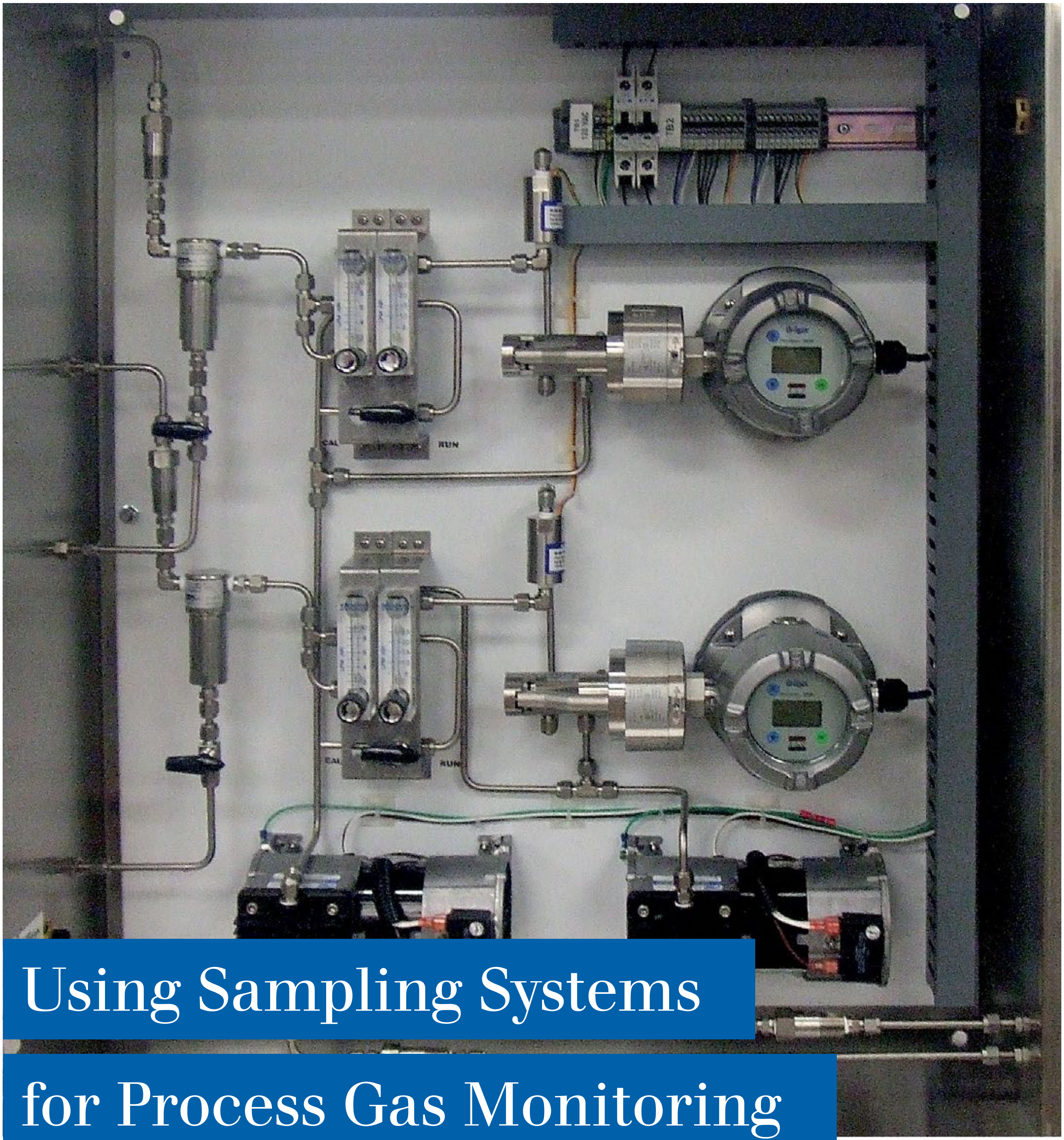


Using Sampling Systems for Process Gas Monitoring

Application Note

Introduction

Dräger Polytron® gas detectors are primarily designed to monitor gases in the ambient air, which minimizes potential issues with flow, pressure, moisture, temperature, access for maintenance and other concerns. In some applications, however, the target gas is in an enclosed area (tank, pipe or duct, room, process vessel, or other closed area) and may require monitoring for several reasons – such to indicate a process upset or contaminant in the exhaust gas. Sometimes sensors are mounted on the enclosure, but often this is inconvenient or the conditions inside the enclosure are not amenable to proper sensor operation. In these cases, an active gas sampling system is often the best solution.

Market Segments

- Chemical
- Oil and gas
- Food and beverage
- Pharmaceutical

Challenges

Gas samples often must be taken in extreme conditions, making it difficult or impossible for many gas-sensing technologies to measure properly. These include a variety of environments, sometimes with several challenging issues present at the same time. Electrochemical sensors (EC) for toxic gases and oxygen and catalytic sensors (CatEx) for measuring explosive/combustible gases are somewhat limited when it comes to measurement and environmental conditions.

Infrared (IR) sensors are more forgiving, but they have the limitations under the following conditions:

- **Measurement area too wet:** Too much moisture can interfere with the measurement stability or impinge on the sensor filter, blocking gas from entering and reacting with the sensor. Wet sensor membranes can also affect gas readings by blocking or trapping gas.

- **Pressure/velocity too high:** In effect, sensors are partial pressure measuring devices, and high pressures can result in erroneous readings or damage a sensor. High flow can affect many sensors, most of which are sensitive to flow effects. High flow can cause instability or even prevent the sensor from reading properly due to Venturi effects. Erratic readings are also possible with pressure effects.

- **Measurement area under a vacuum:** Again, sensors are ultimately partial pressure measuring devices and pressures below the ambient pressure can result in erroneous readings or damage to a sensor.

- **Sample area too hot:** Sensors must be able to compensate for temperature changes, but all have a limited range for proper operation. Outside that temperature compensation range, they are either inaccurate or inoperable. High temperatures can also damage many sensors.

- **Samples too cold:** As with hot temperatures, there is a lower limit for correct operation for most sensors.

- **Samples with particulates:** Heavy particulates can clog EC sensor filters or CatEx sensor frits and impede the measurement ability of an IR sensor.

- **Inaccessible area:** When an area is difficult to reach – due to close quarters, density of objects in the area, height of the monitored area, or other issues – it can create maintenance issues and cause unsafe practices.

- **Enclosed space:** Some areas need to be monitored, but the sensor cannot be located in or on the unit – so a sample is pulled out and sent to the gas detector for monitoring.

- **Over-range target gas concentrations:** When a gas monitor is required for an area where the target gas can intermittently go above the sensor range, it can create sensor issues and delays in response to the actual gas concentration. Over-ranging EC or CatEx sensors can result in slow recovery times and even require a recalibration or power reset of the gas detector.

- **Presence of incompatible gases:** Sometimes the monitored space contains another gas or vapor that can interfere with the measurement of the target gas by creating an artificially high or low reading on the detector. Sometimes it is possible to remove these specific gases from the sample stream before they reach the detector.

You should always consult with a gas detection professional when considering the use of a sample system, because there are additional parameters that need to be defined and understood, such as:

- Is the target gas a very reactive gas (also called 'sticky' gas), making it difficult to pull through sample tubing? This can result in low readings for gases such as SO_2, HF, HCl and others that coat most of the surfaces they touch. At low levels (OSHA PEL for SO_2 is only 5 ppm) with a long tubing run, these gases may never reach the detector.

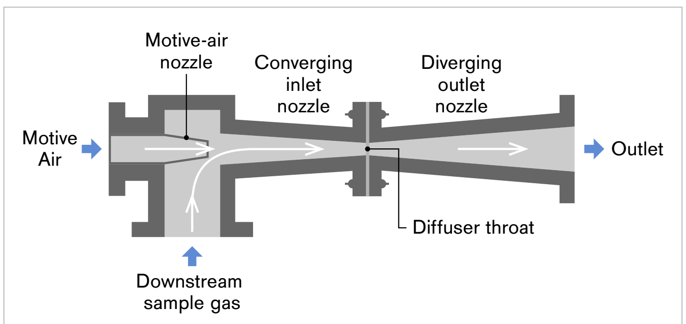
– What response time do you need to changes in the gas measurement? Pulling a sample introduces a dwell time in the tubing: at a typical flow rate of 0.5 liters per minute (LPM), that adds about 1 second per foot of tubing to the sensor's response time.

– What are the typical constituents in the sample, the potential extremes of gas concentrations present, and environmental conditions? Make sure the extremes are within the specifications of the detector and sampling system you select.

The Process

Overview of sampling systems

Sampling systems can take various forms depending on the services available and the preferences of the end user. Two typical configurations use a pump or aspirator as the motive force to present a sample to the detector. In either case, the sample draw device is generally mounted behind the detector in the sample train to avoid pressure issues with the gas sensor.



Aspirated systems are often preferable because there are fewer components that may potentially need to be replaced, so less maintenance is involved after installation. An aspirator is a type of vacuum pump that creates a vacuum by means of the Venturi effect. This vacuum draws the sample through another leg of the aspirator. The aspirator is always placed behind the detector since it dilutes the sample with the applied air stream. Aspirators are very effective and simply require a source of motive air (plant, instrument air, or nitrogen are generally used if available) to operate for long periods.

Vacuum pumps are also used to draw the sample to the detector, particularly when there is not a convenient source of motive air available. These are usually diaphragm pumps and typically run off the same power as the detector. The only disadvantage of a pump is that, unlike an aspirator, they or their components (usually the diaphragm) need to be replaced periodically.

In either an aspirated or a pumped system, several other components are necessary to ensure a good gas sample draw to the detector:

– Most sensors are flow sensitive, so a **flow meter** is placed in front of the detector to control air movement to the sensor. This is usually a simple rotameter, but can be a more sophisticated mass flow device in some cases.

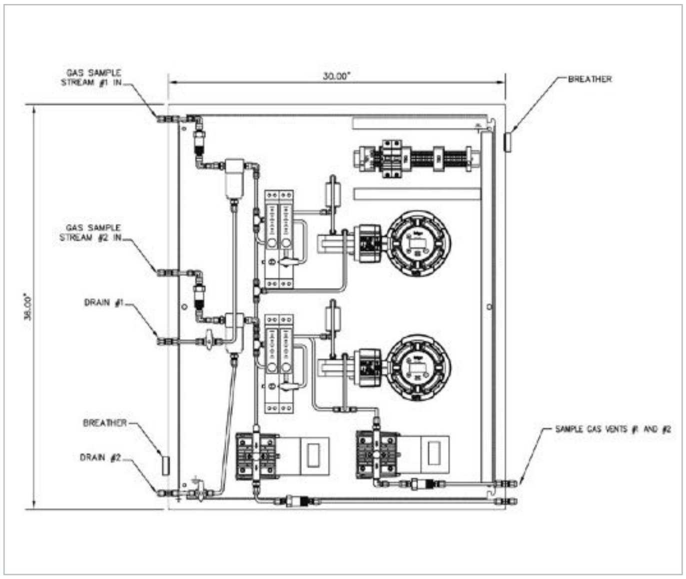
– A **flow switch** is located in front of the detector to ensure that the sample reaches the sensor and that the target sample stream is measured. If flow stops, a warning occurs provides notification that there is a problem and the measurement may not be correct.

– A good sampling system requires its own **integrated power supply** to ensure reliable operation.

– Finally, just before the pump or aspirator, the right **gas detector and sensor** need to be selected for the target gas and the specific application being monitored. For more on selecting the correct gas detector, see the Dräger Solutions section below.

Additional items may be used to help ensure correct measurements and protect the system components. For example, the sample may need to be conditioned to eliminate liquids, so a **coalescing filter** and liquid dropout would be included in front of the other components.

Filters may also be used to eliminate particulates in the sample stream. Any filters used require periodic inspection and replacement to ensure good sample flow and accurate measurements.
If the sample is too hot or too cold, a cooling or heating mechanism may be part of the system.



If the pressure were too high or too low, a **pressure regulator** would be added to the system to bring the sample pressure to near ambient before it reaches the system. In cases where the gas may over range the sensor on occasion, a dilution system can mitigate the problem by lowering the gas level to acceptable levels. Over-ranged sensors can have long recovery times that cause inaccurate measurements for a period of time, or may stress the sensor so a calibration is required.

How to sample

Another consideration is how to sample. Most end users try to place a sampling system and detector on a single point source that should provide a representative sample for the space being monitored. This single-point, continuous monitoring model allows faster response time to dynamic changes in the sample stream. However, it can be expensive and require significant maintenance if multiple sampling points were required for a specific process or gas.

The solution is often to perform **sequential sampling** of several points through a common sampling system and gas detector. This is more expensive than a simple single sample continuous system, but a cost/benefit analysis can show the point that makes it economically viable for multiple sample streams, depending on the application. A sequential system works by pulling each sample to a control block (usually a bank of solenoid valves) that allows one sample at a time to run through the sampling system and to the detector. The detector measures that sample for a fixed period, reports that the value closes off that sample line, and then clean air is pulled through the system to purge it for the next sample. This process repeats for each of the sample lines connected to the system. Often, a PLC (programmable logic controller) or some logic control system is used to manage the divider and report each channel's measured value individually.

While there is a point where it makes economic sense to use a sequential system rather than several continuous systems, there is an 'opportunity cost' associated with sequential sampling. If response time is important, it must be a critical factor in the decision to perform continuous versus sequential measurements. Sequential measurements can take several minutes to cycle through from one sample to the next depending on the type of gas, the dwell time needed to present a representative sample, the sensor response time, and the purge time required to ensure that the samples do not cross-contaminate one another.

Dräger Solutions

Dräger offers a variety of solutions to solve sampling challenges. These include standard continuous sampling systems or custom designed continuous or sequential systems for specific applications. Below is a list of our standard sampling systems. Components can be mounted either on a stainless steel backplate for easy access and quick inspection, or in a stainless steel enclosure for extra protection and security.

These systems can detect a wide variety of toxic gases or oxygen with electrochemical (EC) sensors using our top-rated Polytron® 8100, or monitor combustible hydrocarbons using our unique Polytron 8700 infrared transmitter. Other configurations are available on request.

Standard Sampling Systems

NA10429 – Polytron 8100, Aspirated, Stainless Steel Plate (sensor selection required)
NA10444 – Polytron 8100, Aspirated, Stainless Steel Enclosure (sensor selection required)
NA10445 – Polytron 8100, Pump, Stainless Steel Enclosure (sensor selection required)
NA10446 – Polytron 8700, Aspirated, Stainless Steel Enclosure
NA10447 – Polytron 8700, Pump, Stainless Steel Enclosure

EC: Detecting toxic gases and oxygen using a sample system with electrochemical sensors

Sample draw systems work very well to monitor air for toxic gases and oxygen. The sampling system can help clear the sampled air stream of unwanted constituents, such as liquids and particulates, and mitigate other issues like pressure and temperature. The result is a relatively clean sample that improves the accuracy of the measurement and can prolong the life of the sensor. A remote sampling draw system can also transfer the location of gas detector inspections and maintenance away from a process that is dangerous due to temperature, pressure, height or potential gas leaks to a safer area.

However, monitoring for toxic gases using a sampling system presents several challenges aside from the composition of the sample. Here are some other key considerations when measuring toxic gases:

- **Continuous exposure:** The EC sensors used to detect toxic gases are intended for use in ambient air environments, with only intermittent exposure to the target toxic gas. They are not designed to monitor frequent or constant levels of the gas over long periods of time. Constant exposure to the target gas over long periods will shorten sensor life and increase the frequency of sensor replacement. However, this may be acceptable if you do not have a better means of making the required measurement.

- **Reactive gases:** If you are measuring 'sticky' gases that are very reactive with surfaces, response time will be affected because the sampling system tubing and wetted parts from the sample point to the detector will have to be conditioned (coated with a layer of the gas) to allow a free flow of the gas for accurate readings. If response time considerations are paramount, it may require careful planning of the sampling system when certain gases are involved.

- **Solvent vapors:** Most EC sensors do not work well or have shorter lives in sample streams with strong solvent vapor backgrounds, even below 100 ppm. This vapor attacks the materials used in the sensors, reducing accuracy and shortening sensor life. Please consult with experts on applications with suspect background gases.

- **Oxygen levels:** EC sensors generally measure by reacting an internal chemical electrolyte with the target gas. This reaction requires oxygen to operate properly, at least in the range of several hundred ppm for most sensors, but >5% volume is optimal. The sensor will work for a while on retained internal oxygen (15 – 30 minutes) in an inert atmosphere, but need to come up for air from time to time to maintain proper operation.

- **Low humidity:** EC sensors have the longest life when used outdoors with variable humidity levels. For process applications with continuous dry air, the sample air would have to be humidified using Nafion(R) tubing or other means.

IR: Detecting combustible hydrocarbons using a sample system with infrared sensors

Combustible hydrocarbons (HCs) are often part of a process or exhaust stack from a plant. Often these processes need to be monitored to make sure the hydrocarbon level is not climbing close to an explosive level (high LEL). IR detectors are particularly adept at this measurement and are very fast at responding to changes. Many different hydrocarbons can be monitored with IR – either alone or as a mix of gases. The instruments used for this are non-dispersive infrared (NDIR) – which means they use a single wavelength of light that is absorbed by many different HCs as their measuring beam. If a single gas is present, it can be measured accurately. If there are several HCs in the stream, the settings can be adjusted to monitor the mix in the safest possible way.

The big advantage of IR sensors is that they are not affected by exposure to a constant stream of the target gas. Because of this, there is an opportunity to monitor processes that constantly off gas certain HCs such as methane, solvents, organic compounds and others – without impacting the operation or longevity of the sensor. Other sensor limitations determine the parameters for which a good sample system is designed to compensate.

CatEx: Detecting combustible hydrocarbons using a sample system with catalytic sensors

There are additional ways to measure HCs and other combustible gases, primarily with catalytic sensors. Catalytic sensors actually measure more combustible compounds than IR sensors and are sometimes preferred for gases that do not respond to IR sensors, such as hydrogen. However, catalytic sensors have several disadvantages for monitoring in sample draw systems:

- Like EC sensors, catalytic sensors are not intended for monitoring a constant level of combustible gas over long periods. Constant exposure to the target gas over long periods will shorten sensor life, increasing frequency of sensor replacement.
- Catalytic sensors need more frequent calibration and replacement than IR sensors, which means higher maintenance costs.
- Catalytic sensors actually burn the target gas, so they require oxygen at >10% volume to operate properly. They will shut down in atmospheres that have low or no oxygen. IR sensors do not need oxygen to operate, so inert or low O_2 atmospheres are not a problem.
- Catalytic sensors can be desensitized by poisoning agents such as sulfur compounds, halogens, heavy metals (e.g., lead in gasoline), long-chain hydrocarbons (e.g., polyethylene) and others.
- Catalytic sensors can fail 'unsafe' – meaning that they can desensitize to the target gas over time and stop responding. Even in hazardous conditions, they will read zero, which is often what the end user wants to see. IR sensors do not read zero when they fail: they will go out if the lamp or detector components fail and can warn if the signal level is affected by outside elements.

Advantages of Dräger Solutions

Our **Polytron 8100 standard sampling systems** provide easy installation and startup for a wide variety of toxic gases or oxygen using EC sensors. They are not designed for use with all 32 of Dräger's EC sensors, since some gases have characteristics that require special sampling techniques. Key gases for which we offer standard sampling systems include ammonia, carbon monoxide, chlorine, hydrogen, hydrogen chloride, many hydride gases, hydrogen sulfide, nitric oxide, nitrogen dioxide, select organic vapors, ozone, phosgene, and oxygen.

These standard sampling systems are effective, fast, and easy to set up and operate. Each has everything needed for a sample draw application:

- Motive force: (pump or aspirator)
- Filter (if required)
- 3-way valve for sample flow and calibration selection
- Flow meter
- Flow switch
- Gas detector with sensor

We also stock spares and consumables for these systems to address maintenance requirements.

The **Dräger Polytron 8100** is a universal transmitter that accepts any DrägerSensor® by downloading sensor-specific information from the embedded EEPROM sensor. The transmitter has a large graphic display, 4 to 20 mA and HART output, and uses a unique housing that allows for hot-swapping sensors in hazardous areas.

Electrochemical (EC) **DrägerSensors** provide large electrodes and a large electrolytic reservoir, which allow EC **DrägerSensors** to offer fast response times, excellent measurement accuracy, high stability, and long sensor life. They are all smart sensors with an internal temperature element and an embedded microchip with calibration info and integrated operating parameters to work with any Dräger Polytron EC transmitter. The transmitter includes automatic sensor recognition, numerous self-test functions, remote calibration and signal compensation over a wide operating temperature range of -40 to +149°F.

Dräger Polytron 8700 IR sensors monitor for combustible hydrocarbon gas including CH_4 (methane), providing long life (>10 years) and fast response times. The IR gas detector and transmitter have sophisticated double-compensated optics that provide 4-beam technology and ensure low signal drift to minimize routine maintenance, wide temperature range (-40 to +170°F), and beam block warning before potential failure to allow pre-emptive action to eliminate downtime.

The **Dräger PIR 7000 IR sensor** can be combined with the **Dräger PRC** software for applications where the target gas frequently changes. The most common application are continuous solvent drying ovens where different coatings are dried. Accurate monitoring of LEL levels is key for running high speed dryers safely.

Dräger custom solutions

If our standard systems do not meet your specific needs, Dräger's Custom Engineering group is available to modify them as needed or design a complete sampling system specific to any application. Sequential systems are always custom designed since the number of sample lines, dwell times, and many other key parameters are unique to each application. This allows us to deliver the best system for your budget and monitoring requirements.

Restrictions

– Sampling inert atmospheres with EC or CatEx sensors
– Sampling streams with solvents with EC sensors
– Constant background of target gas for EC and CatEx sensors
– Pressure and flow considerations

Expert technical support

Gas detection can be complicated and specific needs can vary from plant to plant. Dräger gas detection experts have extensive experience and can recommend the best solution for each facility. Dräger customers can take advantage of Dräger's unmatched technical support to discuss their application in detail and create an optimal gas detection solution.

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