



Achieving Enhanced Gas Sensing Capabilities for Improved Performance

XCell® Sensor Technology for Industrial Safety Applications



**SAFEGUARDING PEOPLE,
PLACES & THE PLANET.**

Introduction

Fixed gas detection is a cornerstone of industrial safety, particularly in environments where exposure to hazardous gases can lead to accidents, health complications, or environmental catastrophes. Industries such as oil and gas, chemical processing, and manufacturing are at constant risk of gas leaks and emissions. As a result, reliable, long-lasting, and accurate gas detection systems are an important consideration for maintaining a safe operational environment. MSA's XCell® sensors, designed specifically for fixed gas detection, represent a significant technological advancement in this area. This document delves into the technical intricacies of XCell sensors, highlighting their innovations, applications, and performance benefits in the context of fixed gas detection.

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■ The Valuable Role of Fixed Gas Detection in Industry

Fixed gas detection systems are permanently installed devices that continuously monitor the atmosphere for dangerous levels of gases. Unlike portable gas detectors, which are used for spot-checking and individual safety, fixed systems can provide uninterrupted, automated monitoring, making them indispensable for large industrial complexes.



These systems are designed to detect a variety of hazardous gases, including:

- **Combustible Gases:** Methane, propane, hydrogen, and other gases that present a risk of explosion or fire.
- **Toxic Gases:** Gases like ammonia (NH_3), carbon monoxide (CO), hydrogen sulfide (H_2S), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and chlorine (Cl_2), which can pose serious health risks even at low concentrations.
- **Oxygen Deficiency/Enrichment:** Maintaining safe oxygen (O_2) levels is important in confined spaces, environments where inert gases like nitrogen are used, or areas prone to oxygen enrichment.

Each of these gases presents unique detection challenges, calling for sophisticated sensor technology that can respond quickly, accurately, and reliably over long periods. The failure to detect hazardous gas levels in time can result in devastating consequences, including explosions, asphyxiation, or long-term/life threatening health impacts from toxic exposure.

■ Challenges in Traditional Gas Detection Technologies

Traditional gas detection sensors face numerous limitations that impact their reliability, cost-efficiency, and lifespan. These include:

- **Frequent Calibration and Replacement:** Traditional sensors often require frequent calibration due to sensor drift and degradation over time. Additionally, many sensor types degrade more rapidly in harsh environments, leading to frequent replacement.
- **Susceptibility to Environmental Factors:** Temperature fluctuations, humidity, and electromagnetic interference (EMI) can all impact the accuracy and performance of gas detection sensors.
- **High Maintenance Costs:** The need for regular maintenance, including calibration gas, sensor replacement, and system downtime, can significantly increase the total cost of ownership (TCO) for gas detection systems.



These limitations drove the development of MSA's XCell sensors, which address many of the shortcomings of traditional designs while offering enhanced performance and long life.

■ XCell Sensors: A Revolutionary Approach to Fixed Gas Detection

MSA's XCell sensors were developed to deliver outstanding performance in industrial gas detection systems. By integrating advanced sensor technologies, proprietary materials, and custom-designed electronics, XCell sensors achieve higher levels of accuracy, durability, and reliability compared to many conventional sensor designs. The core technologies that make XCell sensors stand out include:



- **Advanced Electrochemical and Catalytic Designs:** Optimized for detecting toxic gases, oxygen, and combustible gases, these sensors offer enhanced accuracy and longevity in harsh environments.
- **Application-Specific Integrated Circuit (ASIC) Technology:** Enhances signal processing and reduces susceptibility to environmental factors.
- **Proprietary Filters and Materials:** Extend sensor life by improving resistance to environmental poisons and helping to achieve consistent performance across a wide range of operating conditions.

These technological advances help XCell sensors to operate effectively even in extreme industrial conditions, delivering reliable gas detection with fewer maintenance requirements and lower long-term costs.

Core Technological Advancements in XCell Sensors

XCell sensors incorporate several cutting-edge technologies that enhance their performance in fixed gas detection applications. These include:

1 Application-Specific Integrated Circuit (ASIC) Technology

ASIC technology is a cornerstone of MSA's proprietary XCell sensor design. An ASIC is a custom microchip (*Figure 1*) designed specifically to optimize the sensor's operation, providing several key advantages:



Figure 1: ADDING MICROELECTRONICS inside the sensors provides more control and higher performance than previous generations.

- **Enhanced Signal Processing:** The ASIC is responsible for amplifying and digitizing the analog signal from the sensor. By converting the sensor output into a digital signal at the sensor level, XCell sensors reduce noise and interference, enabling a cleaner and more accurate signal to be sent to the gas detection system.
- **Temperature Compensation:** ASIC technology allows for more precise temperature compensation, enabling sensor readings to remain accurate even in environments with extreme or fluctuating temperatures. Traditional sensors rely on external temperature sensors, which can introduce errors if the sensor and the electronics are at different temperatures. In contrast, the ASIC in XCell sensors is integrated directly with the sensing element, enabling real-time and accurate temperature adjustments.
- **Minimized Electromagnetic Interference (EMI):** Fixed gas detection systems often operate in environments with significant electrical noise, such as factories or power plants, where motors, radios, and communication devices generate electromagnetic interference. The ASIC in XCell sensors digitizes the signal early in the process, making the sensors more resistant to EMI and radio frequency interference (RFI), thereby improving the stability of gas readings.
- **Faster Sensor Response:** The integration of ASIC technology enables faster sensor response times by optimizing the flow of data between the sensor and the gas detection system's control unit. This rapid detection is important in high-risk environments where timely responses can help to prevent accidents or dangerous exposures.

2 Innovative Sensor Design for Enhanced Durability and Performance

Each type of XCell sensor is designed to meet the specific demands of the gases they are intended to detect, incorporating proprietary materials and engineering techniques to optimize performance.

Combustible Gas Detection Using Catalytic Bead Technology

XCell combustible sensors use catalytic bead technology (*Figure 2*) to detect combustible gases such as methane, propane, and hydrogen. The sensor components consist of a pair of platinum heating coils embedded in a catalyst. When combustible gases contact the catalyst, they oxidize, releasing heat. This heat changes the resistance of the wire, and the change in resistance is measured and converted into a gas concentration reading. Key design features of **XCell combustible sensors** include:

- **Larger Bead Design for Longer Life:** Traditional catalytic bead sensors use smaller sized beads, which make them more prone to wear and tear from continuous exposure to high temperatures during oxidation reactions. As the beads degrade, the sensor's ability to function diminishes, leading to a shorter lifespan. The XCell combustible sensors utilize a pair of beads with larger surface areas for a faster response time and improved sensitivity to combustible gases. The unique and proprietary bead control design significantly increases the sensor's operational life and reduces the frequency of replacement.
- **Protection Against Vibration and Shock:** Many catalytic bead sensor designs lack the structural reinforcement needed to withstand the shock and vibration common in industrial environments. Without proper support, the fine platinum wire inside the bead is more susceptible to damage, which can shorten sensor life and compromise reliability. XCell sensors address this weakness with a rugged mechanical support post that stabilizes the bead and helps protect against mechanical stress. This added durability not only extends the operational life of the sensor but also ensures more consistent performance over time—making it a more dependable choice for tough applications.
- **Long-Term Zero Drift with Glass Coating:** XCell combustible detectors utilize a pair of beads, where one bead is glass-coated to remain inert and serve as a stable reference bead. This reference bead provides a baseline signal to compensate for environmental changes, such as temperature and humidity shifts, ensuring minimal long-term drift. The glass coating helps to eliminate the need for compensating resistors, which can cause operational drift, enhancing the sensor's long-term stability and accuracy.

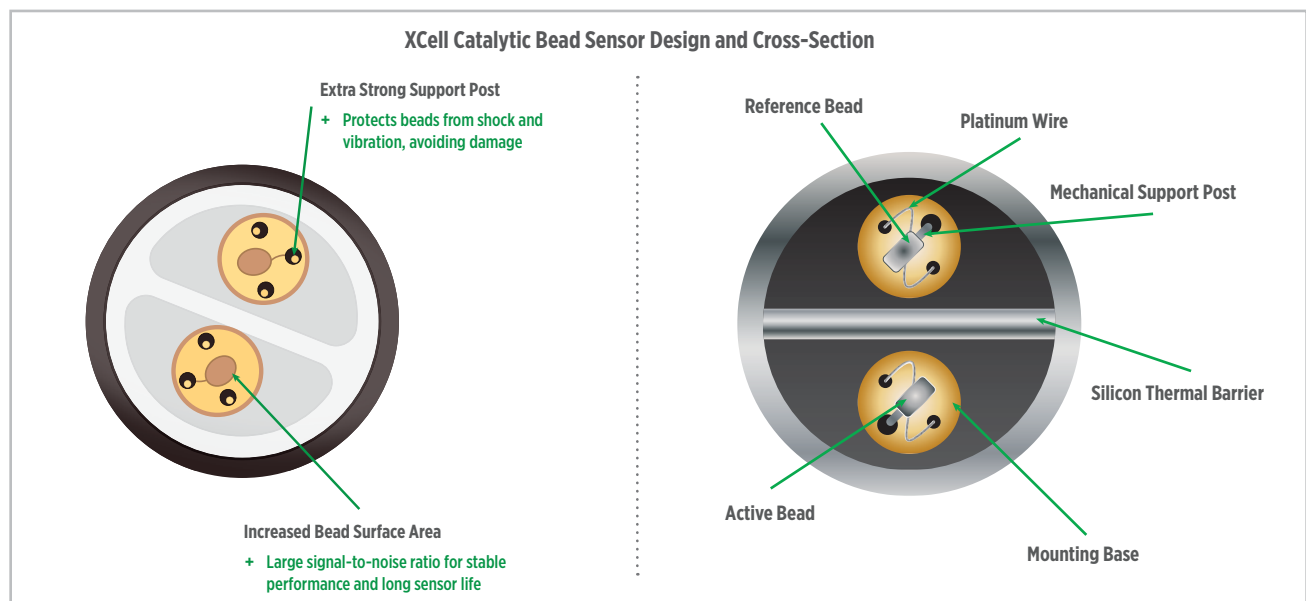


Figure 2: CATALYTIC BEAD SENSOR DESIGN showcasing durable construction and precision components that support best-in-class gas detection performance.

Electrochemical Sensors for Toxic Gas Detection

XCell electrochemical sensors are used to detect toxic gases such as carbon monoxide (CO), hydrogen sulfide (H₂S), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), ammonia (NH₃), and chlorine (Cl₂). These sensors operate based on an electrochemical reaction that occurs when the target gas comes into contact with the working electrode of the sensor. This reaction generates a current proportional to the gas concentration, which is then measured by the sensor (*Figure 3*).

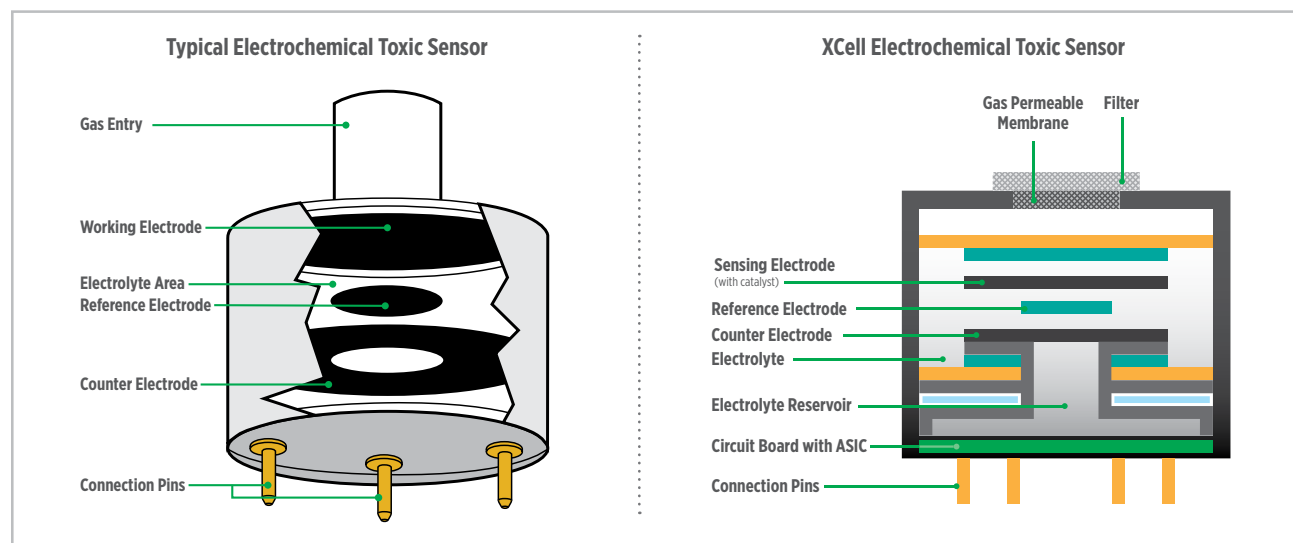


Figure 3. THE MECHANICAL DESIGN of the XCell sensor is optimized for the most effective interaction between the electrolyte catalyst and target gas, regardless of environmental conditions to overcome.

Key features of **XCell electrochemical sensors** include:

- **Optimized Electrochemistry for Greater Sensitivity:** XCell sensors use carefully selected catalyst and electrolyte materials that maximize the sensitivity of the sensor to the target gas. This results in highly accurate readings, even at low gas concentrations.
- **Humidity Compensation:** Electrochemical sensors can be sensitive to changes in humidity, which can affect the transport of gas molecules to the sensing element and lead to false readings. XCell sensors are designed with proprietary gas and electrolyte barrier systems that mitigate the effects of humidity, providing more stable readings in environments with fluctuating moisture levels.
- **Longer Operational Life:** XCell electrochemical sensors are engineered to maintain their sensitivity over longer periods, reducing the need for frequent recalibration or sensor replacement. Using ionic liquids in the design of XCell electrochemical sensors significantly extends sensor life by addressing the limitations of traditional aqueous electrolytes. Unlike water-based solutions, ionic liquids are non-volatile and do not evaporate over time, preventing electrolyte drying—a common cause of sensor failure. They also offer superior thermal stability, allowing sensors to operate reliably across a wider temperature range without compromising performance. Additionally, ionic liquids are more chemically resistant to contaminants and interfering gases, reducing the risk of electrolyte degradation or sensor poisoning. This enhanced stability helps preserve the sensor's sensitivity and accuracy over time, resulting in less drift, longer calibration intervals, and an overall longer operational life.
- **TruCal Sensing Technology:** For hydrogen sulfide (H₂S) and carbon monoxide (CO) detection, TruCal® sensors enhance standard XCell electrochemical sensors by adding Advanced Environmental Compensation (AEC) and optional Diffusion Supervision. These features work together to maintain sensor accuracy by compensating for environmental fluctuations, reducing the need for manual calibration, and verifying that the sensor is exposed to ambient air—ensuring long-term reliability in demanding applications. Learn more about TruCal sensing technology [here](#).

Oxygen Sensors for Fixed Gas Detection Systems

Unlike traditional lead-based oxygen sensors that rely on chemical reactions consuming their reactive materials, XCell oxygen (O_2) sensors use a non-consuming mechanism which helps to ensure that the core reactive elements do not deplete over time. This makes them a reliable choice for continuous monitoring in industrial settings.

Key benefits of **XCell oxygen sensors** include:

- **Lead-free Optimized Design:** The operational process of oxygen detection for XCell sensors involves two primary stages (Figure 4):
 1. **Reduction at the Working Electrode:** When oxygen enters the sensor, it undergoes a reduction reaction at the working electrode, where it is converted into water by gaining electrons. This reaction is important for detecting oxygen levels with precision, especially in low-oxygen or oxygen-deficient environments.
 2. **Oxidation at the Counter Electrode:** The water molecules generated at the working electrode then move to the counter electrode, where they undergo an oxidation reaction, returning to oxygen, thus completing the non-consuming reaction cycle.
- **Extended Lifespan:** With no reactive material consumption, the XCell oxygen sensor can last significantly longer, with operational lifespans exceeding 5 years compared to the 18-24 months typical of lead-based sensors. This reduces the need for frequent sensor replacements and can lower overall maintenance costs.
- **Consistent Performance:** The cyclic reduction-oxidation process allows for sustained accuracy in oxygen detection, even in fluctuating environmental conditions such as temperature and humidity changes, which are common in industrial settings.
- **Minimized Downtime:** With a longer operational life, there is less need for maintenance, calibration, or replacement, which minimizes downtime in critical operations, such as in chemical plants, confined spaces, and industrial manufacturing.

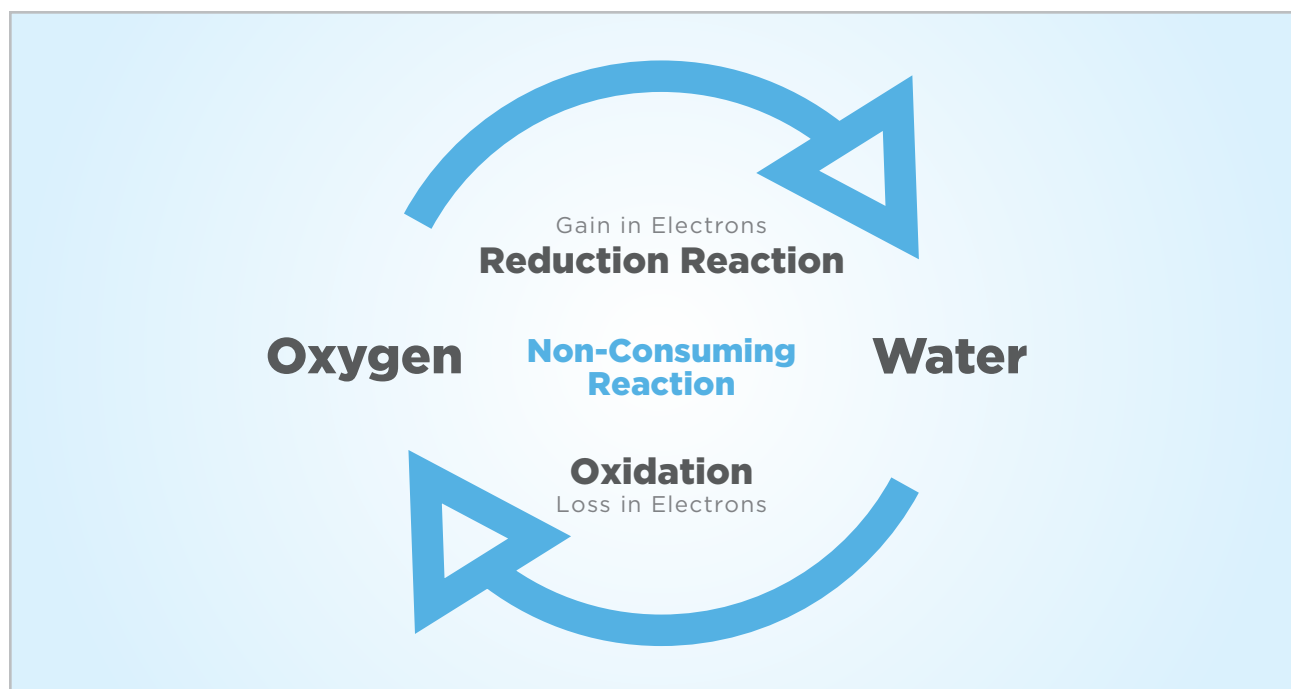


Figure 4: THEORY OF OPERATION: **Step 1:** Undergoes reduction reaction at the working electrode and turns into water. **Step 2:** Water molecule travels to the counter electrode where it is oxidized back to oxygen.

3 Cross-Sensitivity Mitigation and Enhanced Selectivity

Cross-sensitivity refers to a sensor's response to gases other than the target gas. For instance, a carbon monoxide (CO) sensor may also respond to hydrogen (H₂), leading to inaccurate readings in environments where both gases are present. XCell sensors are designed to minimize cross-sensitivity through:

- **Selective Filters:** Each sensor is equipped with filters that block interfering gases, helping to enable that the sensor only responds to the target gas. For example, XCell CO sensors use a carbon filter to reduce cross-sensitivity to hydrocarbons and volatile organic compounds (VOCs).
- **Custom Catalyst and Electrolyte Pairing:** By carefully selecting the materials used in the sensor's electrochemical cell, MSA engineers have optimized the selectivity of XCell sensors, allowing them to differentiate between gases more effectively.

4 Proprietary Filters for Enhanced Poison Resistance

Sensor poisoning occurs when a gas other than the target gas reacts with the sensing element in a way that permanently reduces its sensitivity. Common poisons include silicone vapors and sulfur compounds, which can deactivate catalytic bead sensors and reduce the lifespan of electrochemical sensors. XCell sensors incorporate advanced filtering technology to help protect against these poisons:

- **Silicone Scrubber:** Combustible sensors, in particular, are vulnerable to poisoning by silicone vapors, which are present in many industrial lubricants and sealants. XCell combustible sensors are equipped with a pressed-pellet silicon scrubber that help remove silicone vapors before they reach the sensing element.
- **Sulfur Scrubber:** Many toxic gas sensors, including those for H₂S and SO₂, are susceptible to poisoning by sulfur compounds. XCell sensors use an active chemical filter to remove these compounds, helping to ensure longer sensor life and more accurate readings.

Cost-Effective Calibration and Maintenance

Calibration is an important maintenance task for any gas detection system, helping sensors remain accurate over time. However, calibration can be costly, particularly in systems with a large number of sensors that require frequent recalibration.

XCell sensors are designed to reduce calibration costs:

- **Longer Calibration Intervals:** XCell sensors are engineered to maintain their accuracy over longer periods, helping to reduce the frequency of recalibration. This can be particularly important in remote installations or hazardous environments where access to the sensors is limited.
- **TruCal 2-year Calibration Intervals:** XCell sensors with TruCal technology automatically and periodically perform self-checks on the sensor and monitor inlet for blockages without user intervention or the application of calibration gas for up to two years. This is accomplished by combining an internal electronic interrogation of the sensor functionality (Pulse Check) with an acoustic system which monitors the flame path (sinter/frit) for blockages, which would prevent gas from reaching the sensor (Diffusion Supervision). Interpreting the results of these two tests and either adjusting the sensor's sensitivity or alerting the end user the sensor's inlet is blocked, is automatically performed every six hours without any user intervention.

Case Study: Fixed Gas Detection in Oil and Gas Refining

The oil and gas refining industry presents one of the most challenging environments for fixed gas detection systems. Refineries are large, complex facilities where combustible and toxic gases may be present at every stage of the refining process, from crude oil distillation to product storage. A facility operator may employ continuous monitoring to detect leaks and help prevent catastrophic accidents, such as fires, explosions, or toxic gas releases.

Challenges:

- **High-Temperature Environments:** Refining processes often operate at elevated temperatures, which can affect sensor performance.
- **Exposure to Corrosive Gases:** Hydrogen sulfide (H_2S) is a common byproduct in refining and is highly corrosive to many materials, including sensors.
- **Desire for Fast Response Times:** In a refinery, the ability to detect a gas leak within seconds can mean the difference between a safe evacuation and a disaster.



Solution:

XCell sensors were an excellent choice for use in oil and gas refineries due to their robustness and enhanced performance characteristics:

- **Temperature Compensation:** The ASIC in XCell sensors helped enable the sensors to remain accurate even in high-temperature environments, making them reliable in refinery applications.
- **Durability:** In the harsh environment of the refinery, the XCell sensors demonstrated exceptional durability. With more rugged catalytic beads, the sensors lasted 5+ years, compared to an average life of 2–3 years for traditional sensors. This resulted in fewer sensor replacements and reduced maintenance downtime.
- **Lower Total Cost of Ownership:** Factoring in reduced calibration gas cycles for its H_2S sensors, fewer sensor replacements, and extended maintenance intervals, the refinery estimated a 20–30% reduction in the total cost of ownership for its gas detection systems, translating into savings of approximately \$50,000 over 5 years.

These technological enhancements enable XCell sensors to function reliably in the most demanding industrial environments, reducing the need for frequent maintenance and significantly lowering long-term operational costs.

Conclusion

MSA's XCell sensors represent a significant advancement in fixed gas detection technology. By integrating ASIC technology, optimized sensor designs, and proprietary filtering systems, XCell sensors offer enhanced performance, extended operational life, and lower total cost of ownership compared to traditional sensors. These features make XCell sensors an ideal choice for industries that require continuous monitoring of combustible and toxic gases, such as oil and gas, chemical manufacturing, and pharmaceuticals.

With their ability to withstand harsh environmental conditions, resist sensor poisons, and reduce maintenance costs, XCell sensors can provide a reliable and cost-effective solution for industrial gas detection. By investing in XCell sensor technology, companies can enhance safety, improve operational efficiency, and reduce long-term costs.

For more technical specifications and detailed product information, please contact MSA's technical support team or msasafety.com/detection for the latest resources.

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