INTRINSICALLY SAFE ULTRASONIC SENSING

Sage Miles, Migatron Corp., USA, outlines how intrinsically safe ultrasonic sensors are advancing precision measurement and safety in hazardous mining environments.

Within the mining industry, there is an increased need for mining equipment that is intrinsically safe. Whether underground or above surface, there are many areas that can accumulate methane gas and combustible coal dust in the atmosphere that could increase serious ignition risks in an explosive environment.

The multiple challenges of dust, gas, and motion

When it comes to certain applications that require object detection,

distance measurement, or material handling, engineers and OEMs are constantly searching for sensing technologies that not only deliver accurate and reliable readings, but are also designed particularly for hazardous locations. Because of this, coal mine workers are specifically in need
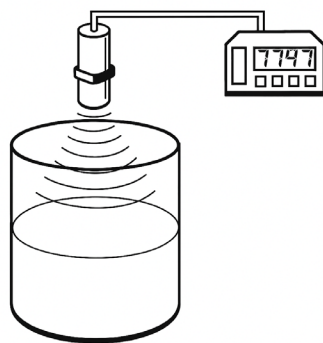

Figure 1. Migatron's product line of intrinsically safe ultrasonic sensors built for explosive environments and hazardous areas.
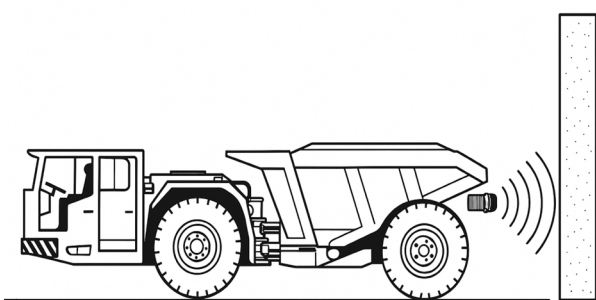
Figure 2. Distance measurement.
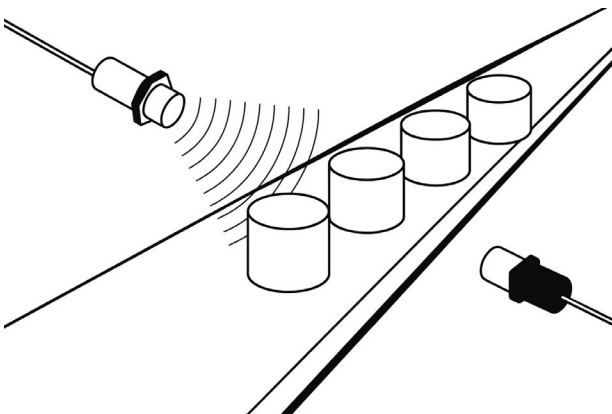
Figure 3. Object detection.

Figure 4. Gauging fluid level.

of sensors that are intrinsically safe, so that way they can be used in areas that might be filled with firedamp or coal dust. Compared to intrinsically safe enclosures, IS devices avoid heavy housings, simplify maintenance, and allow live work without gas clearing. Non-contact measurement further reduces mechanical ignition sources, such as probe friction or jammed paddles.

For over 20 years, Migatron Corp. has developed intrinsically safe ultrasonic sensors that are approved for use in areas that are exposed to firedamp and coal dust. These sensors are engineered to provide accurate measurements in explosive atmospheres and hazardous locations, along with the durability required by manufacturers operating in such environments. Recognising the growing need for intrinsically safe equipment in the coal mining industry, Migatron has introduced its intrinsically safe ultrasonic sensor solutions to engineers and OEMs, enabling them to obtain precise measurements in these hazardous areas.

Ultrasonics + intrinsic safety

Ultrasonic signals are like audible sound waves, but they give off higher frequencies. Compared to time-of-flight radar, ultrasound is immune to dielectric-constant shifts and is less affected by build-up on antenna faces. When it comes to ultrasonic sensors, they use ultrasonic waves to measure distance (Figure 2), detect objects (Figure 3), or gauge fluid levels (Figure 4) by emitting high-frequency sound waves and analysing their reflections. In silos with foam or soft coal blends, laser and radar beams often pass through voids above the bulk, whereas ultrasonic echoes return from the first solid surface, providing a conservative, safety-oriented reading.

Through these short bursts of ultrasonic waves, they can measure the time it takes for the waves to bounce back after hitting the object. They shoot out the waves, wait for them to hit something, and count how long it takes for them to come back. Using this time and the known speed of sound, the sensor can determine distances without any physical contact – an especially valuable feature for coal mining applications like conveyor belt alignment, collision detection systems, and measuring cake thickness levels. Additional advantages of ultrasonic sensing technology include:

- Discrete distances to moving objects can be detected and measured.
- Less affected by target materials and surfaces, and not affected by colour.
- Solid-state units have virtually unlimited, maintenance-free life.
- Can detect small objects over long operating distances.

- Resistance to external disturbances, such as vibration, infrared radiation, ambient noise, and EMI radiation.

Within the coal mining industry, there are many environments where confined ventilation areas can fill up with flammable gases and combustible coal dust, requiring coal mine workers to use mining equipment that is specifically built to be explosion resistant. In order to be used in these challenging conditions, certain pieces of equipment must be thoroughly tested so that they can be approved for intrinsically safe use in these environments. A typical IS ultrasonic assembly encapsulates the piezoelectric transducer in polymer (PVC or PPS) to eliminate sparking contacts.

Migatron Corp. has ensured that its ultrasonic sensors are not only reliable and durable, but also specifically engineered for use in explosive environments and hazardous locations. Their product line of intrinsically safe ultrasonic sensors are approved for intrinsic safety in Australia and New Zealand (ANZEx), Europe (ATEX), internationally (IECEx), North America (C-UL-US), as well as MSHA (approval pending). Built with IP66/IP67 rated enclosure, these ultrasonic sensors are designed to be relied on and to last long even in intense conditions. With an Ma equipment protection level (Ex ia I Ma), they can remain energised and operational in coal mines that are filled with firedamp and/or coal dust. These intrinsically safe ultrasonic sensors are also designed to meet the highest level of intrinsic safety, allowing it to be deployable in Zone 0, 1, 2, 20, 21, or 22 explosive atmospheres and Class I, II, III hazardous locations. Coal mine workers and engineers value having the right sensing technology that gives the right measurements they need, but it is especially valuable when the ultrasonic sensors that are being used are approved for intrinsically safe use, allowing it to be used in areas where firedamp and coal dust fills up the environment.

Application solutions

From conveyor belts to heavy machinery, the coal mining industry includes many applications that have the mining equipment involved put thoroughly to the test. In some aspects of the industry, having the right sensing technology is essential when certain applications require the need for accurate measurements or simply detecting oncoming objects, such as distance ranging for mining equipment or detecting misalignment on conveyor belts. However, in areas where methane gas and coal dust may saturate the environment, intrinsically safe sensors are essential for safe operation in these hazardous locations. Migatron Corp.'s product line of intrinsically safe ultrasonic sensors are designed specifically

to provide the needed solutions for these applications, even in challenging circumstances; they are designed to not only be durable, but to provide precise measurements for the application.

Conveyor belt alignment is crucial for maintaining efficiency in the coal mining industry. If some pieces are out of place, this could lead to spillage, damage to the belt itself, and unwanted interruptions. In areas that are prone to have firedamp and coal dust in the air, engineers and OEMs require the right sensing technology that can stay operational over a period of time within a hazardous location. With that in mind, Migatron Corp. engineer their intrinsically safe ultrasonic sensors to address these challenges. When mounted overhead near the belt's edge, the ultrasonic sensor will continuously measure the belt position using ultrasonic pulses, transmit the analog output to PLC, and will enable real-time correction to reduce the odds of belt drift, wear, and potential stoppages.

Coal bunkers and silo levels are utilised throughout the industry, also requiring efficiency and consistency. Bunker volumes may exceed 2000 m^3, and the filling cycle can produce dust densities above 500 mg m^{-3}. When an intrinsically safe ultrasonic sensor is mounted 0.5 m below the roof beam, angled <5°, it prevents false echoes from the opposite wall. Engineers typically select a sensing range 20% longer than the bunker height to reserve headroom for dust attenuation at warm temperatures (sound velocity increases ≈0.17 % K-1). Comparative tests at Midwest power stations showed that an intrinsically safe ultrasonic unit with 70 kHz transducer maintained ±2% full-scale accuracy after 72 hours of continuous reclaim, matching TDR probes but without mechanical wear.

Other applications within the coal mining industry require sensing technology that can detect an object or material from a certain distance. For

Figure 5. Migatron's RPS-409A-40P-MSHA.

engineers, accurate sensor readings are essential in applications such as detecting cake thickness, enabling collision avoidance systems, and other similar tasks. Migatron Corp. provides a line of intrinsically safe ultrasonic sensors with a variety of sensing ranges available. Depending on how thick the cake needs to be, or what the specifications are for the collision detection systems, these ultrasonic sensors enable engineers to receive the pinpoint, trustworthy readings they need without worrying about physical contact between the sensor and the object. No matter what the application is, Migatron's ultrasonic sensors offer accurate, non-contact distance measurements with approvals for intrinsically safe use in explosive environments and hazardous locations.

Case study: Ensuring conveyor belt alignment in underground mining

An OEM specialising in advanced underground mining equipment – and a leader in the design and manufacture of heavy-duty machinery for the mining industry – required an intrinsically safe ultrasonic sensor to monitor conveyor belt alignment within MSHA-regulated mining environments. The solution had to withstand firedamp and coal dust while offering accurate detection and easy integration into existing systems to reduce downtime. Migatron Corp. collaborated closely with the OEM's engineering team over a multiple-year period to develop a custom solution using two RPS-409A-40P-MSHA intrinsically safe ultrasonic sensors (Figure 5).

Features
- Analogue voltage output (0-10 VDC) for real-time distance measurement.
- IP67-rated housing to protect against harsh conditions.
- Temperature compensation for accuracy across underground climate variations.
- MSHA approval.

To achieve MSHA approval, the system included an MSHA approved safety barrier, a DIN-rail mounted component for use with RPS-409A-40P-MSHA ultrasonic sensors.

Results
- Accurate, non-contact alignment monitoring of critical conveyor belt systems.
- Operational safety with MSHA compliance.
- Minimised wear and maintenance through immediate detection of misalignment.
- Seamless integration with their PLC-based control systems.

This collaboration allowed the customer to confidently operate machinery in environments where safety and consistent operation are paramount – setting a new standard for precision sensing in the mining industry.

Conclusion

The need for intrinsically safe equipment and accessories within the coal mining industry continues to grow, including sensing technology. Intrinsically safe ultrasonic sensing offers coal operators a mature, field-proven solution that combines regulatory compliance with reliable measurement under extreme circumstances. With that in mind, Migatron Corp. continues to make sure to provide its customers with solutions for their applications by means of its product line of intrinsically safe ultrasonic sensors. Even in explosive atmospheres and hazardous locations, engineers and OEMs can be confident that these sensors will be functional with its reliability and durability, while also providing precise measurements for their sensing applications. By using certified ultrasonic sensors, engineers can simultaneously mitigate explosion risks – delivering measurable uptime and safety gains without invasive mechanical devices. *WC*