

Improvements in DP Level Measurement

Differential pressure (DP) level measurements are widely used in chemical and petrochemical facilities for their reliability and ease of use. Recent development in DP level technologies is making them even more reliable and easy to use.

By Ehren Kiker, Endress+Hauser, Product Marketing Manager - Pressure/Temperature

Differential pressure (DP) (Figure 1) is the most commonly used level measurement technology in the chemical and petrochemical industries thanks to its reliability, ease of use and adaptability to a variety of applications.



Figure 1: Differential pressure is the most widely used level measurement method in the chemical and petrochemical industries.

While there are many benefits to working with DP measurement on level applications, there are also some drawbacks. Fortunately, several new advances in the design of seals and sensors, as well as new manufacturing techniques for filling remote seal systems, are expanding the functionality of DP level systems into applications that previously required alternative level technologies. These advances are also improving the reliability of DP level measurement in existing applications and making them even easier to install.

DP Level Measurement

DP level measurement has been used for decades, and for many reasons. DP instruments are easy to install and configure, and the technology can be used in open and closed tanks. The sensors do not have to be inside the tank,

so internal obstructions are not a problem, and maintenance of the sensors does not require shutting down the process.

DP instruments can be used for a variety of measurement applications including level, flow, filter monitoring, gauge pressure measurement, and so on. Therefore, instrument technicians worldwide are familiar with the technology, so training is usually not required, and spares can be kept in stock on site for use in many different applications.

DP instruments are adaptable to process conditions such as corrosive media, high or low temperatures, foaming, clean or dirty fluids, etc. For these and other reasons, DP has become the default technology for level measurement in many chemical and petrochemical facilities.

To measure level using DP, pressure from the high pressure and low pressure connections are sent to a DP transmitter (Figure 2). This is typically done via either impulse lines, or remote diaphragm seals with capillaries. Both types are commonly used in a variety of applications in chemical industries and have different advantages/disadvantages.

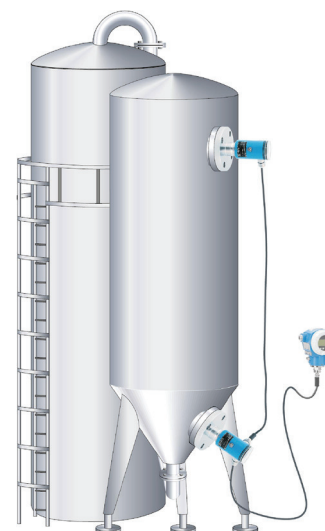


Figure 2: A DP level measurement instrument consists of two pressure sensors—one above the maximum level and one at the bottom—and a transmitter that calculates level.

An impulse line is a rigid metal tube that allows the process media to directly contact the DP sensor body. Impulse lines are easy to install on site to a stock DP transmitter, provide a fast response time to level changes, provide good accuracy for DP level measurements, and protect the transmitter from temperature extremes of the fluids stored in the tank.

But the fluid in the impulse lines can cause problems, mainly due to changes in viscosity as ambient temperatures change, which can cause inaccuracy in pressure readings, and hence level. If ambient temperatures become very cold, the fluid can freeze, leading to a total loss of measurement. Impulse lines can be insulated and heat traced, but this adds costs up front and increases required maintenance.

On closed tank applications, impulse lines use either a dry leg or wet leg configuration. Dry/wet leg configurations are susceptible to measurement errors due to condensate collecting in dry legs or evaporation causing loss of fluid in wet legs. Such applications require regular maintenance to ensure measurement reliability. Also, impulse lines are metal tubes, and can be difficult to fit into confined areas, particularly when insulated.



Figure 3: Remote diaphragm seals use flexible capillaries to send pressure to the DP transmitter.

Remote diaphragm seals consist of a sensing diaphragm mounted on the side of the tank, and an oil-filled capillary tube connecting to the transmitter's pressure sensor. Unlike rigid impulse lines, the capillaries are flexible (Figure 3) and hermetically sealed.

A variety of fill fluids are available to handle different process conditions such as high or low temperatures, and the diaphragms are available in a wide range of materials to deal with corrosive process fluids. Remote seals can be provided with appropriate process connections and appropriate wetted materials to mount directly to a vessel.

But as with impulse lines, fill fluids are susceptible to temperature fluctuations depending on the length and diameter of the capillary and the type of fill fluid, which can

cause significant measurement errors. Remote seal systems typically have a slower response time than impulse lines. Larger diaphragms required for better sensitivity and accuracy can result in higher costs, especially when exotic materials such as Hastelloy or Tantalum, and/or larger flange ratings, are required.

Remote seal systems have higher stocking costs because they are all-welded systems. This reduces the flexibility of stocking items for several different applications, as can be done with impulse lines.

By using impulse lines and remote seal systems interchangeably depending on the specific process conditions and requirements, users can employ DP level measurement in a wide variety of applications throughout a facility. The disadvantages of using impulse lines or remote seal systems lead to a small but not insignificant number of problems. In many cases, these performance issues are tolerated due to lack of an acceptable alternate level measurement technology.

DP transmitters will provide extremely accurate and stable measurements across a wide variety of process conditions, but are dependent on sensors. New developments in both technology and production techniques are improving sensing, so DP level measurement can be used in applications where either poor performance or high maintenance was previously tolerated. These advances include asymmetrical-flexing diaphragms for improved response time and reduced temperature effects; application-specific fill fluids for improved performance; and electronic DP measurement for elimination of problems with impulse lines and remote seal systems.

Asymmetrical-Flexing Diaphragms

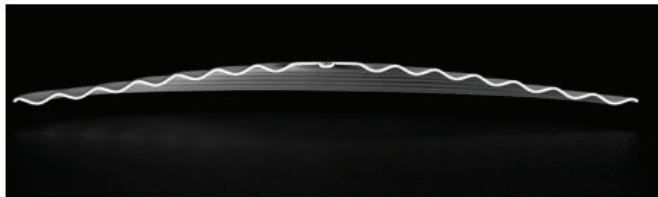
Many issues that arise with DP measurements are related to remote seal issues, specifically temperature-related errors and response time.

Standard diaphragm seals flex symmetrically; i.e., when pressure is applied the diaphragm flexes the same in all directions around the center point. Diaphragm seals are designed to minimize the volume of fill fluid (to reduce process/ambient temperature effects) and the thickness of the diaphragm seal (to provide higher sensitivity). Seal manufacturers constantly strive to reduce the volume of fill fluid and diaphragm thickness to improve performance without compromising the integrity of the seal.

Symmetrically flexing diaphragms are susceptible to measurement errors and slower response times caused by changes in process and ambient temperature.

Some manufacturers of diaphragm seal systems have recently started using seals that flex asymmetrically in opposite directions around the center point (Figure 4). The result is a

diaphragm seal that flexes predictably with good repeatability, while using less fill fluid; this allows for thicker diaphragm seals that provide greater durability and maintain sensitivity for adequate turndown.



Conventional
– Symmetric mode –



TempC
– Asymmetric mode –

Figure 4: A symmetrical remote seal diaphragm flexes the same in all directions, while an asymmetrical diaphragm flexes in opposite directions.

Products such as Endress+Hauser’s TempC membrane have a seal profile that allows it to flex asymmetrically. The result is a diaphragm seal that has higher sensitivity and lower temperature-related measurement errors than symmetrical-flexing diaphragms (Figure 5).

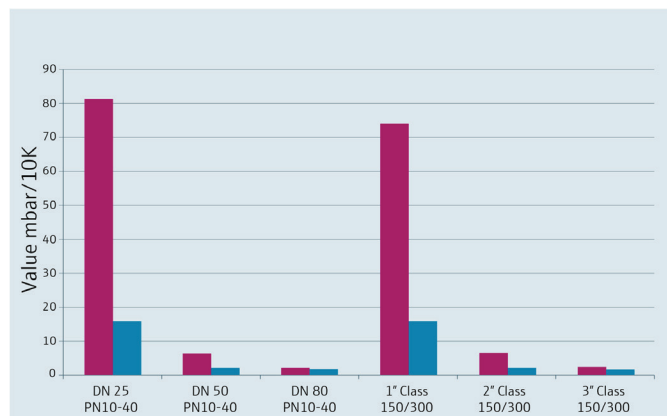


Figure 5: Temperature changes affect accuracy of remote seal systems at various flange sizes. The red bars show errors with conventional symmetrical diaphragm seals, while green shows the lesser effect of Endress+Hauser’s TempC asymmetrical diaphragm.

Asymmetrical diaphragms can often provide better accuracy and stability with smaller diaphragm seals than standard symmetrical-flexing diaphragms. As a result, use of asymmetrical seals can allow designers to use smaller flange sizes for process connections. When dealing with large projects requiring many DP level measurements, each needing high flange ratings and/or exotic materials, this can result in significant cost savings. In addition, smaller flange sizes save costs due to smaller isolation valves and other associated accessories.

Application-Specific Filling Systems

Diaphragm seals are filled with a minimal amount of fill fluid to promote the best possible response time and sensitivity to pressure change. In standard filling processes, the seal itself is cleaned thoroughly and exposed to vacuum for some time to get all the gas out before the filling is done. This is a critical part of the process because a small amount of residual gas in a diaphragm seal system can make a pressure measurement unstable and inaccurate.

Prior to filling, the fill fluid is treated to reduce its viscosity and ensure a good fill. Once the fill is completed and the capillary is welded to the transmitter, the pressure instrument is calibrated to customer requirements.

This diaphragm seal-filling process is roughly the same in all filling facilities around the globe, regardless of supplier, but this “one size fits all” process does not account for the effects of application-specific process conditions, and these can adversely affect the measurement.

Recently, manufacturers have begun using new filling methods to address this issue. In these new processes, the filling of the fluid under deep vacuum conditions is still more or less the same as standard procedures. However, the amount of fill fluid is now pre-determined per seal system. When the fill is performed, the amount of fill fluid that went into the diaphragm seal system is measured to ensure the device is filled completely.

The next step in this unique filling process is determining the position of the measuring membrane. The position is adapted to the customer application, the type of fill fluid required, and material of the membrane itself. This means that if the customer provides process data that tells the manufacturer the seal will be exposed to a working temperature of 300°C (572 °F), the amount of oil and position of the membrane is corrected in such a way that the membrane is in its best possible position under those specific process conditions.

This new way of producing DP pressure instruments with diaphragm seals and capillaries gives users increased accuracy and more reliable process information under tough conditions.

Electronic DP Level Measurement

As mentioned previously, the major limitations when implementing a DP level measurement system have nothing to do with the transmitter. Most problems instead arise with the impulse lines or remote seal and capillaries. Impulse lines are susceptible to plugging, leaking and icing—all of which negatively affect measurement. Remote seal systems are also prone to large measurement errors due to ambient and process temperature swings.

Until recently, the only solutions have been to use smaller diameter impulse lines or capillaries—which adversely affect response time—or use costly insulation or heat tracing systems. Now many of those issues can be avoided by using electronic DP transmitters.

Rather than transmit pressure from the high pressure and low pressure connections via impulse lines or remote seal/capillaries, electronic DP transmitters measure level with two pressure sensors mounted at the top and bottom of the vessel, with one sensor always being below the minimum process fluid level and one always being above the maximum process fluid level. Each sensor independently measures gauge or absolute pressure, but sends signals back to a DP transmitter electronically. Sensors are mounted directly to the vessel, and signal wiring connects the sensors to the transmitter, eliminating the need for impulse lines or capillaries (Figure 6).



Figure 6: Electronic DP level systems, such as this Endress+Hauser Deltabar FMD72, eliminate the need for impulse lines or capillary tubes because the sensors connect to the transmitter via wiring.

Without impulse lines or capillary tubes, an electronic DP transmitter eliminates issues related to leaking fittings, plugging, icing and slow response times. Advantages include less maintenance, low or no temperature affects, and fast and stable response times. An electronic DP system is modular, so components can be individually replaced as needed.

An electronic DP system can easily be retrofitted using the same process connections, mounting and wiring as the existing DP level system. The system connects to the same input point on the control system, with the same scaling as the DP level system being replaced.

With electronic DP level systems, end users can still have the advantages of DP level measurement, while eliminating many of the disadvantages limiting applications.

Summary

While there are many different level measurement technologies, DP is the most commonly used in chemical and petrochemical facilities. DP level measurement can be susceptible to a variety of issues such as plugging of impulse lines or temperature-related drift when using remote seals and capillaries. Fortunately, manufacturers are developing new technologies such as asymmetrically-flexing diaphragms, application-specific filling techniques, and electronic differential pressure transmitters. These technologies can be used to improve existing DP level measurement applications, and open up new areas where the DP was not up to the task.

About the Author



Ehren Kiker is Product Marketing Manager for pressure and temperature products at Endress+Hauser. He has more than 20 years of automation experience focusing on process measurement instrumentation.