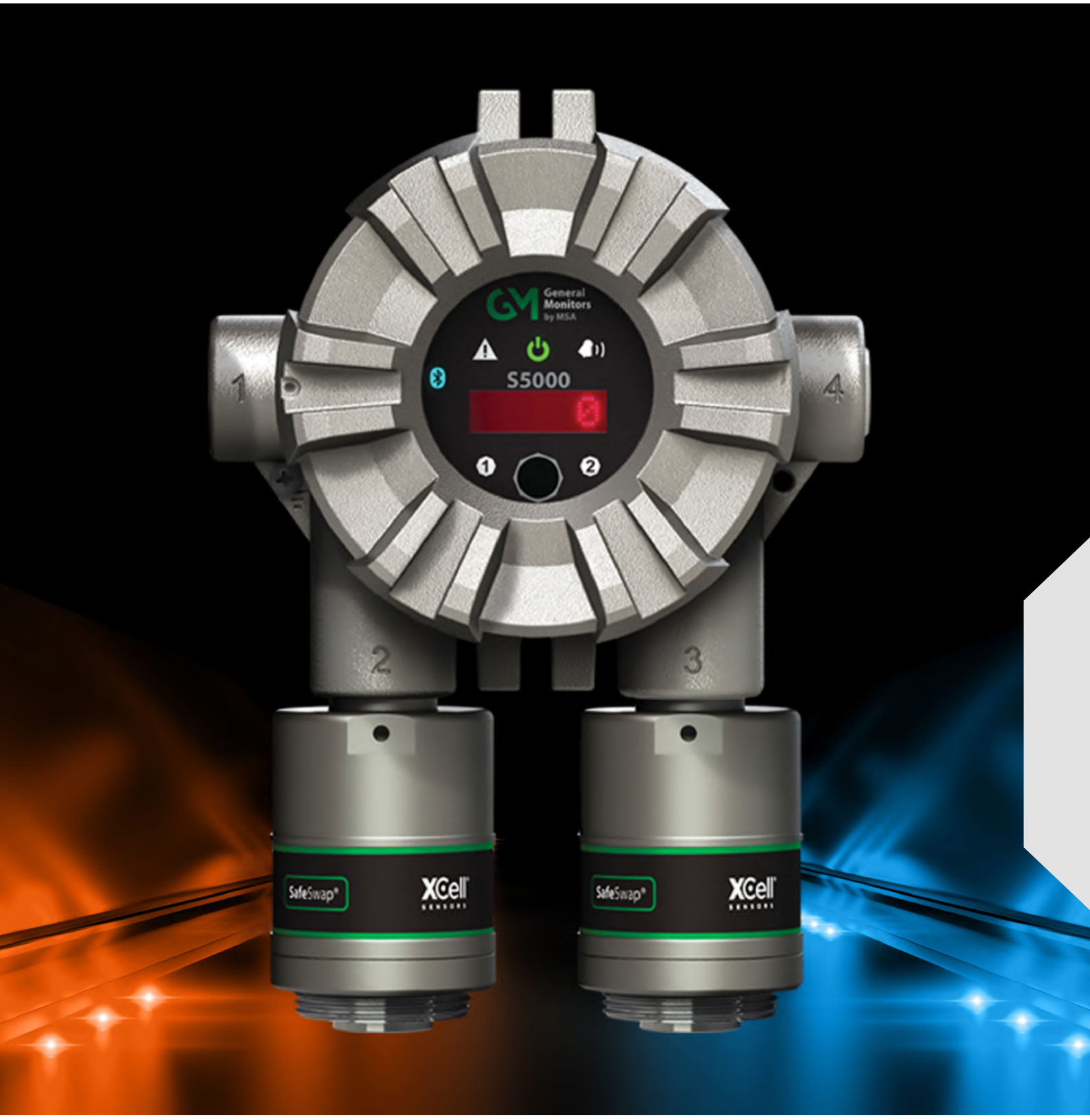
Upgrading from MOS to Electrochemical Sensors for Hydrogen Sulfide Gas Detection

Technical White Paper

MSA
The Safety Company



WE KNOW WHAT'S AT STAKE.

This paper is intended for users of MOS (Metal Oxide Semiconductor) H_2S gas monitors, who are considering upgrading to the latest technology that is now available. It will cover a brief history of H_2S gas detection, the advantages and disadvantages of both the MOS and the traditional Electrochemical sensors and the technology behind the features and benefits of the latest H_2S Electrochemical sensors.

History

In 1972, when General Monitors (acquired by MSA Safety in 2010) launched the world's first fixed gas monitor using a MOS sensor to detect H_2S, it soon became the preferred sensor technology for many users around the world. This was particularly the case in countries with extremely hot climates, where the traditional Electrochemical sensors were not performing particularly well.

The advantages that the new MOS sensor technology offered over the legacy Electrochemical sensors, were:

- **Higher operating temperature:** up to +75˚C, compared to the typical temperature range of +40°C to +50°C.
- **Longer operating life,** especially in hot climates when Electrochemical sensors may have an operating life of less than 12 months.
- **Longer shelf-life,** as unlike the Electrochemical sensor, the effective life of the MOS sensor did not start from the day it was manufactured, but from when it was installed. This also meant the MOS sensor had a longer warranty, which was 2-years from date of shipment.
- **Faster recovery** than Electrochemical sensors after being exposed to high concentrations of H_2S. Some Electrochemical sensors may never recover when exposed to high concentrations for an extended period.
- MOS sensors were **not affected by being regularly exposed to low levels of background H_2S**, unlike the traditional "consuming" Electrochemical sensors.
- **Better performance** than Electrochemical sensors in very **dry climates with low humidity levels,** which affected the Electrochemical sensor's stability and operating life.
- Because of these benefits, users quickly found the new MOS sensors also offered them a **lower cost of ownership,** as they would not need to replace their sensors as frequently as they did with the Electrochemical sensors.

MOS sensors had the above mentioned benefits over the legacy Electrochemical sensors, but users often found that the MOS sensors had the following limitations:-

- The MOS sensor was slow to respond to low concentrations of H_2S gas, typically below 50 ppm and lower which was used for calibrations. This would lead some customers to prematurely replace sensors.
- To avoid moisture affecting the sensor, it was important to always keep the desiccant bag close to the sensor's inlet when the detector was not powered up. This may sometimes be overlooked, as the desiccant bag and red cap to hold it in place had been discarded after installation/commissioning.
- MOS sensors' zero was very stable, but the span could drift and require more frequent calibrations to adjust its sensitivity.
- The poisoning of MOS sensors by a limited range of substances was also possible, which was not the case for Electrochemical sensors.
- Although the General Monitors MOS sensor was not affected by paint fumes, lubricant aerosols or Methane, some MOS sensors were affected and either lost sensitivity or would give a false gas alarm.
- In the event of poisoning or other forms of contamination that could affected the sensor's performance, the MOS sensor, being a passive sensor, was unable to automatically monitor its condition and ability to respond to gas. As MOS sensors were not capable of initiating a fault signal if it could not detect gas, they were not Fail-Safe sensors.
- A common disadvantage of both the MOS and the traditional standard Electrochemical gas detectors was that neither detector could initiate a fault signal when the sensor had reached the end of its life and was no longer capable of detecting H_2S gas.
- Due to the issues relating to drift and the possibility of it not being able to detect gas, it was often recommended to calibrate the MOS sensor between every 1 and 3 months; depending on the environment and whether they were located in a manned or unmanned area.

The development of new sensor technology

In the last few years, there have been several significant improvements in H_2S sensor technology. The new generation of H_2S sensors offer the user a high level of safety with **fail-safe capability,** but at the same time due to the revolutionary technology, they also offer the user the benefit of a **lower cost of ownership.**

MSA started the R&D project to design a new H_2S sensor in 2013. Like all MSA projects to design a new product, the first step was to listen to the customer – whether they were an existing MSA user or not. The **"Voice of Customer"** was extensive and feedback was received from around the world, from H_2S gas detector users in all types of climates, using detectors in many different applications.

There was a large amount of feedback given and some of the common requests/suggestions from the users, which formulated the main design criteria for the R&D team, were as follows:-

- **Fail-Safe sensors,** so when the sensor dies, has any issue and cannot detect gas for any reason, a fault signal is initiated by the transmitter.
- **Self-calibrating sensor technology,** extending manual calibrations up to 2 years.
- MOS users in particular wanted a **faster response** time.
- Users of Electrochemical sensors in countries with extremely hot climates, asked for an H_2S sensor with a **higher operating temperature.**
- All MOS and Electrochemical sensor users asked for sensors with a **longer operating life.**
- Electrochemical users wanted to be able to keep spare sensors in stock, without them having their effective operating life significantly reduced the longer they were on the shelf.
- The ability for the sensor to **inform the user of its condition** and when it was reaching the end of its life.

With these main criteria and specifications in mind, the MSA engineers started on a what would become a 4-year development project. It culminated in the 2017 launch of the **General Monitors S5000 detector and the revolutionary XCell® H_2S Electrochemical sensor.**

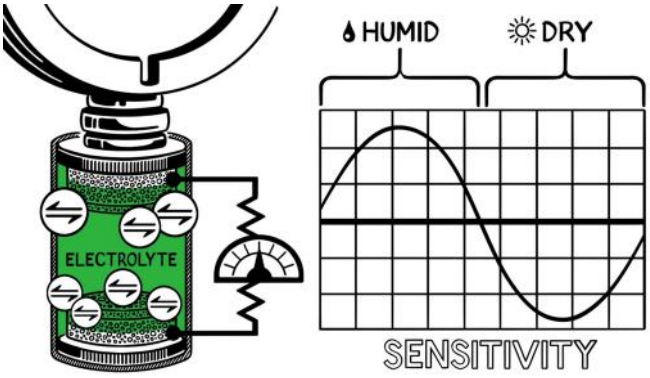
The XCell H_2S Electrochemical sensor from MSA is the most advanced sensor the company has ever developed for the detection of H_2S.

Revolutionary new technology - How the customer's requirements were achieved:

Fail-Safe Sensors

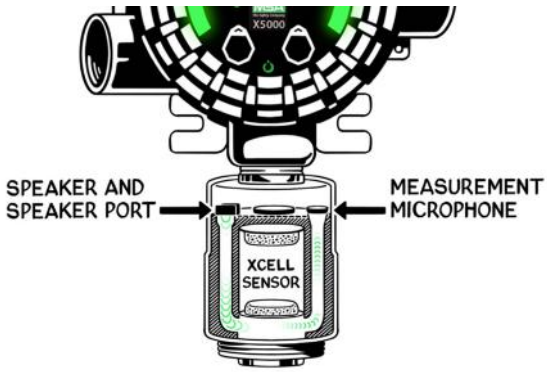
Being able to warn the user of a sensor failure, end of life or any reason a gas leak could not be detected, was MSA's no. 1 safety objective.

Developing an H_2S sensor that could perform a self-test to monitor its life and capability of detecting gas, was a main priority. MSA's new **TruCal® sensor technology** achieved this goal. During TruCal®, the sensor performs a complete **sensor self-check every 6 hours**. In the event of any issue with the sensor e.g. reaching the end of its life or any failure, it will initiate a fault signal.



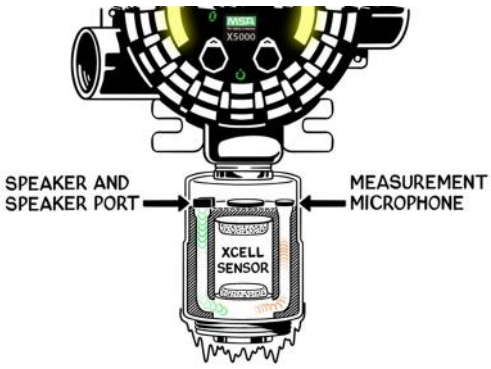
All sensors drift as environments change.

Another part of TruCal® is AEC (Adaptive Environmental Compensation), which occurs every 6 hours and compares the current accuracy of the sensor to the last manual gas calibration. If the sensor has drifted due to the environment (temperature, pressure, humidity) or age, then the sensor will **self-adjust its zero and measurement readings.**



No blockage and sound waves can pass through the sensor's inlet, with the microphone detecting a "normal" signal.

The final part of TruCal® is **Diffusion Supervision,** which is an industry first. This unique feature also occurs every 6 hours and is the sensor's ability to **automatically monitor its inlet for blockages.** Should the inlet of a traditional sensor become blocked, then this critical condition would only be identified during a manual calibration. Now with Diffusion Supervision, the detector will initiate a fault signal to alert the user that the sensor is blocked and cannot detect gas. This technology uses sound waves emitted from its built-in speaker, which pass across the inside of the sensor inlet and are picked up by the built-in microphone.



When more than 95% of the sensor's inlet is blocked, Diffusion Supervision automatically detects this and alerts the user.

In the event the sensor's inlet becomes more than 95% blocked, the sound waves do not pass through the sensor's inlet and the change in the amplitude and frequency is detected by the microphone. Once TruCal® verifies the blockage, a fault signal is initiated alerting the user of this critical condition. Immediate action is then required, as gas can no longer be detected.

TruCal® can now reassure the user:

1. **The sensor is responsive and can detect gas.**
2. **The zero and measurement values are both accurate.**
3. **The inlet is not blocked and gas can reach the sensor.**

Greater Stability

TruCal® reduces calibrations from once every 3 to 6 months to once every 2 years.

As AEC performs a self-calibration every 6 hours as part of TruCal®, this means there is no longer a requirement to perform a manual gas calibration every 3 to 6 months. **The XCell H_2S sensor does not need to be manually calibrated for up to 2 years.** The manual calibration period was originally 18 months, but based on more than 3 years of field proven data and long term sensor testing without any calibrations, this was extended to 2-years. Local requirements to be considered.

If a standard XCell H_2S sensor is being used and not the optional Diffusion Supervision sensor, then MSA recommends the sensor should have bump test(s) (safety functional test) in between calibrations to confirm that the senor inlet is not blocked.

Faster Response Time

Electrochemical sensors are faster to react to H_2S gas than MOS sensors, so the new XCell sensor was always going to satisfy MOS users with its better response time. However, the XCell response time was improved over our earlier range of Electrochemical sensors and the **H_2S XCell T-90 is <23 seconds.** With alarm levels in the range of 10 and 20 ppm, the real time to alarm is even faster – approximately <5 seconds. This makes it one of the fastest sensors currently available.

Higher Operating Temperature

The S5000+H_2S XCell sensor is suitable for the deserts in the Middle East to the ice fields in Alaska, from -40 to +60˚C.

The certified operating temperature of the sensor and not only the transmitter is critical. It's important to check that the sensor, as well as the transmitter, both meet your temperature requirements.

The XCell H_2S sensor has increased the certified operating temperature to **60˚C.** It also has a very low operating temperature of **-40°C,** so is suitable for both extreme environments.

Longer Operating Life

The financial impact for a user when replacing H_2S sensors every 12 to 18 months, can be huge. This is often the case in hotter climates and something that may not be considered when buying a detector.

MSA's new H_2S sensor is no longer based on the traditional "consuming" electrolyte gel/liquid and has developed for the first time a sensor that uses an **ionic liquid electrolyte.** Ionic liquids have an extremely low vapour pressure and do not evaporate, providing greater long-term stability and most importantly as they are "non-consuming" they offer a much longer life.

The H_2S XCell sensor has an **operating life of > 5years** and an industry leading **3-year manufacturer's warranty.** Another benefit of this new non-consuming technology is that its life does not start from when it is manufactured like traditional consuming sensors. It can therefore be kept in stock by the user for significantly longer periods. MSA recommends up to a maximum 3-years, but also recommends to always use the oldest sensor first.

XCell sensor's 5-year life and 3-year shelf life reduces costs.

Sensor Health Indication

The heart of a gas detector is the sensor and knowing the state of its health is a huge advantage for the user.

Knowing when the H_2S sensor is **reaching the end of its life** offers users the advantage of being able to reduce the number of spare sensors kept in stock.

MSA has achieved this and it is part of the sensor's TruCal self-test. When the sensor indication changes from "GOOD" to "FAIR", the sensor will need to be replaced in approximately 2 months.

Other Features and Benefits

These revolutionary developments in H_2S sensor technology achieved what our customers wanted from the next generation H_2S gas detector. However, the MSA engineering team didn't stop there!

Universal Transmitter

The S5000 is a universal transmitter, meaning that it can accept not only the H_2S sensor, but can also be used with other sensors for toxic gases, a Catalytic Bead sensor for flammable gases and an Infrared sensor for Hydrocarbon-based flammable gases.

XCell Electrochemical

Infrared

XCell Catalytic Bead

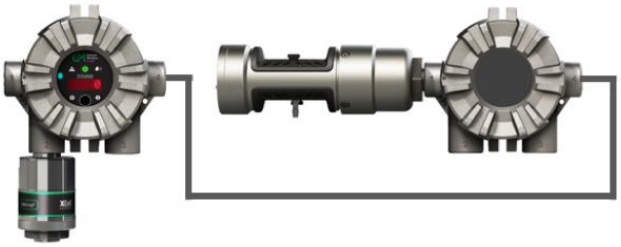
MOS

Dual Sensing Capability

The S5000 transmitter can also be **fitted with two sensors,** either mounted directly to the transmitter or one or both of the sensors can be remotely mounted. This allows for greater flexibility during installation, but also reduces the initial cost as only a single transmitter is required rather than two. The installation costs are also reduced as less cable, cable racks, junction boxes etc. are required.

XCell Electrochemical + Catalytic Bead

Infrared + XCell Electrochemical or Catalytic Bead

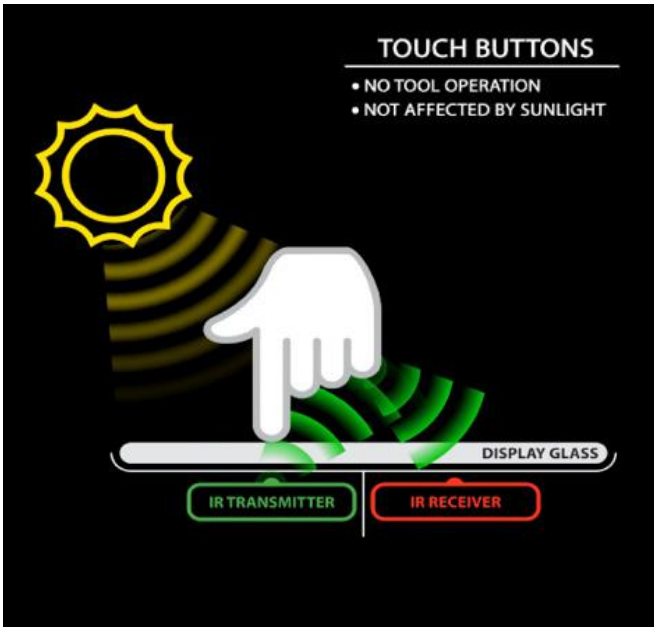


XCell Electrochemical or Catalytic Bead + remotely mounted Infrared

Tool Free User Interface and Optional Bluetooth

In this day and age of touchscreen phones and other devices, MSA thought the next generation of detectors should have the same easy user interface. This was achieved and now there is no requirement to buy any expensive HART® communicators or other accessories to interface with the detector. **Configurations, calibrations, sensor checks can be performed at any time using your finger.**

To make the user's life even easier and save on set-up time, there is an option to use a Bluetooth® device and the **MSA X/S Connect App** to communicate with the sensor for configurations, calibrations etc., but also to download various reports stored by the detector.



Remote Calibrations

Being able to remotely access the detector using the Bluetooth® communication to perform a calibration is a big advantage. However, the calibration gas still needs to be applied to the sensor and at the right concentration to perform an accurate calibration. **Remote gassing adapters only allow for a remote bump test/ functional safety check** and cannot be used for an accurate calibration. This is because they are "open" to allow gas, from a real leak, to pass through the adapter and reach the sensor. This open adapter also allows the calibration gas to escape, so as the correct volume and concentration does not reach the sensor, an accurate calibration cannot be performed. With gassing adapters, direct access to the sensor is required to fit the correct calibration adapter.

MSA's unique solution to this problem is the **CalGard Remote Calibration Adapter.** The CalGard RCA has an internal bellows mechanism and when the calibration gas reaches the CalGard RCA, the gas pressure forces the bellows to move up and seal around the sensor's inlet. This allows for accurate remote calibration, without having to gain direct access to the sensor. After the calibration gas is removed, the pressure drops and the bellows return to the normal position, which then allows any leaking gas to pass through the mesh of the CalGard RCA and be detected.

Simple Upgrade for General Monitors' Existing 4000 Series MOS Users

For users of the S4000 Series MOS gas detectors, **the upgrade to the S5000 is quick and simple.** The mounting footprint and cable entries of the two transmitters are identical, allowing for the same mounting and installation accessories to be used. The cabling and existing gas controller also does not need to be changed. Within minutes you can upgrade and start taking advantage of the latest technology!

Conclusion

The XCell H_2S sensor is the most advanced H_2S sensor ever developed by MSA and offers the user an exceptional level of safety - protecting your plant and most importantly the people working in the hazardous areas where H_2S risks exist. The world's first sensor with:

- **Fail-Safe capability**
- **Alerts user when sensor reaches end of life or can't detect gas**
- **Self-calibrates every 6 hours**
- **Diffusion Supervision that monitors and alerts for sensor blockage**

No other H_2S sensor can offer all these features with this level of safety!

At the same time, the **XCell sensor offers the user the lowest cost of ownership** due to its >5-year operating life, 2-year calibration period and when taking advantage of the Diffusion Supervision sensors, **no servicing or maintenance of any kind is required in between calibrations.**

The S5000 with H_2S XCell sensor is the future of H_2S gas detection.

MSA—**The Safety Company**

Our business is safety. We've been the world's leading manufacturer of high-quality safety products since 1914. MSA products may be simple to use and maintain, but they're also highly-sophisticated devices and protective gear—the result of countless R&D hours, relentless testing and an unwavering commitment to quality that saves lives and protects millions of hard working men and women each and every day. Many of our most popular products integrate multiple combinations of electronics, mechanical systems and advanced materials to help ensure that users around the world remain protected in even the most hazardous of situations.

Our Mission

MSA's mission is to see to it that men and women may work in safety and that they, their families and their communities may live in health throughout the world.

MSA: WE KNOW WHAT'S AT STAKE.

sales@norrscope.com