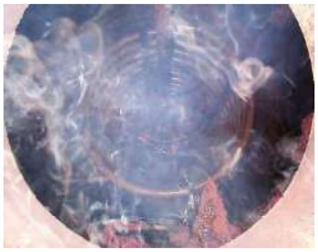
Ultrasonic vs radar in the water industry

Letting the application drive the right technology

In recent years, the debate about which technology is best suited for level monitoring and open channel monitoring (OCM) applications has taken some traction. There are those who argue that ultrasonic level technology has been uncontested as the standard for level and OCM applications in the water industry. The counter-argument is that radar technology is more effective because it is more robust and accurate than ultrasonic technology. This is because electromagnetic waves are not affected by temperature changes and radar technology is virtually unaffected by volatiles or foam. Moreover, radar transmitters can handle higher temperatures than ultrasonic level instruments. In recent years, radar level transmitters have become easier to setup, and higher accuracies are now being achieved with newer designs.

All of this makes radar technology very attractive to apply across all industries but their liberal application can undermine the benefits offered by ultrasonic transmitters and controllers, and it can introduce a higher cost of ownership. For example, in some cases, radar transmitters are applied in applications where even some end-users consider the choice an overkill solution. This can be easily understood considering that to one extreme, the technology is well-suited for chemical reactors and extremely dusty applications and to the other extreme, it has been oriented toward significantly less aggressive applications like water and sludge level to OCM. Using a one solution fits all approach in the long run can lead to unfavorable consequences.



Vaporous and high temperatures are common in the industrial market

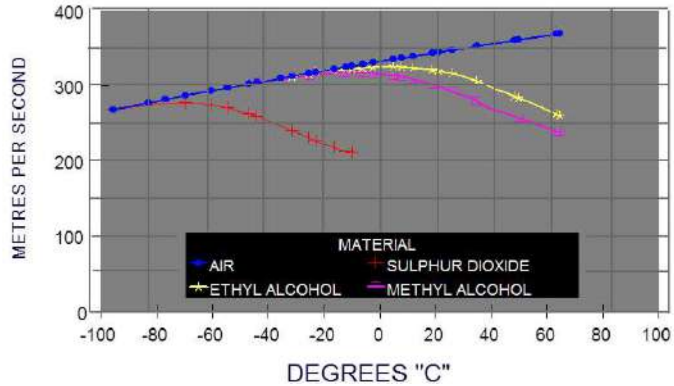
There is no denying that radar technology has strong attributes, but one has to wonder why radar technology is actively promoted as the right level solution in the water industry. When all is said and done, understanding the limitations and benefits of each technology can prove valuable when making the switch from one level technology to another. A choice simply made for the sake of certain attributes may not result in a prudent decision. What follows are the ostensible good reasons why to make the move to a newer technology, namely radar, and the argument why ultrasonic technology is the right fit, for the most part, or the water industry.

What process conditions challenge ultrasonic level technology?

Some of the challenging level applications encountered in the industrial segment where ultrasonic technology underperforms can often be resolved using radar technology. Radar is well-suited for level applications where temperatures can range from moderate to over 300F°. It is also beneficial where vapors may develop due to volatiles (e.g. gases) or where pressures exceed the specifications for ultrasonic transducers. Nevertheless, most of the conditions that limit the use of ultrasonic technology are mostly found in the industrial market and are not common in the water industry.

There are many difficult process conditions in the industrial market that are primarily found in the chemical and petrochemical industries. Solvents, for instance, can form vapors that can stratify under the right conditions. The stratification of vapors or gas layers has an effect on the speed of sound since the acoustic wave will travel at different speeds as it travels from one layer to the next. This scenario will yield erroneous level measurements when using ultrasonic technology. Advanced ultrasonic level transmitters have manual means to correct for the speed of sound when a vaporous atmosphere exists. However, implementing speed compensation for these conditions can become a nuisance if such conditions occasionally change due to external influences, e.g. hot or cold weather, whereby vapors can develop and subside. This is an unnecessary task when using radar transmitters because electromagnetic waves are, for all practical purposes, unaffected by vapors and their propagation speed virtually remains the same.

These stratification issues are typical with solvents, and atmospheres other than air are not a common occurrence in the water industry. Nevertheless,

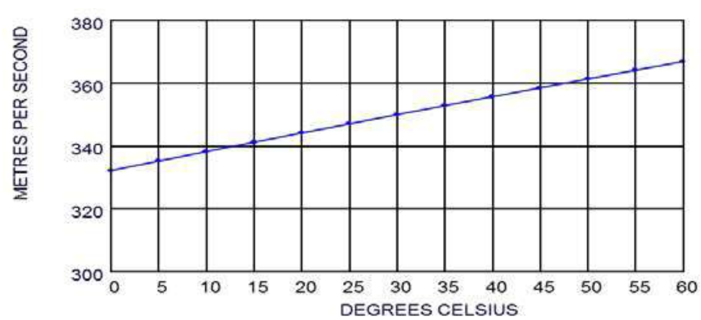


Sound speed varies with some atmospheres requiring alternate technology to ultrasonic

something that is worth mentioning is that many of the vessels or tanks used in the industrial market are often vented to the atmosphere, thereby decreasing vapors concentration. Ultrasonic transmitters are often successfully used in these applications by automatically compensating for the speed of sound in the air space between the media and the sensor.

Ultrasonic level is susceptible to process temperature changes

The speed of sound depends on the property of substance through which the soundwave travels. Non-contacting ultrasonic transmitters in general are used in applications where that substance or medium is air. The speed of sound is also dependent on air temperature. The electromagnetic wave signal for radar transmitters travels at the speed of light and is not influenced by the temperature of the medium.



Accuracy maintained by monitoring temperature and compensating speed of sound.

There is a misconception in relation to the accuracy of ultrasonic level devices in that they suffer due to air temperature changes in the vessels or in the air above the PMD in OCM applications. For almost two decades, ultrasonic level transmitters and controllers have had integral temperature sensors in their transducers. These temperature values are sent to the main electronics where a speed of sound compensation is made to continually track the level accurately.

The accuracy associated with most ultrasonic level devices is typically +/- 0.25% of the measurement span, and it is well-accepted for the applications where these instruments are applied. For instance, on OCM applications where the accuracy narrative is more prevalent, newer ultrasonic controller designs meet and exceed the accuracy requirements by achieving accuracies down to +/- 1mm. However, it is important to keep in mind what the overall effect on accuracies is when the whole system is considered. For example, in outdoor applications where tanks are subject to the weather, on a hot day, volume expansion takes place and this introduces error on the level measurement. On a cold day, volume contraction also occurs and the storage vessel undergoes expansion and contraction. These types of conditions will affect the level measurement taken by a radar transmitter regardless of how accurate it is. As it pertains to OCM applications, the accuracy argument of one technology being better than another is difficult to sustain or dispute because flumes and weirs can, under real applications, struggle to achieve accuracies that surpass +/- 5%. (This will be discussed further in the section below.) Forcing radar as a technology for all level and flow applications is similar to the hammer approach: where everything looks like a nail. This creates confusion to those involved in water management and instrumentation personnel alike who are often bombarded with superfluous and conflicting messages and, as a result, the water industry is not well-served.

More on accuracy as it relates to Primary Measuring Devices (Flumes and Weirs)

The current situation in the water industry is that for many years controllers based on ultrasonic technology have a long history of performing well as the secondary element measurement device. Radar technology is now being presented as a better alternative, based mostly on the tight accuracies the technology offers. The established reputation attained by robust ultrasonic controllers is one of the reasons ultrasonic technology is well-accepted as the standard by a vast majority in the water industry. The U.S. Bureau of Reclamation acknowledges that primary (element) selection is not an easy task since it requires the evaluation of site-specific factors and variables down to the unique operational requirements and projected water demands. Selecting a secondary measuring device, one using a non-contacting technology like ultrasonics, should not be as involved as it is with the selection of the primary element or primary measuring device (PMD) if accuracy is the end goal.

The target or desired accuracy of the measurement system is an important consideration in primary measurement method selection. This is where the possibility for the largest accuracy limitations could come from; thus, better than 5% accuracies are hard to obtain and difficult to maintain. Under laboratory conditions, 1% accuracy is possible. Replicating these conditions in the field is not only costly, but also difficult because of the special designs and continual maintenance that is required (Water Measurement Manual, 1997).

The task of achieving tight accuracies with the utilization of PMDs is very difficult. According to the South Florida Water Management District Water Use Flow Monitoring and Calibration Guide, "All calibration methods' accuracies are tightly clustered and rarely exceed +/-2 to 5% (laboratory rating) and +/-5 to 10% in field use." (South Florida Water Management, 2014, p. 5)

Although the accuracies of secondary devices is a lot better than the PMD, when considering the aforementioned challenges, it can be deduced by comparison that their beneficial effect is negligible when the whole system accuracy is accounted for. Thus, the persuasion of choosing radar transmitters over ultrasonic controllers based on accuracy could lead to misguided expectations.

The right choice based on the application instead of the technology?

In the water industry, ultrasonic technology has a proven performance record that can be traced back to the vast number of instruments across the industry and the number of instruments that are still running after 10-20 years. However, this is not to say that radar technology is not suitable for simple level applications as well. Radar technology has some distinctive attributes that make it the right technology where ultrasonic technology would not work well or would not work at all. Radar transmitters are ideal for applications that reach elevated temperatures, high pressures, vacuum or extreme dust. While these conditions are not typical in the water industry, radar technology is still applicable. In applications where carbon dioxide or CO_2 is present, as it is in the case of aerobic digesters, radar should be the technology of choice. Since CO_2 absorbs the ultrasonic signal, this application should be monitored using a level radar transmitter and a pressure transmitter. As the bacteria decays in the digester, heavy or dense foam develops as a result of the bacteria decomposition, or bug population dying off. In general, foam is problematic for many level technologies but the key element here is heavy or dense foam.

When this condition occurs, a suitable radar transmitter can detect it and alert the operator before a spill occurs and the pressure transmitter continues tracking the liquid level in the digester. There is also the possibility that the process connection of a vessel containing alum or polymers, for example, is too small to fit in an ultrasonic sensor. In such cases, rods and small horn antennas in radar transmitters can prove more flexible installation wise. However, these types of antennas do have a signal with wide beam angle, which could lead them to detect tank walls and obstructions along the signal path. In such cases, additional configuration and expertise beyond the basic setup is required.

Switching to radar technology based on the attributes mentioned above can easily undermine the benefits that ultrasonic controllers are endowed with. The comprehensive functionality on ultrasonic controllers makes them readily applicable in various applications that are common in the water and wastewater treatment process. Although radar transmitters have come down in price considerably, they are mainly designed to provide level measurement and any additional control will have to be programmed on the Programmer Logic Controller (PLC). Because of their integral design, radar's accessibility for configuration is best when installed in the process connection on top of a tank or vessel. They are not practical for underground installations, i.e. below the cover or concrete slab of a wet well. Ultrasonic level transmitters with an integral design (sensor and electronics in one piece) face the same installation challenges. This makes both transmitters impractical and relatively unsafe for personnel to install and troubleshoot when inside a wet well.

Furthermore, when the whole instrument is inside the process, the potential for moisture ingress into the electronics exists since potting compounds are not commonly used to protect the electronics. Some of the newer radar transmitters, where the electronics and horn are encapsulated in one piece, are only partially potted. If moisture or chemicals reach the electronic board, performance and durability will be compromised. This is not the case for an ultrasonic controller and transducer arrangement configuration. Moisture ingress into the transducer is virtually impossible since it is hermetically sealed.

Any application requiring more than just a level input will require additional configuration at the PLC. In today's world, where more automation is being implemented, the full functionality of the controller is sometimes bypassed and executed by PLCs. Nevertheless, cautious users opt to configure the relays and pump control functions offered by ultrasonic controllers and resort to them in case the PLC is brought down by some unforeseen cause. Additionally, ultrasonic controllers are well-suited for remote locations and the alarm, pump and data logging functions can be executed within the controller itself.

How a comprehensive solution differs from one that offers a single function?

The utilization of any level device regardless of technology designed merely to monitor level yields nothing more than the level measurement. Anything else will have to be characterized. For example, when a level transmitter is used for open channel flow, the flow is usually characterized via head versus flow values that

Hermetically sealed transducer is impervious to chemical or moisture ingress

are entered in a table to create a head-flow correspondence curve. In such cases, the resolution suffers. Modern ultrasonic controllers have a full suite of advanced control functions, enhanced flow logging capability and preset precise calculations for commonly used flumes and weirs. This makes their configuration easy to setup without sacrificing the resolution.

For decades, level measurement and open monitoring has been and continues to be reliable while using transmitters and controllers based on ultrasonic technology. The list of capabilities shown below illustrates the functionality that is readily available with ultrasonic controllers.

Ultrasonic-based controllers provide:

- Level measurement or flow measurement or both (dual point models)
- Alarms relays, pump control and energy saving pump algorithms
- Discrete inputs
- Direct selection of primary device (flume & weirs)
- Data logging
- Maximum and minimum flow rates records
- Totalization and sampling
- Local display- flow, head, totalizers, etc.
- Separation between controller and transducer of over 1,000 is possible
- Unrestricted use by the FCC in open air applications
- Submergence protection during flooding conditions
- Self-cleaning transducers

Mechanical vibration keeps transducer face clean

Self-cleaning capabilities - a side benefit of acoustical energy

Although self-cleaning is listed last, this requires its own treatment. This feature is inherent in ultrasonic transducers. As the name implies, the transducers are electro-mechanical devices that convert electrical to acoustical energy and acoustical to electrical energy. What this means is that there is some vibration on the face of the transducer. As the acoustical energy leaves the face of the sensor, this mechanical movement inherently serves as a cleaning mechanism and keeps the face free of build-up or condensation. The signal produced by a radar level transmitter is electromagnetic, which means there is no mechanical movement on a radar transmitter emitter or the surface of an encapsulated antenna. Any conductive build-up will eventually demand some kind of maintenance over time to prevent signal degradation. This additional maintenance will result in a higher cost of ownership, which in some cases can be significant since it can consume the better part of a day when accounting for the associated travel time to distant locations.

Conclusion

Radar technology has gained favor in difficult level applications that exhibit temperature gradients, high pressure, vaporous and dusty atmospheres. Because of these capabilities, the technology is being applied in areas where these conditions are minimal or non-existent in the water industry. In general, radar level transmitters offer greater accuracy than ultrasonic controllers. This is trivial because in most cases, the substances being monitored in the water industry do not demand the accuracy expectations of high-end specialty chemicals or the stringent requirements encountered in custody transfer scenarios. Additionally, most of the errors in flow monitoring are introduced by the PMD. In applications where tight tolerances are required, careful attention is a must in the specification and installation of the PMD with the understanding that achieving accuracies better than 2% in the field is virtually impossible.

Knowing the application particulars is most valuable in deciding which technology to choose. Choosing radar transmitters for level and OCM applications found in the water industry should be an exception and not the rule, especially when the criteria calls for the right tool and not the latest tool. Until radar integrates the functionality found in high-performance ultrasonic controllers, the water industry will continue to benefit by utilizing ultrasonic technology in most of its level and flow applications. The benefits offered by ultrasonic level instruments surpass the particular attributes found in radar transmitters as they are not essential in the water industry.

Clean fresh water is not a new thing

If radar can do all of the things mentioned at the beginning of this document, then why is there still a need for other level technologies such as ultrasonic, guided wave radar, laser, pressure, weighing or even gamma rays? All of these technologies have a place where they are best applied in many industries. But, in the water industry, ultrasonic technology is naturally driven as the sound choice by most level and OCM applications.

If you are wondering about the validity of the sheer number of ultrasonic instruments installed across the industry, consider this: radar transmitters began to make reasonable progress into the industrial market in the early 2000s and it was much later when they began to appear in the water industry. The water industry successfully managed to provide clean and fresh tasting water for a U.S. population of almost 300 million before radar came into play. If that does not prove ultrasonic technology is the sound choice, then what does?

Sources:

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