bottom, with its datum line at or below the lowest interface elevation. The low-side seal is near the top of the tank, its datum line at or above the highest interface elevation. Under all interface conditions, the minimum level of liquid in the vessel must be above the low seal element near the top of the vessel.

Figure 8. While this setup for level measurement uses only one seal, the low side of the transmitter is connected to the vapor space by a dry leg.

Figure 9. For level measurement on liquids when readily condensible liquids are present, the elevated placement of the transmitter assures that any condensate will drain back into the tank.
When the vessel is open or under positive pressure, the transmitter can be between the two seals, or above or below both. The preferred site is midway between them. This minimizes the capillary length required, and usually provides the most uniform distribution of ambient temperatures. If, instead, the operating-pressure range includes pressures below 1 atm, the transmitter must be below the high-side seal, as with vacuum service.

**Density measurement**

A differential-pressure instrument using two isolation seal systems can measure liquid density or specific gravity. The high-side seal element is located near the bottom of the vessel and the low-side element, near the top. The minimum level of liquid in the vessel must be above the low seal element at all times.

When the vessel is open or operating under positive pressure, the transmitter can be located between the two seals, above both seals, or below both seals. The preferred location is midway between them. If the pressure range extends below 1 atm, the transmitter must be located below the high-side seal.

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