ADVANCED HIGH-TECH GAS DETECTION

Electrochemical Technology at the Forefront

Honeywell

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SAFETY FIRST, SAFETY ALWAYS

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The importance of electrochemical gas detection in meeting gas detection requirements today...and tomorrow.

GREATER RELIABILITY, EASIER TO USE, MORE COST-EFFECTIVE

Gas detection has been an important safety precaution in many industries since 19th-century scientist John Haldane figured out that carbon monoxide was causing miners' deaths and subsequently introduced canaries as perhaps the earliest gas detection "sensors" – much to the detriment of the canary population.

Canaries were actually still used until the late 20th century in some locations, but gas detection technologies have advanced well beyond avian options since then. Today, integrated gas detection systems enable remote monitoring, predictive maintenance, and data-driven decision-making.

This is an important concept for all industries where gases pose potential problems, which is just about everywhere: toxic gases are present in nearly every industry. A few of the most common – and dangerous – places where effective gas detection is critical include gas and oil drilling, chemical plants, refineries and petrochemical facilities, power generation, water treatment, pulp and paper production, marine environments, semiconductor manufacturing, and military and national security. There are many more too, where the safety of workers and facilities depends on the accuracy, reliability, and response time for gas detection.

In this white paper, we'll explore today's gas detection options and how one specific technology, electrochemical, is often suitable for a wide variety of applications.

A QUICK SUMMARY OF GAS DETECTION TECHNOLOGIES

While this white paper is focused on gas sensors using electrochemical technology for reasons outlined in more detail in the next section, there are a number of types of technology used in various other gas detecting devices that may be useful for comparison purposes. Here are some of the most commonly utilized types of gas-detection technologies available for safety applications today, as well as the types of gas detection situations where they might be used. Incorporating different technologies in a "layered" fashion can be useful in complex detection environments, which we will explore later in this white paper.

1. **Colorimetric gas detection** uses a color reagent to develop a color. When exposed to a color reagent chemical, specific gases have different chemical reactions that result in a color change, generally called a stain. The stain color intensity is proportional to gas concentration. This provides visible evidence for the presence of a gas and is a cost-competitive solution to detect ppb level concentration, but it requires a complicated mechanical system and narrow operating conditions to work effectively.

2. **Metal oxide semiconductor sensors (MOX) or nanomaterial- and polymer-based sensors (CP)** detect toxic gases such as carbon monoxide (CO) and volatile organic compounds (VOCs), as well as nitrogen dioxide (NO_2), and other reducing or oxidizing gases. They are passive devices that work by sensing the variation in electrical conductivity of a semiconductor material in the presence of target gases due to ambient temperatures in the operating environment. Advantageously, these sensors are CMOS-compatible, small in size, are highly sensitive in that they can measure low and even trace gas concentrations (as low as parts per million [ppm] or even parts per billion [ppb]), easy to use, and usually very economical. Disadvantages are low selectivity that results in poor precision, high temperature operation and power consumption, sensitivity to humidity, and the necessity of incorporating a heater and conditioning circuit.

   The surface of nanomaterial- and polymer-based sensors (CP) can detect multiple gases simultaneously and absorb gases, resulting in changes in conduction that can be detected by resistance variations. They usually operate effectively at room temperature, so no heating circuit is required, have a quick response time, and exhibit good resistance to humidity and chemical attack. They are therefore versatile, require very little power, and again, are inexpensive. However, their sensitive materials may age over time and lead to limited sensor life, and recovery time can be slow.

3. **Non-dispersive infrared sensors (NDIR)** are most commonly used in the detection of carbon dioxide (CO_2) and flammable gases such as methane (CH_4). Each gas has a unique infrared absorption signature, allowing the sensor to identify and quantify surrounding target gases by measuring the difference in infrared light by the receptors where light is absorbed by the gas molecules. These devices are highly selective and accurate and when outfitted with the right optical filters can detect multiple gases (not all of these sensors have multiple-gas optical filters). They cannot detect diatomic gases (H_2, CL_2, F_2) and are not as effective at detecting gases at ppb levels.expensive, both in terms of the actual devices as well as related operational costs.

4. **FTIR**, an acronym for Fourier Transform Infrared spectroscopy, is a gas measurement technology used for simultaneous measurements of multiple gases. Because all molecules can be identified by their characteristic absorption spectrum, various types of gas molecules absorb infrared radiation at their own unique wavelengths. The strength of that absorption is directly proportional to concentration, making it possible to use IR spectrum for accurate determination of gas concentrations.

   Unlike NDIR gas detection technology where only one component can be analyzed from a single measurement and interference cannot be compensated, an FTIR spectrometer measures all the IR wavelengths simultaneously and produces a full spectrum. All components can be analyzed from a single measurement and interferences are resolved. However, FTIR systems can be more complex to use and usually require calibration with reference gases. They are also usually more expensive, both in terms of the actual devices as well as related operational costs.

5. **Photoionization detectors (PID)** are used in detecting thousands of volatile organic compounds (VOCs) by measuring the ionization of gas molecules by a UV light source that triggers the formation of positive and negative ions which can then be determined by the sensor and transformed into a gas concentration value.

6. A detector element sensitive to combustible gases that contains catalytic material is used in **catalytic bead gas sensors** to measure combustible gases, which react, burn, and cause a rise in temperature and resistance. Catalytic bead sensors exhibit high sensitivity to a range of combustible gases, including methane, propane, and hydrogen, making them versatile for different applications. They are designed for rapid response times, often within seconds, which is critical for safety applications in industrial environments.

7. **Electrochemical detection technology** uses electrochemical reactions to detect gases such as carbon monoxide (CO), sulfur dioxide (SO_2) or ammonia (NH_3). Target gases react with sensing electrodes to generate a measurable electrical current signal that is proportional to the concentration of the gas. There are two types of electrochemical sensors, amperometric or potentiometric: amperometric sensors measure a change in current, thus necessitating the use of an analog conditioning circuit, while potentiometric sensors measure a change in voltage.

   Depending on the gases involved, electrochemical detectors may have a more limited lifespan, can require specialized application knowledge if not provided by manufacturers, and can sometimes be more sensitive to temperature fluctuations. However, electrochemical gas monitoring systems use variations on one of the most versatile, reliable types of technology for effective gas detection and offer multiple advantages:

   - High sensitivity: can detect low concentrations (down to ppb [parts per billion]) of target gases, making them suitable for applications requiring precise measurements.
   - Selectivity: can be customized to respond specifically to a particular gas, reducing the likelihood of false alarms caused by interference from other gases.
   - Low power consumption: compared to other gas-detection technologies these typically require less power to operate, often making them ideal for portable or battery-operated devices.
   - Fast response times: respond quickly to changes in gas concentration, allowing for real-time monitoring of gas levels.
   - Compact size: enables easy integration into various devices and systems.[1]

1. https://www.electricity-magnetism.org/electrochemical-gas-sensor/

THE VERSATILITY AND ACCURACY OF ELECTROCHEMICAL GAS DETECTION

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Gas detection systems do not prevent a hazardous situation: their purpose is to alert workers to the presence of a leak and, therefore minimize any impact from the consequences of an event that has already occurred, thus minimizing harm to workers, facility assets, and the surrounding environment.

Effective selection of detection techniques and an adequate number of detectors are necessary to ensure the effective use of any type of gas detection device. As our focus is on electrochemical gas detectors in this white paper, let's now take a more detailed look at how they work.

BASICS OF ELECTROCHEMICAL DETECTION TECHNOLOGY

Electrochemical gas detection is widely used for both portable and fixed detection systems and operates on the interaction between a target gas and an electrolyte within the sensor.

Electrochemical gas detection devices contain two or three electrodes or occasionally even four in contact with an electrolyte. These electrodes are typically fabricated by fixing a high surface area of precious metal onto a porous hydrophobic membrane. The working electrode contacts both the electrolyte and the ambient air to be monitored via the porous membrane.

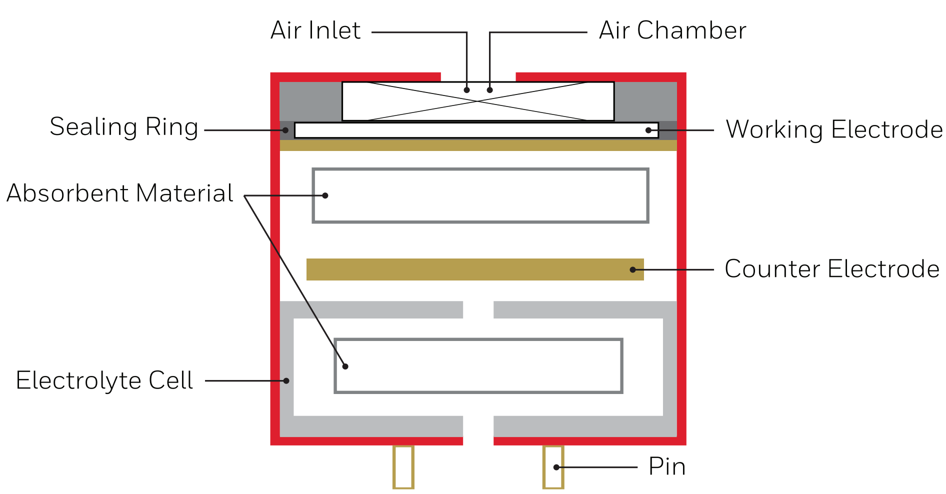
Once in contact with the sensor, the gas diffuses into the sensor through the porous membrane to the working electrode where it is oxidized or reduced. This electrochemical reaction results in an electric current that passes through the external circuit, which measures, amplifies, and/or performs other signal processing functions. Gases that are more easily oxidized, such as alcohols and carbon monoxide, can result in cross-sensitivity, but this interference can readily be minimized through the use of a chemical filter that reacts with and removes common interferences.

The magnitude of the current is controlled by how much of the target gas is oxidized at the working electrode. The gas supply is usually limited by diffusion to make the sensor output linearly proportional to the gas concentration. This linear output is one of the advantages of electrochemical sensors over other sensor technologies whose output must be linearized before they can be used. Linear output allows for accurate, precise measurement of low concentrations and much simpler calibration since only a baseline and one other point are needed.

Changing the diffusion barrier allows the sensor manufacturer to tailor the sensor to a particular target gas concentration range and since the barrier is primarily mechanical, the calibration of electrochemical sensors tends to be more stable over time and they require much less maintenance.[2]

To summarize, then, the detector design of an electrochemical sensor, pictured below, consists of the following components:

- Gas permeable membrane – this material covers the sensing electrode and controls the amount of gas molecules reaching the electrode surface. The membrane also performs an important role in filtering unwanted particulates.
- Electrode (anode) – to create an effective reaction with gas molecules, the electrode is typically made from metals such as platinum or gold and works as a transducer. The anode is the point at which the current enters the electrode.
- Electrode (cathode) – this is the point where the current leaves the electrode.
- Electrolyte - the electrolyte facilitates the cell reaction and carries the ionic charge across the electrodes.[3]



2. https://en.wikipedia.org/wiki/Electrochemical_gas_sensor
3. https://www.processsensing.com/en-us/blog/how-do-electrochemical-sensors-work.htm

OVERALL ADVANTAGES OF TODAY'S ELECTROCHEMICAL GAS DETECTION SYSTEMS

While electrochemical sensors have been in use for many years, today's requirements have enabled continuous technical improvements of the technology.

As noted earlier, electrochemical gas detectors are a popular choice for many applications due to their high sensitivity, selectivity and specificity, and low power consumption. Because of their direct linear output of current to gas concentration, they can provide a real zero reading. They operate well in harsh environments as they require little power and therefore are intrinsically safe; their much lower power consumption requirements also allow them to be used for many years without battery replacement.

Because they have a working pressure range of 10 percent within atmospheric pressure, they require minimal to no recalibration if used at differing elevations. Their efficiency is not dependent on size so they can be very small and still very efficient, making them highly versatile.

Their thermal stability has been enhanced substantially in recent years to enable high performance in ambient conditions, including their performance in low-humidity conditions where previously cells could dry out and degrade performance over time. Additional improvements have included plug-and-play designs, field-selectable gas ranges that do not require extensive operator training and extended operating temperature ranges. In summary, these advantages also result in considerable cost savings over their lifespan.

MAINTENANCE AND CALIBRATION

Over time, the performance of electrochemical technologies may be affected by factors such as electrode degradation, electrolyte evaporation, and membrane contamination. To ensure accuracy and reliability, periodic calibration with appropriate calibration equipment may be necessary. However, some advanced electrochemical gas detectors incorporate self-calibration features to minimize the need for manual intervention and simplify maintenance.[4]

The lifespan of electrochemical gas monitors can range from less than two years for highly combustible or corrosive gases to more than five years for sturdier types. A typical lifespan encompasses several key stages:

1. Manufacturing of the device
2. Shelf life, in which the device is stored before being used
3. Operational life, lasting from when the sensor is first used until it is no longer functional
4. Maintenance and calibration, when devices undergo regular servicing (manufacturers usually provide guidelines for testing and calibration)
5. End of life, when the sensor no longer works effectively and must be replaced

Honeywell has addressed many lifespan points in the long-life cartridges in the Midas® S2 Gas Monitoring System, which utilize a single, smart factory-calibrated sensor cartridge and offer an onboard 'e-calibration' certificate. The cartridges can operate for at least two years without additional calibration, and the device lifespan can be extended by another year if calibration is successful at the two-year mark.

In addition to eventually replacing inoperable devices, upgrading gas detection equipment should be considered when new technological advancements are available, regulatory standards change (necessary to ensure devices are in compliance with new standards from industry organizations such as OHSA), or industry best practices are updated and revised.[5]

4. https://www.electricity-magnetism.org/electrochemical-gas-sensor/)
5. https://www.gasdetection.com/gas-detection-knowledge-base/how-fast-does-a-gas-detector-sense-toxic-gas-5-common-questions-professionals-ask-about-gas-detection/

TOTAL COST OF OWNERSHIP

Return on investment (ROI) is important for any equipment purchase since, as outlined earlier, analyzing the costs associated with regular maintenance weighs those costs against the potential financial consequences of equipment failure. As anticipated, the cost of maintenance is generally much lower.

That being the case, price alone should not be the only consideration. What matters in the long run for company financials, including potential impacts on safety and end-product performance, is the total cost of ownership (TCO), which is the price plus soft costs.

Soft costs can be hard to quantify but could include time spent preparing reports and confirming regulatory compliance and hours calibrating gas detectors for the workday. Overlooking these expenses can result in a less expensive detection system which, however, is much more expensive overall than a device with a higher initial price tag that requires less time spent on these soft costs. Generally speaking, the more durable and self-actuating the device, the lower the total cost of ownership. There are several common hidden costs that should be considered in addition to the actual price of the device:

Performing regular bump testing and calibration manually is not only prone to human error, but it also increases the time spent and the cost of using calibration gas. Devices that require very little manual maintenance can easily recoup a higher initial price.

The durability of the device itself is also important. A high-quality product should be robust and long-lived, include a lengthy or extended warranty period, and require minimal maintenance, such as inspecting, cleaning, disinfecting, updating settings, and recharging and replacing batteries.

Record-keeping time, including monitoring and tracking, can also take more time with lower-quality sensors.

From minor equipment tweaks to major explosions or safety incidents, disruptions related to any of the above can be devastating to facility assets, from equipment to buildings, and can also add social costs ranging from reputational damage to litigation expenses

As with maintenance and calibration, these elements have also been considered in the functionality of the Honeywell Midas® S2 Gas Monitoring System; more details are included at the conclusion of this white paper.[6]

6. https://ionscience.com/usa/news/the-cost-of-ownership-for-gas-detection-equipment/

WHAT'S THE MARKET OUTLOOK FOR ELECTROCHEMICAL GAS DETECTION?

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> Electrochemical technology is one of the best solutions available to increase safety and productivity in a wide variety of applications across multiple industries. Detection systems using this technology perform valuable roles that ensure that companies meet their business targets, environmental mandates, and workers' expectations for safe working conditions.

Protecting against gas leaks requires low ppm (parts per million) detection. This allows continuous sampling of all air moving through enclosed areas and specialized monitoring systems used in specific areas or steps in the manufacturing process. As a result, electrochemical gas detectors can be found in many areas of a semiconductor manufacturing facility:

- PPM (parts per million) detection in ventilated gas cabinets, enclosures, process equipment chases, and clean rooms
- General monitoring for toxics and combustibles in storage areas, distribution, delivery piping, and equipment chases

WHERE ARE ELECTROCHEMICAL GAS DETECTION SYSTEMS USED NOW...AND WILL CONTINUE TO BE IMPORTANT TO THE INDUSTRY?

Because of their versatility and dependability, electrochemical gas detection is used for a variety of applications in many different industries. It is often suitable for industrial and semiconductor manufacturing and national and university labs specializing in semiconductor processing research.

In the semiconductor industry, for example, the manufacturing process for semiconductor wafers includes steps such as deposition, etching, and other procedures, many of which must occur in a clean-room environment. The tools and operations used to create semiconductors require the utilization (and therefore storage) of a variety of hazardous and toxic gases, including hydrogen, hydrogen chloride, ethylene oxide (EtO), chlorine, arsine, phosphine, diborane, silane, ammonia, and oxygen.

Although semiconductor manufacturing production areas are generally highly ventilated, any time these types of gases are present, there is always a risk of fire, explosion, and contamination of the site, equipment, process, or product. While asset protection is important, the health and safety of workers should, of course, always be a first priority, including maintaining regulatory compliance for safety protocols.

Widely used throughout many other industries, electrochemical gas detection plays important roles in the following types of applications.

Detection of toxic vapors – the presence of toxic gases almost always leads to an increased focus on worker safety in the oil and gas industry as well as chemical and petrochemical processing. Government environmental and industry regulations, such as COSHH and OSHA, require limited exposure to such conditions for workers, leading to increased use of electrochemical gas sensors, which provide improved sensitivity and selectivity for a broad range of toxic gases.

Environmental monitoring – detecting components of air pollution, including nitrogen oxides, sulfur oxides, hydrogen sulfide, and some volatile organic substances, has become increasingly important as air quality around the world continues to degrade and become a high-level, highly regulated environmental concern.

Mining and tunneling – methane, carbon monoxide, and hydrogen sulfide are just a few examples of potentially dangerous gases that should be monitored to lower the chance of accidents and improve worker safety. In addition, the absence of oxygen (oxygen depletion) can be a very serious safety hazard in mining operations and should be carefully and continuously monitored.[7,8]

Layered Application Settings

No single gas detection technology alone is 100 percent effective, which is where a layered approach comes in[9]. By integrating layers of protection, employers can minimize risks and be better informed to take steps to keep their workers and assets protected. A layered approach integrates independent yet interrelated layers of protection and security controls across the entire plant and business networks for early indication of equipment that is not working properly, and alerts for harmful gases.

In a mixed technological approach for gas and flame detection, each solution complements the effectiveness of the previous one, adding to the safety case. As each one acts independently, an unexpected issue will not affect more than one layer. For example, for fire and gas detection systems, gas detection and flame detection are two separate layers. Flame detection comes into play if an issue with the gas detection layer and a fire ignites. Simply put, more layers of gas leak detection provide more comprehensive protection.

One very effective layered application design is to deploy colorimetry, FTIR, and Electrochemical devices. Layered applications can also be created using infrared detectors.

7. https://www.gasdetection.com/gas-detection-knowledge-base/gas-detection-and-analysis-in-2023/
8. https://www.processsensing.com/en-us/blog/how-do-electrochemical-sensors-work.htm
9. https://ohsonline.com/articles/2021/12/01/layered-gas-detection.aspx

WHAT LIES AHEAD FOR ELECTROCHEMICAL GAS DETECTION?

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The importance of gas detection devices and the analysis they make possible for our collective future should not be underestimated. Gas detection systems have become effective instruments for in-the-moment monitoring and decision-making due to the integration of advanced sensors, sophisticated analytics, and Internet of Things (IoT) connectivity, and it will continue to be important for innovations to address new global standards, requirements, and expectations.

TECHNOLOGICAL INNOVATIONS

There are several promising new innovations in electrochemical gas monitors and the field of gas detection overall. The ability to detect an increasing number of gases is key, as well as the development of smaller, more compact gas detection devices that are easy to carry and integrate. There's also a growing emphasis on easy integration with (IoT) for real-time monitoring and data analysis, enhancing safety and operational efficiency and low power consumption in devices to reduce operational costs and minimize environmental impact.

The demand for gas detection devices with longer lifespans is rising to reduce the need for frequent replacement and maintenance, and wireless options are becoming increasingly popular due to their flexibility and ease of installation. Devices that can monitor multiple gases simultaneously are particularly crucial in industries such as pharmaceuticals, scientific research, agriculture, and industrial safety, where integrating these detectors with IoT platforms enables real-time monitoring and data analysis. Incorporating nanotechnology for future devices and the widespread availability of wearable or implantable technology may lead to highly personalized safety systems for workers in high-risk industries.

Advanced gas detection can improve accuracy and reliability through the use of advanced algorithms and technologies. Wireless gas detection systems can connect to mobile devices or control rooms for real-time monitoring capabilities and expanded response strategy opportunities. Integrating these advanced sensors with predictive analytics tools and other systems offers a more comprehensive approach to safety and environmental monitoring. While devices with these capabilities can be more expensive initially, long-term cost savings can be realized with early detection and response to gas leaks, which can avoid potential costs associated with damage restoration or shutdowns.[10, 11]

10. https://www.gasdetection.com/gas-detection-knowledge-base/how-fast-does-a-gas-detector-sense-toxic-gas-5-common-questions-professionals-ask-about-gas-detection/
11. https://www.gasdetection.com/gas-detection-knowledge-base/gas-detection-and-analysis-in-2023/

IMPLICATIONS FOR STANDARDS AND REGULATIONS

International laws and safety norms are constantly changing to meet the demand for better environmental and safety monitoring. Climate agreements between multiple countries and geographic regions make it necessary for manufacturers of equipment used in one country to be acceptable in many. To ensure their gas detection and analysis technologies meet or exceed the necessary performance criteria, businesses must stay current with these changes.

With increasing attention to sustainability and environmental preservation, greener processes are strongly encouraged, if not required, throughout supply chains, from raw materials to finished goods. As a result, more energy-efficient gas detection and analysis technologies have emerged and are becoming standard expectations.

Regulations for specific sensor performance characteristics—such as response time, sensitivity to meet Threshold Limit Value (TLV), sensor drift, interference, false alarms, and potentially questionable safe operating procedures—are becoming much more commonplace. This creates the need for ongoing innovations to meet customer and governmental demands.

The constantly changing environment of gas detection and analysis technology necessitates continual innovation in developing and producing technology that meets current difficulties and seizes market opportunities; this will push manufacturers and their customers' businesses to invest in research and development.[12]

WHAT DOES THE FUTURE MARKET LOOK LIKE?

Based on all of the above, in addition to many market projection models, the current outlook for industrial gas sensing devices is positive and many opportunities exist for customer-friendly, effective electrochemical gas monitoring systems. There is a growing demand for these devices due to increasing concerns regarding workplace safety and environmental regulations. The market is driven by factors such as the strict implementation of safety standards, technological advancements, and the need for real-time gas detection and monitoring.

Strong growth is expected, particularly in emerging economies such as China and India which are undergoing rapid industrialization. Globally, the adoption of automation and IoT technologies will drive the demand for gas sensors, detectors, and analyzers, as will the growing focus on renewable energy sources and the need to monitor and control emissions.

Additionally, the aftermath of the COVID-19 pandemic has emphasized the importance of monitoring air quality and ventilation in industries and buildings which also require gas sensors and analyzers. Advancements in technology, such as wireless connectivity and remote monitoring capabilities, will continue to enhance the efficiency and effectiveness of gas detection and analysis, including the implementation of wireless sensor networks for remote monitoring, the integration of artificial intelligence and machine learning capabilities for advanced data analytics, and the increasing use of IoT in industrial processes.

HONEYWELL IS HERE TO HELP

Innovations in gas detection technology are constantly leading to technological advancements as the industry works to meet escalating demands for better environmental and safety protection. Honeywell is here to help.

As a leader in gas detection systems for semiconductor manufacturers for nearly a century, we bring extensive experience and engineering expertise to our gas detectors portfolio, including gas monitoring for applications which can benefit substantially with the use of electrochemical gas detectors. One of our newest product offerings is the Midas® S2 gas monitoring system, which brings new visibility, reliability, and ease of use to gas detection in semiconductor and industrial manufacturing, oil and gas laboratories, solar manufacturing operations, and national and university labs that specialize in semiconductor processing research.

The Midas® S2 is a fixed, extractive single-point, single-gas transmitter that incorporates patented technology to regulate flow rates and ensure error-free gas detection to enhance the performance characteristics of the legacy Midas® device. It draws a sample locally or remotely to a sensor cartridge. An extensive range of over 40 toxic, flammable, and oxygen gas sensor cartridges are available. Additional benefits include:

- Modular plug-and-play design in a compact package makes installation and commissioning easy in crowded, complex environments where space is at a premium with front access for both sensor and pump replacement (cartridge does not need to be removed) and no need for an internal filter.
- Clear visibility amplified through an enhanced Human Machine Interface (HMI), including a larger graphics screen incorporating a TFT (Thin Film Transistor) color LCD display for better visibility of instrument status icons, monitoring points and location names, and instant alerts to gas readings or alarm levels.
- Factory pre-calibrated sensor cartridges provide reliable gas detection performance by using traceable gas standards and approved calibration methods.
- Long-life sensor cartridge (minimum 2 years) maximizes uptime and reduces need for frequent maintenance.
- Optional automatic Line Integrity Test (LIT) detects tubing leaks with a pneumatic signal change from valves at the end of the sample line.
- Patented, state-of-the-art diagnostics for increased flexibility and accuracy with Reflex® technology.
- Greatly reduced cross-sensitivity susceptibility, including gas mixtures with cross-sensitive characteristics.
- Innovative Power over Ethernet (PoE) protocol serves as a single connection for all power, control, and communication and an internal web server provides excellent data logging capability.
- Password-protected menus for integrated security to maintain system integrity.
- High-quality, long-life, user-friendly performance results in positive total cost of ownership.

Midas® S2 Gas Detector

For more information on the Midas® S2 or any of our other gas detection solutions, explore tech specs for the Midas® S2 on our website, or get in touch with us through the contact information below. If none of our thousands of devices cater to your needs, our clean-sheet engineering teams can develop/customize something for your specific requirements.

We know that convenience and efficiency are critically important as you consider your choices in gas detection, and Honeywell can further simplify your monitoring, maintenance, and system or product updates with our Service Solutions for Fixed and High Tech gas detectors. No less a business-consulting expert than the Harvard Business Review supports the integration of OEM service partners in ongoing relationships as they provide support of their original systems and devices in your business structure, stating that such service partnerships generally offer customers the best balance between productivity, safety, risk management, adherence to proper service protocols, and implementation of best practices.

With Honeywell as your service partner, we can bring a new level of performance excellence to your organization when you choose fixed gas detection and high-tech devices like Honeywell's Searchline Excel®, FS24X, Vertex®, and Midas® to help you keep your operations running smoothly. We provide application support for a variety of requirements and industries, whether your business is semiconductor or industrial manufacturing, vehicle production, commercial equipment manufacturing, any type of processing, or even aerospace engineering.

With Honeywell, you can have it all…from a global leader in the most important business. Yours.

WARRANTY/REMEDY

Honeywell warrants goods of its manufacture as being free of defective materials and faulty workmanship during the applicable warranty period. Honeywell's standard product warranty applies unless agreed to otherwise by Honeywell in writing; please refer to your order acknowledgment or consult your local sales office for specific warranty details. If warranted goods are returned to Honeywell during the period of coverage, Honeywell will repair or replace, at its option, without charge those items that Honeywell, in its sole discretion, finds defective. The foregoing is buyer's sole remedy and is in lieu of all other warranties, expressed or implied, including those of merchantability and fitness for a particular purpose. In no event shall Honeywell be liable for consequential, special, or indirect damages.

While Honeywell may provide application assistance personally, through our literature and the Honeywell web site, it is buyer's sole responsibility to determine the suitability of the product in the application.

Specifications may change without notice. The information we supply is believed to be accurate as of this writing. However, Honeywell assumes no responsibility for its use.

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