Intrinsically Safe Ultrasonic Testers: How important are they?

Introduction

The use of ultrasonic devices for non-destructive testing (NDT) has become more common in recent years as equipment has increased in capability and decreased in price.

Ultrasonic NDT devices work by creating a pulse of high-frequency sound, generally in the range of 2.5Mhz to 10Mhz, and then measuring the return, a process that makes it possible to measure and resolve anything from the simple thickness of a material through to corrosion and even weld or flaw inspection.

The use of ultrasonic NDT devices is attractive because of their non-invasive nature. They don’t require a plant shutdown to obtain a measurement. However, deploying this kind of device within a hazardous (classified) location has implications for safe use that even NDT inspectors may not be fully aware of.

The basics of ultrasonic measurement

As briefly outlined above, an ultrasonic device operates by combining the creation of a pulse or series of pulses of sound with measurements of the return of those pulses from target back to device. These pulses and echoes are sent and received by a piezoelectric transducer.
Equipment that employs the pulse/echo to operate use transducers to:

- **Convert electricity into sound = pulse**
- **Convert sound into electricity = echo**

Simple thickness measurement devices, for example, measure the time of flight of the sound wave between the pulse and the echo. The time between the pulse and the echo equates to two times the material thickness when multiplied by the known material velocity value.

Fig 1.1 shows the schematic of a pulse/echo ultrasonic thickness measurement device. The pulser/receiver in this example excites the transducer, which fires a sound wave into the pipe and measures the time it takes for the rear surface echo to return to the transducer.
Since the time required for the wave to return is actually the time it takes for the wave to travel from the transducer to the rear surface and back to the transducer, this actually represents twice the thickness of the pipe wall.

Fig 1.0 shows the thickness measurement equation when using ultrasound.

T = (V) x (t/2)

where

T = the thickness of the part

V = the velocity of sound in the test material

t = the measured round-trip transit time

Fig 1.0 Thickness measurement equation

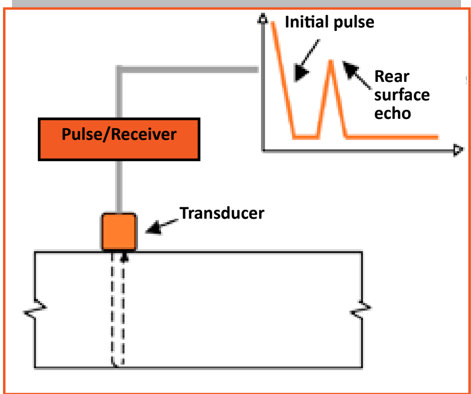

Fig. 1.1 Schematic representation of ultrasonic test device

Measurement accuracy

Measurement accuracy ultimately depends on the accuracy of the time measurement, but more importantly, it depends on the velocity of sound in the material being measured.
Also known as the “material velocity,” this value changes from material to

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Material	Material Velocity (m/s)
Steel, Mild	5900
Steel, Stainless	5800
Iron	5900
Iron, Cast	4600
Aluminium	6300

Fig 1.2 Material velocity examples

Two advantages of an ultrasonic tester are its ability to measure the thickness of a material, such as a pipe wall, and to test for corrosion.

material and must be known if an accurate measurement is to be derived by the device.

Figure 1.2 shows a selection of approximate material velocities for typical industrial materials.

These numbers can be difficult to remember, especially for NDT inspectors who move from one material to another. Higher-end ultrasonic testers allow users to select material velocities from a drop-down list and can even store material information in a database that links the testing location, parameters and measured value for later analysis.
This is important, because the more accurate the material velocity data, the more accurate the UT device reading will be.

Transducer selection

Handheld UT devices designed for NDT inspections generally operate with transducers in the region 2Mhz -> 10Mhz. A rule of thumb for transducer selection is higher frequency = higher resolution.
For thin-film or high-accuracy coating inspections, a 7Mhz transducer is usually the best choice, whereas for depth penetration a 2.5Mhz transducer is selected.

For standard NDT and corrosion inspections, a 4Mhz transducer will provide optimal depth penetration with an accuracy of ±0.1mm.

Classified (hazardous) locations

Classified/hazardous locations are a prime example of the application of ultrasonic NDT. Pipelines located within petrochemical facilities both on and offshore represent an ideal environment for using ultrasonic testers for basic thickness measurement through to corrosion, weld and flaw detection.

Ultrasonic testers in highly corrosive offshore installations can help prevent pipeline failures by providing the information required to schedule planned maintenance. Operations thereby avoid unplanned maintenance due to failure.

However, classified locations present their own particular problems. Devices used within these potentially explosive atmospheres must comply with legal codes designed to prevent explosions.

These codes apply to ultrasonic testers in the same way as multimeters or other IS devices, with the added complications of the higher voltages required to excite the transducers and the power generated by the transducers themselves, even if disconnected from the pulser/receiver.

The commonly used term for devices certified for use within these areas is intrinsically safe.

Intrinsically safe requirements

Intrinsically safe devices are designed to limit power both at the source (battery) and component level to prevent a spark or heat source powerful

Thickness measurement

Ultrasound is perfect for measuring thickness, because it requires access to only one side of the material being measured. In the case of a pipe, the pipe can even be filled with fluid and in operation, which means an outage is not required to conduct the test.

A simple thickness measurement can be enhanced by using predefined max/min alarms to help deskill the task of identifying problem areas.

Typical thickness measurement applications include:

- **Thick cast metal parts**
- **Thick rubber tires and belts**
- **Most thick or sound-attenuating materials**
- **Fiberglass storage tanks**
- **Composite panels**

enough to ignite a gaseous atmosphere.

Even the casing and neck strap of an intrinsically safe device must be manufactured from a certified anti-static material to prevent a spark.

Ultrasonic testers that are intended for use within hazardous/classified areas should comply with the specific requirements and be certified as intrinsically safe, based on third-party standards such as ATEX, NEC and IEC/Ex.

Battery systems

In the context of intrinsically safe devices, batteries are defined into two categories:

- **Primary cells (non-rechargeable)**
- **Secondary cells** (rechargeable)

Handheld NDT devices are, almost without exception, battery powered. It is a common misconception that for a device to be deemed intrinsically safe, only the battery must be considered and protected.

While the battery is very important, many additional rules and regulations define how an intrinsically safe device must be designed and built to win certification for use in classified locations. Some of these considerations are discussed later in this document.

All batteries must undergo at least a spark ignition test in order to be considered acceptable power sources. In many situations, additional testing is required prove compliance.

SAFETY TIP: Just because a AA battery may fit into your IS device and can indeed power it, if the battery isn't specified as acceptable by the device manufacturer, then the device itself is no longer certified for use in the classified (hazardous) area,.

Transducers

The critical ultrasonic transducers themselves must be protected to prevent a voltage being created at the leads when the transducers are subjected to series of severe impacts. Even the cable itself must be supported regularly to prevent shorting between conductors that may cause a spark.

Testing for these protections is a requirement for any transducer certified for use in a classified area, whether or not it is field removable. The test results usually demonstrate the need for custom-made transducers with built-in protection.

Pulser/receiver

Once the transducer itself is protected, the pulser circuit must be evaluated to prevent an excitation voltage that is in excess of the protection circuitry.

For example, a standard non-intrinsically safe ultrasonic testing meter uses around a 100V pulse to generate ultrasound waves via the transducer, whereas

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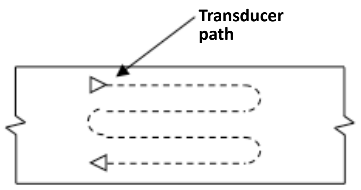
Corrosion inspection

Using an ultrasonic tester for corrosion testing is more complex and requires a more capable device. Corrosion testing generally requires the transducer to be moved in a snake motion within a 100mm x 100mm box on a specific area of interest. See Fig 1.3.

The device will monitor the thickness reading across the path and provide the user with a max, min and average reading so that it is possible to define areas of pipe wall thinning quickly and easily.



The snake shape transducer path enables corrosion to be detected early by using max/min and average readings taken across the path, a must for any NDT professional.

Fig 1.3 Corrosion inspection path using UT equipment

an intrinsically safe device must operate at a much lower voltage to comply with the power limitation requirements.

The result is that in order to achieve the penetration and accuracy required, extremely high-tolerance, high-sensitivity transducers must be designed not only to comply with the impact testing requirements of the standard, but also to react to pulses at a much lower voltage.

Screen/display

Wouldn't we all like a high-resolution, full-color backlit display for use in low-light areas with multiple readings? But how does this requirement impact equipment certified as intrinsically safe? As always, it all comes down to power. Because an intrinsically safe device has to be sure its power is limited to non-incendiary levels, addition of a backlight is a challenge, especially when coupled with a high-resolution, multi-function display.

High-specification protection systems must be designed and implemented in order to provide users with a device that is both functional and flexible enough to be upgradeable without replacing components.

Alternative options could include low-cost LED matrix displays, which are simpler to protect but have less functionality and upgradeability.

Communications

If a device stores data to be downloaded to a PC or other device, the communication port, such as a USB connection, should be protected to prevent mains voltage being applied and damaging the internal protection. Although the standard allows manufacturers to specify a maximum input voltage, this is more of a "get-out" rather than a means to provide true protection.

Users can check this by either asking the manufacturer, checking the device itself or consulting its Safe Operation Manual for an indication of the level of protection provided.

Generally, higher-quality devices incorporate protection within the communications circuitry, which protects the safety of the device – and therefore your plant – even if a mains voltage is inadvertently applied to the communication line.

Additional communication and location options, such as RFID scanners, provide additional certification challenges for a manufacturer, because stored power must be accounted for and protected against, again to prevent ignition sources.

Bottom line: wherever there is power, there must be protection. Where higher voltages are used, special protection must be designed to ensure the device is always in a safe condition, even if there is a short circuit failure.

In the field

Now that we have a snapshot of the requirements of an intrinsically safe ultrasonic tester, what benefit does such a device provide?

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- **Most important of all, we do not need any hot work permits to operate. We can come and go within the classified area as we please, saving valuable time and money, even as we help keep personnel safe by reducing the risk of explosions.**
- **We have a device that provides an invaluable NDT function that is flexible enough to be used in a variety of areas.**
- **And we have a high-quality device that performs basic functions in ways that save time and money.**

Trending and reporting

Taking thousands of measurements across a plant is a daunting task for any inspector. Even though some safe area ultrasonic testers store data for download to a PC, such a large number of measurements present inspectors with another problem: How do they know where each measurement was taken? Record a measurement number by hand? Type a location into the device each time it takes a reading?

Recent advances in RFID technology offer a better solution: devices that include a tag scanner that can automatically record the location of each individual reading and all the parameters associated with the reading, for later analysis and reporting.

This advance in automation technology significantly reduces the time required to consolidate data and create a trend, a significant cost saving in both manpower and the cost of potential failures that are prevented due to forecasting.

Conclusion

So, as we review all these capabilities and factors, how important are intrinsically safe ultrasonic testers?
As a baseline, a device that automates simple tasks as much as possible is a must for any petrochemical professional.

Add the advantages of RFID technology to capture location and test information, Smart PC software to store data, and intrinsically safe certification that removes the requirement for hot work permits, and an intrinsically safe ultrasonic tester becomes an indispensable tool for petrochemical professionals.

With offices in the UK and US, CorDEX Instruments has an expanding global distribution network.

For more information and customer testimonials, contact...

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