Fixed Systems for your Flame and Gas Detection Application Solutions

Today's modern industrial sites are complex environments that present many challenges for effective hazardous gas safety monitoring. Application solutions not only include hazard assessment based upon the specific industry, but must also consider land topography, facility construction and layout, as well as risks present based upon equipment, design and placement.

Many industrial processes can potentially produce hazardous gas concentrations. Permanently-mounted or "fixed" gas detection systems, those that are permanently installed within a facility or location, offer many options to accommodate ongoing monitoring for ordinary occurrences as well as for those of an emergency nature.

These systems may comprise point detectors or numerous single sensors mounted at pre-determined intervals for leak detection, as well as open-path systems that monitor perimeters via line-of-sight optical technology. Relatively new technology uses ultrasonic sensors to detect gases within windy environments that would otherwise disperse gas plumes too quickly to be monitored via other sensor types.

Gas detection technologies can vary widely in price, from the relatively lower cost of catalytic bead technology to that of higher-priced open-path and infrared. Different technologies also may pose interferent gas issues. In gas detection terminology, an interferent is defined as any gas other than the target gas that will cause a response from a gas sensor. Suppliers of gas detection equipment can provide detailed breakdowns of sensor technology pricing and options, and assist you with decisions concerning those technologies best suited for your applications.

This guide's purpose is to assist new users of fixed gas detection systems with basic understanding of available detection technologies. Listed here are typical uses of several system types that are integrated to provide overall hazardous gas detection coverage. Your facility's gas detection requirements should of course, be determined by a qualified safety professional.

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Designing a Fixed-site Gas Detection System

Gas detection systems are essential for any plant, facility or place of employment where gases are used, generated or transported.

This document aims to help architects, engineers, plant managers and supervisors gain an initial understanding of fixed-site gas detection systems, including concerns to address when planning a gas detection system, and a comprehensive listing of available technologies.

Modern fixed-site gas detection systems are combinations of point detectors and networked monitoring and automatic response functions, complete with audible and visual alarms. To find the right gas detection system, first understand the gas hazards likely to be present at your facility. Then carefully evaluate available technologies to detect these potential hazards.

The following five areas of consideration may be helpful when considering system design:

1. **Understand Your Application**. Determine if you must comply with federal, state or local workplace, building or fire safety regulations. Are gases at the site combustible, toxic or both? Will gas detection sources be placed outdoors, indoors or both? Is a power source available for outdoor gas detection systems?
2. **Identify Potential Danger Points.** Danger points are identified in one of two ways, **release points** and **receptor points**.
   - **Release point** - location where potentially hazardous gases may be released, also referred to as the **source**.
   - **Receptor point** - location where potentially hazardous gases may threaten personnel, property or facilities. Also, the area between release and receptor points must be monitored.
3. **Establish Design Goals.** If a gas leak or rupture is detected, what actions should follow? Gas detection systems can notify and warn employees, trigger automatic ventilation systems, shut down related processes such as flow controls valves, or enunciate the need for workers to evacuate and for responders to arrive.
4. **Determine Gas Characteristics.** For example, what is the vapor density of the gas in question? Some gases are heavier than air and will collect in low-lying areas; other gases are lighter than air and will collect at or near ceilings of indoor spaces. Another gas characteristic is that temperature and vapor density have an inverse relationship; as temperature increases, vapor density decreases. As temperature cools, vapor density increases. There are many other dynamics to consider that a gas detection system provider can explain to you.
5. **Profile the Facility.** Consider the physical, environmental and air flow constraints where gas detectors and sensors will be installed. You will want to minimize the need for sensor relocation and false alarms. Make certain the detection system is right for your location, whether indoors or outdoors. Sensors mounted in low-lying areas should be kept clear of transportation routes and protected from areas where routine cleaning or precipitation may splash and possibly affect sensor ability to function properly. Again, these concerns are just a few facility physical aspects to consider when designing and installing your fixed-site gas detection system.

Sensor Technologies

Catalytic bead sensors , also known as pellistors, oxidize combustible gas. Heated catalyst-coated wire coil burns (catalyzes) the gas of interest; wire temperature increases along with its electrical resistance. Wheatstone Bridge circuitry employs two detectors, one for detection and one for compensation. The first detector converts the resistance change into a corresponding, measurable signal. The second detector compensates for temperature, pressure and humidity. Gas readings display as % LEL (Lower Explosive Limit).	• ***Pros***: long life, less sensitive to temperature, humidity, condensation, and pressure changes (as compared to NDIR), high accuracy, fast response, monitors a wide range of combustible gases and vapors in air. • ***Cons***: subject to sensor poisoning, requires air or oxygen, shortened life with frequent or continuous exposure to high LELs, non-specific detection, requires flame arrestor.
Electrochemical sensors for oxygen deficiency and enrichment use an electrolyte and electrodes to produce an electrochemical reaction to generate a current proportional to the gas concentration. Gas reading displays as % by volume.	• ***Pros***: high sensitivity, ease of handling, low power consumption. • ***Cons***: limited shelf life, sensor lifetime is reduced when used in very dry, hot environments, within enriched oxygen environments, or complete lack of oxygen. Lead-based sensors are subject to environmental disposal issues.
Electrochemical toxic gas sensors (e-chem) use an electrolyte and active electrodes to produce an electrochemical reaction to generate current proportional to the present gas concentration. Gas reading display as parts per million.	• ***Pros***: high sensitivity, ease of handling, low power consumption. • ***Cons***: limited shelf life, sensor lifetime is reduced when used in very dry, hot environments, can be affected by interferents, requires oxygen.
Flame ionization detectors (FIDs) are generally used to detect organic compounds. Compounds of interest are ionized using a small hydrogen flame generated within the detector. The resulting charged ions create current between electrodes; this measurable current is used to determine the proportion of carbon that has been reduced by flame exposure. Gas reading displays in picograms.	• ***Pros***: high sensitivity, ease of use. • ***Cons***: high maintenance sensor, requires presence of hydrogen and air, gas sample is destroyed by FID process.
Ion Mobility Spectroscopy (IMS) sensors ionize vaporized samples via an electrical charge. Resulting ions drift through a sensor tube to the sensor detector. Varying ion drift speed is used to identify the original sample. Current generated at the detector; resulting spectrum is analyzed for sample identification and concentration.	• ***Pros***: highly sensitive, speed of chemical analysis. • ***Cons***: sample pre-concentration for lowest ranges, not real-time if sample pre-concentration is used. Some systems require a vacuum, some require a radioactive ionization source.

Metal oxide semiconductor sensors (MOS), also known as solid state sensors, detect combustible and toxic gases. Metal oxide, through use of electrodes, changes resistance in response to gas presence. Resistance change is measured and is proportional to the gas concentration of interest. Gas reading displays as **ppm** (parts per million).	• *Pros*: high sensitivity (detects low concentrations), wide operating temperature range, long life. • *Cons*: cross-sensitive to other compounds, humidity-sensitive, subject to poisoning, requires air/oxygen for proper function.
Multi-spectral radiation silicon carbide-based photo detection technology is often used in combination with infrared detection (IR, UVIR, IIIR, and MSIR), monitors for fire or flame from hydrogen-or hydrocarbon-fueled fires.	• *Pros*: reduce the possibility of false alarms, as sensors must receive fire radiation proper wavelength, duration and intensity before alarm activates. • *Cons*: sensitivity is limited by distance, size of flame and background radiation.
Open (long) path infrared sensors (OPIR) measure hydrocarbon gas, but differ from point infrared detectors in that the IR source is separated from the detector. Open-path IR sensors employ a multiple beam concept to sample gas clouds at a distance of up to 100 meters. When a gas cloud crosses the beam, the sample signal is absorbed or reduced in proportion to the amount of gas present; reference beam stays constant. The system calculates the comparison to produce a readable signal. Gas readings display as % LEL per meter.	• *Pros*: high accuracy and selectivity, large measurement range, low maintenance, chemical poison-resistant, requires no oxygen or air. • *Cons*: unsuitable for hydrogen detector path (subject to environmental obstructions such as smoke, mist and fog), does not isolate leak source.
Paper tape technology is based upon use of absorbent filter paper strips that act as a dry reaction substrate. Classic colorimetry techniques used are capable of extremely low toxic gas detection limits.	• *Pros*: highly sensitive and selective for toxic gases. Leaves physical evidence of gas exposure. No false alarms. • *Cons*: requires extraction system. May need sample conditioning. High maintenance.
Photo ionization detectors (PIDs) use ionization to detect volatile organic compounds (VOCs). Ultraviolet lamp within sensor ionizes the compound of interest. Collected ions and current produce a readable concentration of the compound of interest. Gas reading displays as parts and sub-parts per million.	• *Pros*: fast response speed, very low level detection, detects any compounds. • *Cons*: high maintenance, limited operating life, requires frequent calibration, humidity-sensitive.
Photoacoustic infrared sensors (PIR) and Fourier transfer infrared (FTIR) sensors detect combustible and toxic gases. A gas sample is exposed to infrared light; as the gas absorbs light, a signal is generated that is proportionate to the concentration. Gas reading displays as % LEL, % by volume, parts per million (ppm), and parts per billion (ppb).	• *Pros*: high sensitivity, stable with ease of handling, not subject to poisoning. • *Cons*: not all gases can be detected by infrared technologies, can be affected by vibration.
Point infrared short path sensors (AKA non-dispersive infrared or NDIR) measure hydrocarbon gases and carbon dioxide. Detectors are sensitive to varied infrared wavelength ranges. The gas of interest and inert reference gas are exposed to infrared light; amount of light transmitted through each sample is compared to determine gas of interest concentration. A micro-processor monitors signals ratio and correlates results to a readable signal.	• *Pros*: high accuracy and selectivity, large measurement range, low maintenance, chemical poison-resistant, requires no air or oxygen, long operating life (as compared with catalytic bead). • *Cons*: unsuitable for hydrogen detection.
Surface acoustic wave (SAW) sensors composed of piezoelectric (electrically-charged) crystals detect chemical vapor mass that is absorbed into chemically- selective coatings on the sensor surface. Absorption causes sensor resonant frequency change; internal microcomputer measures changes to determine chemical agent presence and concentration. Gas reading displays in milligram per cubic meter (mg/M^3), parts per million or trillion, or present/not present.	• *Pros*: stable and reliable, detects trace chemical concentrations, low instances of false positives and false alarms. • *Cons*: some detectors only read present/not present and lack additional specificity.
Thermal conductivity sensors for combustible and toxic gases measure the gas sample's heat transmitting ability by comparing it with a reference gas (usually air). Two detectors (detecting and compensating) are built into a Wheatstone Bridge circuit. Gas sample exposure changes its electrical resistance proportional to the present gas concentration. Compensating sensor verifies resistance change. Gas reading displays as parts per million up to 100% by volume.	• *Pros*: wide measuring range. • *Cons*: cross-sensitive to other compounds), ineffective in measuring gases with certain thermal conductivities (close to air). Usable for only binary gas streams.
Ultrasonic gas leak detectors are used to detect leaks from high pressure systems. This device detects the airborne acoustic ultrasound generated when pressurized gas escapes from a leak. When such a leak occurs, the ultrasound generated travels at the speed of sound, through the air, from the source to the detector. These detectors do not measure gas concentration, but rather a high pressure leak occurrence. These devices are therefore often used to supplement traditional gas detection devices and can serve as early warning systems.	• *Pros*: unaffected by weather conditions that cause gas dispersal, low maintenance. • *Cons*: any object in the sensor path will return an echo. Sensor reach is limited to shape and size of sound wave emissions.

Fixed Gas Detection Applications

Oil, gas, petrochemical refineries, chemical plants

- UV and IR radiation of hydrocarbon-based fires
- OPIR for long-range hydrocarbon detection
- Non-dispersive infrared sensor (NDIR) and point IR for toxic and combustible gas monitoring
- E-chem toxic gas leak detection, oxygen within confined spaces
- E-chem for oxygen deficiency for confined space entry
- Catalytic bead and NDIR for combustible gas detection

Automotive manufacturing facilities

- Catalytic bead LEL, e-chem, infrared LEL for toxic and combustible gases within test cells, laboratories
- Catalytic bead LEL for combustible gases in fuel storage, gasoline distribution areas, fuel blending areas, tank areas
- Point IR for refrigerant gases used in mechanical rooms
- Point IR for toxic and combustible gases including Dowtherm J heat transfer fluid

Municipal water, waste water treatment facilities

- UV/IR for hydrocarbon-based fires
- E-chem for chlorine, sulfur dioxide, hydrogen sulfide, oxygen as water treatment by-products
- Point IR, catalytic bead for combustible methane and petroleum vapors within wet well areas

HVAC

- PIR for refrigerant gases
- Catalytic bead and NDIR for refrigerants, cleaning agents and solvents in mechanical equipment rooms
- E-chem for carbon monoxide and nitrogen dioxide in parking garages, tunnels, furnace, and maintenance rooms
- NDIR, MOS and e-chem for carbon monoxide, nitrogen dioxide, refrigerants

Hospitals/other medical facilities

- E-chem for ethylene oxide leaks within laboratories, surgical areas, ICUs
- E-chem for refrigerant gas leaks in mechanical chiller rooms
- Catalytic bead for hydrogen detection
- E-chem for oxygen deficiency within MRI rooms
- E-chem for nitrous oxide leaks within cylinder storage areas

Iron and Steel

- E-chem for toxic gases or oxygen deficiency; catalytic bead for combustible and toxic gases, potential oxygen deficiency in blast furnace operation maintenance, converter operation, furnace/gas pipeline leaks, metal mining, finishing work, fuel storage, coking operations, welding, confined space
- NDIR point IR for refrigerant gases used in maintenance rooms (chillers)

Airports

- Catalytic bead, NDIR, PIR for combustible and toxic gases in fuel storage/fuel loading areas, pump houses, storage hangars
- Point IR, e-chem for carbon monoxide/nitrogen dioxide buildup within baggage handling areas, parking garages
- IMS for explosive residue screening
- UV, UVIR for flame detection within hangars and storage areas

Mining

- NDIR for combustible gases within confined space, mechanized coal cutting, diesel-powered machinery exhaust
- E-chem (oxygen) for confined space entry, toxic gases in metal mining, diesel exhaust, diesel-powered machinery, blasting

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