Refinery Application

Improve reliability and decrease alarm count

By: Bill Sholette, Level Product Business Manager – Endress+Hauser
Chris Fournet, Level Products Business Manager – Vector Controls & Automation Group

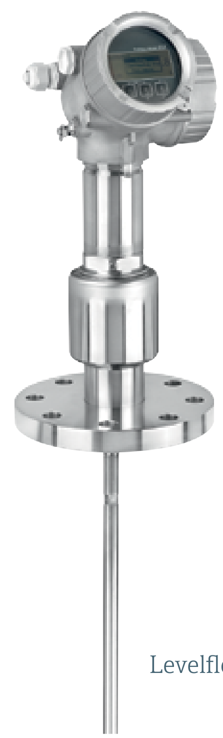
The purpose of this paper is to discuss how to decrease alarms due to redundant level devices not matching especially in applications with high pressure and/or high temperature. The importance of Gas Phase Compensation (GPC) and how it affects level readings of guided wave radar (GWR) devices is critical. The presence of polar gas also can have an effect on the accuracy of any GWR that does not have GPC when installed in applications where high temperature or pressure is present. This paper will discuss these issues and address how to overcome them.

Are you experiencing deviation alarms in your high pressure process vessels? In many high pressure vessels, redundant level measurement technologies are employed to provide multiple level indications for safety. It is common for the level measurement instruments to be different technologies in order to provide what is referred to as "diverse redundancy". Conceptually, diverse redundancy is a great idea. A process condition that may affect one technology will likely not affect the other(s) ensuring that a reliable level measurement is being provided by at least one technology.

This concept does introduce additional issues and concerns. From a safety standpoint, double or triple redundancy provides additional security. However, it also introduces the need to monitor each level measurement technology to compare the outputs and provide an alarm if the outputs deviate by a pre-determined percentage. While it is true that a process condition may "upset" a particular technology, it is very difficult to determine which of the redundant technologies is in an upset condition and which is operating properly. For safety reasons, it becomes necessary to take corrective action whenever the deviation between the level measurements exceeds this predetermined value.

In the case of high pressure process vessels, safety is of paramount concern. Diverse redundant level measurement is common in these applications to ensure safe operation. It is important to select technologies that are reliable and repeatable to reduce alarms due to deviation.

One technology that has become very popular for level measurement in high pressure vessels in recent years is Guided Wave Radar (GWR). Guided wave radar, also called time-domain reflectometry, is a time-of-flight level measurement technology. A microwave pulse is launched from the transmitter and follows a wave guide to the surface of the material being measured. The change of impedance created by the change from the gas phase to the material being measured causes the microwave pulse to reflect and return to the transmitter. The time the pulse takes to reach the material surface and return is divided by two, which provides the distance to the material being measured and allows the level to be calculated.



Levelflex FMP54

As with any measurement technology, it is important to understand how an instrument will function in the application in which it is being applied to. This is particularly true of guided wave radar transmitters in high pressure vessels. Typically, guided wave radar will send a pulse through the upper gas phase in the vessel to reflect off of the liquid (or solid) material being measured. In most applications, this is very efficient and provides a reliable and repeatable level measurement. However, in high pressure applications where the upper phase is made up of a gas with a polar molecule, special consideration needs to be taken to attain this repeatable measurement.

Polar molecules alter the speed of the microwave pulse. The microwave is slowed by the polar molecule resulting in an error in the measurement. Common polar molecule gases are steam (H2O), hydrogen, and ammonia. When these gases are present as the upper phase in high pressure vessels level measurements using guided wave radar will result in an error unless the reduction in speed of the microwave pulse is compensated. Polar gas depending on what type and what concentration, can dramatically affect the accuracy of the measurement of a GWR device. When a polar gas is present in the “Gas Phase” of a level application, the indicated level reading from the GWR will be less than the actual process level. This happens because the speed of the GWR pulse slows as it propagates through the upper polar gas phase. Since the level measurement is based on time – this causes an error and can result in alarms if the is another level technology being used in the same vessel

For an example, let’s consider a steam drum application. The steam above the liquid water in the drum is made up of a polar molecule (H2O) which will change the speed of the radar signal in the gas phase area. This creates an error in the level reading which will be proportional to the pressure and temperature. The chart in Figure 1 shows the percent error based on temperature and pressure. Note that in a high pressure steam drum at 2,900 psi the error would be as high as 76%. This error is not acceptable for safety or for measurement purposes. Even at lower pressure you can see the error can be substantial. This becomes important also when other level devices are measuring the same level and a deviation alarm is configured to look at the difference between level transmitters. In many cases, this could result in a deviation alarm.

Gas phase	**Temperature**		**Pressure**							
	°C	°F	1 bar 14.5 psi	2 bar 29 psi	5 bar 72.5 psi	10 bar 145 psi	20 bar 290 psi	50 bar 725 psi	100 bar 1450 psi	200 bar 2900 psi
Steam (water vapor)	100	212	0.26%							
	120	248	0.23%	0.50%						
	152	306	0.20%	0.42%	1.14%					
	180	356	0.17%	0.37%	0.99%	2.10%				
	212	414	0.15%	0.32%	0.86%	1.76%	3.9%			
	264	507	0.12%	0.26%	0.69%	1.44%	3.0%	9.2%		
	311	592	0.09%	0.22%	0.58%	1.21%	2.5%	7.1%	19.3%	
	366	691	0.07%	0.18%	0.49%	1.01%	2.1%	5.7%	13.2%	76%

Figure 1: Percent error based on temperature and pressure

Clearly, when using guided wave radar for measurement in high pressure applications with polar molecules in the gas phase, some way to correct for the resulting error must be made. Calculations for correction can be made based on pressure and temperature measurements however; these corrections would need to re-calculated with every pressure change. This can be problematic especially during startup operations.

A guided wave radar can be manufactured with a reference section that provides the required compensation. Figure 2 illustrates the reference concept. A reference rod is added to the wave guide near the top of the sensor. This reference rod is slightly larger than the measuring rod. When the microwave pulse reaches the end of the rod it will see a change of impedance causing a reflection back to the transmitter. Since the reference rod is in a fixed location the reflection from the rod should always be in the same location. As the pressure in the vessel increases and the microwave pulse begins to be affected by the polar molecules, the reference point will begin to look like it is further down the sensor.

Gas Phase Compensation: Construction/Preconditions

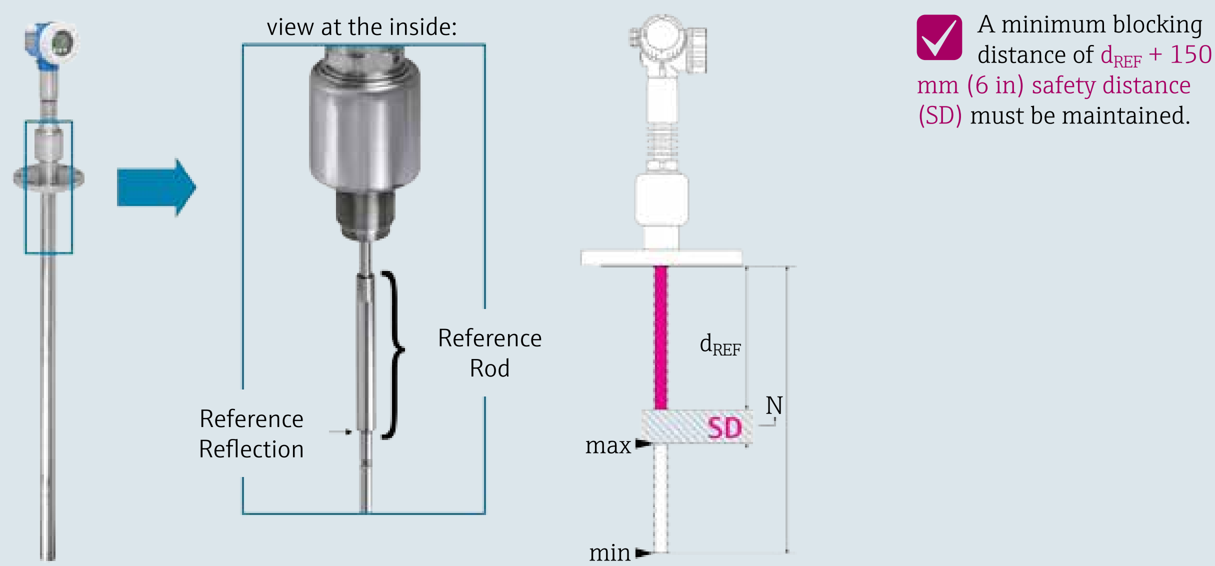


Figure 2: Gas Phase Compensation; Construction/Preconditions

The transmitter can use the differential between where the reference is expected be to where it is reporting to be to compensate for the speed change and thereby provide a correct level measurement (see Figure 3).

Gas Phase Compensation using the reference rod is a dynamic real time correction. That is, the correction is ongoing and compensates for changes in pressure that occur during the operation of the process. This is particularly helpful during startup and shut down operations when pressure is changing dramatically.

Gas Phase Compensation: Function of automatic compensation

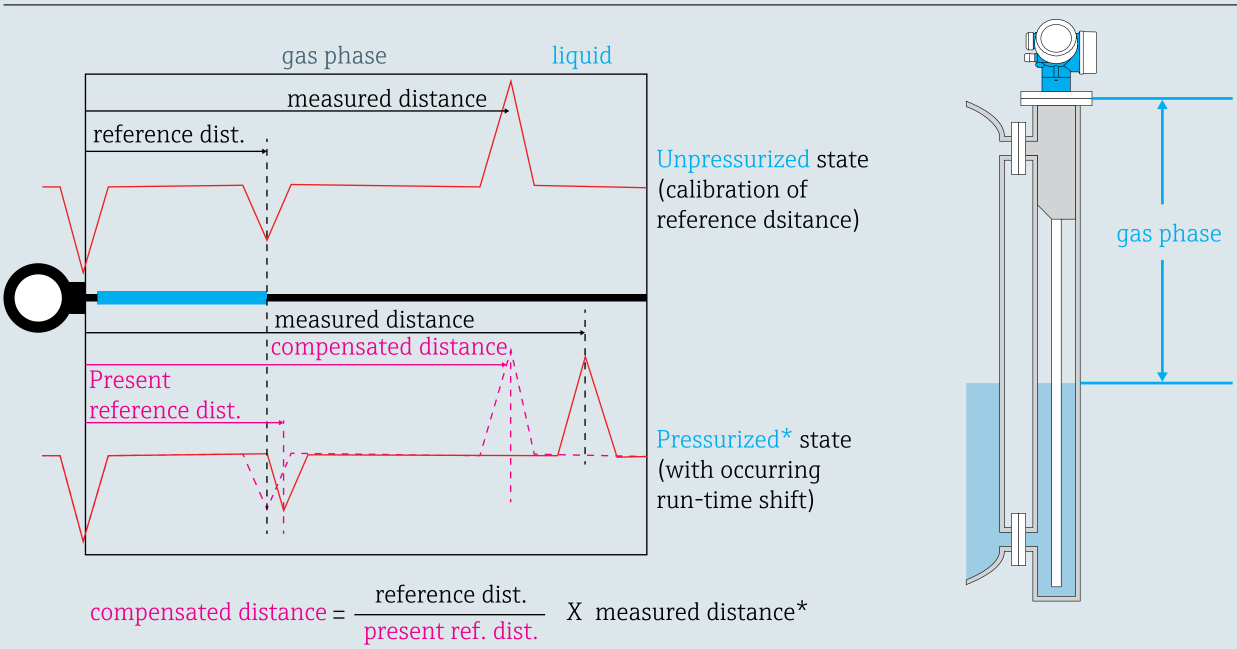


Figure 3: Gas Phase Compensation, function of automatic

Guided wave radar transmitters are an excellent choice for many level measurement applications. For high pressure vessels containing gases with polar molecules, a reliable and repeatable measurement is achievable. It is important to select guided wave radar that provides gas phase compensation to correct for changes in speed of the microwave pulse.

Endress+Hauser Solution: Many level refinery applications have high pressure/temperature steam or hydrogen present in the upper gas phase. In many cases, there is a 10% deviation alarm in place to help ensure a reliable level reading is always achieved. Most of the time when multiple level devices are used, refineries elect to use different technology on these devices (as was the case on the CEP project) such as a wet-leg Dp, Capillary Dp, Magno-restrictive and GWR. In applications such as this, it's obvious to see how polar gas affects a level reading. What you would expect to see is the GWR showing a lower reading than the rest of the level devices. Of course, the only way to truly see this deviation is when all the other instruments are calibrated and set up properly.

Endress+Hauser recognized the effect polar gas has on GWR and developed a device that compensates for the level deviation. The FMP54 was developed specifically for high pressure and temperature applications with a unique reference rod built-in to the top section of the unit to combat the issue of polar gas. With this technology, Endress+Hauser can ensure reliability and accuracy on these types of applications and minimize deviation alarms.

Bill Sholette is the Level Products Business Manager for Endress+Hauser in the Northeast. Bill has been involved in level measurement for the past 33 years in virtually all aspects of process level measurement instrumentation - from manufacturing and sales, to his present position in product management. He is currently responsible for level products in Northeast United States. Bill attended Villanova University and has certification in management and marketing.

Chris Fournet is the Level Products Business Manager for Endress+Hauser and Vector Controls & Automation Group in the Central US. Chris has been involved with instrumentation for the past 25 years with a focus on level measurement for the last 10 years. He spent 22 years in one of the largest refineries in the USA, ending his career there as the Instrument QA/QC Specialist. He is currently responsible for level, pressure and temperature products in Central United States which include TX, NM, OK, KS and MO. Chris attended Lamar University with a degree in Instrumentation and is also CCST certified from ISA.

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Endress+Hauser, Inc.
2350 Endress Place
Greenwood, IN 46143
Tel: 317-535-7138
Sales: 888-ENDRESS (888-363-7377)
Service: 800-642-8737
Fax: 317-535-8498
info@us.endress.com
www.us.endress.com

Endress+Hauser

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