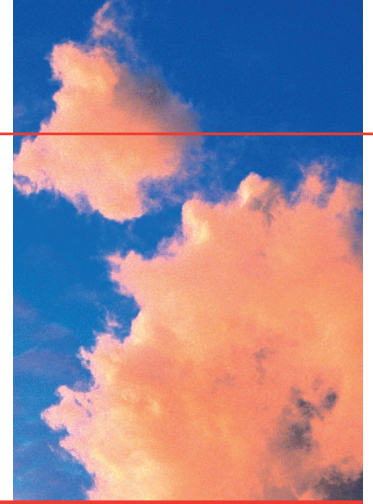


Direct Reading Gas Detectors FOR TOXIC KILLERS



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GAS Detection

Recent disasters point to the importance of identifying specific toxic hazards in the workplace, and doing something about them.

On 23rd December 2003 a gas well blowout near the city of Chongqing in central China released a deadly mixture of natural gas and hydrogen sulphide. The toxic cloud killed 243, caused the hospitalization and treatment of more than 9,000, and the evacuation of more than 60,000 nearby residents. Only two of those killed were gas field employees. The rest were residents of the surrounding area. Although official figures report 243 deaths, many survivors say that the true number exceeds 300.

On 16 April 2004 five large chlorine tanks at a chemical plant in central China exploded, killing nine workers, and leading to the evacuation of over 150,000 nearby residents. The tanks had been in the process of being drained when a sudden rise in temperature led to the explosion. Three remaining chlorine gassifier tanks had to be destroyed by military armour-piercing anti-tank weapons. Over 3,000 policemen, 650 armed police soldiers and 160 firemen were involved in the emergency response and detonation of the remaining tanks.

The Organization of Economic Cooperation and Development (OECD) produce a list of High Production Volume (HPV) Chemicals. According to the OECD, over 5,000 toxic chemicals are produced or imported in volumes in excess of 1,000 tons per year in the North America. On average, there are about 400 major accidents per year in the United States and Canada involving these chemicals.

Many of the most common toxic gases, including carbon monoxide, hydrogen sulphide, sulphur dioxide, chlorine, ammonia, cyanide, ethylene oxide, nitric oxide, nitrogen dioxide and chlorine dioxide can be measured by means of compact, substance-specific electrochemical sensors. Gas that enters the sensor undergoes an electrochemical reaction that causes a change in the electrical output of the sensor. The difference in the electrical output is proportional to the amount of gas present. The sensors are designed to minimize the effects of interfering contaminants on readings. Electrochemical sensors are compact, require little power, exhibit excellent linearity and repeatability, and generally have long life span.

New sensor technologies such as miniaturized photoionization detectors (PIDs) for volatile organic contaminant (VOC) measurement, and non-dispersive infrared (NDIR) sensors for CO₂ have increased the number of toxic gases that can be measured by means of compact, portable gas detectors. As exposure limits continue to drop, atmospheric monitoring programs increasingly need to include direct quantifiable measurement for many additional toxic substances.

Don't overlook the most obvious hazards: CO and H₂S

Carbon monoxide (CO) and hydrogen sulphide (H₂S) are still the two most commonly encountered toxic gases. CO is a by-product of incomplete combustion, and will always be present where combustion occurs. CO causes more accidental poisonings than any other chemical substance. According to the Journal of the American Medical Association (JAMA),

1,500 persons are killed every year in North America, while 10,000 more are forced to seek medical attention because of accidental exposure to this substance. While the majority of these incidents are not work related, many workplace environments and activities are highly associated with this hazard. Fossil-fired power generation stations, steel mills, foundries, aluminum mills, mines, vehicle maintenance facilities and confined spaces are all prone to the presence of CO. Fire service personnel, parking garage attendants, propane powered equipment operators, warehousemen, and shipyard workers are just some of the workers frequently at heightened risk of exposure.

Carbon monoxide is a chronically toxic gas.



Compact personal gas detectors are available for a variety of specific toxic hazards including H₂S, CO, SO₂, Cl₂, ClO₂, NH₃, NO₂, ETO and O₃.

Prolonged or repeated exposure to relatively low concentrations of CO can eventually lead to injury, illness, or death. Although high concentrations of carbon monoxide may be acutely toxic and lead to immediate respiratory arrest or death, it is the long-term physiological effects due to chronic exposure at lower concentrations that take the greatest toll of affected workers. This is the situation with regards to smokers, parking garage attendants, or others chronically exposed to carbon monoxide in the workplace. Even when exposure levels are too low to produce immediate symptoms, small repeated doses can reduce the oxygen carrying capacity of the blood over time to dangerously low levels. This partial impairment of the blood supply may lead over time to serious physiological consequences.

Exposure limits for CO vary widely as a function of jurisdiction and workplace activity. The most widely recognized standards for CO reference an 8-hour TWA of 25 ppm, 35 ppm or 50 ppm, and a Ceiling (peak concentration) of no more than 200 ppm. A concentration of 1,200 ppm should be regarded as immediately dangerous to life and health. A concentration of 1,600 ppm can cause death in an hour-and-a-half to two hours.

As awareness of the toxicity of H₂S grows, workplace exposure limits are being reduced

H₂S is produced by the action of anaerobic, sulphur fixing bacteria on materials that contain sulphur. It is a constituent of natural gas, petroleum, sulphur deposits, volcanic gases and sulphur springs. It is especially associated with oil production, refining activities, sewers, and many types of confined spaces. Tragically, hardly a week goes by that does not include a fatal accident somewhere in the world due to H₂S exposure.

Hydrogen sulphide (H₂S) is a colorless gas that at low concentrations famously has an odor similar to rotten eggs. At higher concentrations, H₂S rapidly deadens the sense of smell. For most persons, a concentration of 150 ppm is enough to immediately deaden the sense of smell. At air concentrations of about 750 ppm, inhalation of hydrogen sulphide gas can cause immediate collapse and unconsciousness. A single breath at a concentration of 1,000 ppm results in immediate loss of consciousness, followed by cardiac arrest and death unless the unconscious individual is successfully revived. Many of the villagers killed in the China disaster died in their sleep, without even an opportunity to attempt to escape. The corrosive properties of H₂S were especially apparent in newspaper photos of the victims of the China disaster. Many had eyes swollen shut, with faces horribly burned by exposure to the corrosive vapours. Many more have suffered permanent damage to delicate lung tissues exposed to the gas. For many survivors there will never be a full recovery.



Exposure limits for H₂S also vary widely as a function of jurisdiction. The most widely recognized standards for H₂S reference an 8-hour TWA of 10 ppm or 20 ppm, and a 15-minute STEL of no more than 15 ppm. Concentrations above 100 ppm should be regarded as immediately dangerous to life and health.

The American Conference of Governmental Industrial Hygienists (ACGIH™) publishes guidelines to assist in the control of health hazards in the workplace, including toxic gases like H₂S. ACGIH™ recommendations are published as Threshold Limit Values (TLVs™). In many jurisdictions, ACGIH™ TLVs™ have the force of law. In some cases, local regulations, or corporate guidelines may take an even more stringent approach.

The ACGIH™ TLV™ currently in effect for H₂S consists of two parts, an 8-hour TWA of 10 ppm, and a 15-minute STEL of 15 ppm. Increasing awareness of the hazards associated with chronic exposure to even low concentrations of hydrogen sulphide has led to a draft proposal by the ACGIH™ to lower the workplace exposure limits for H₂S to an 8-hour TWA of only 1.0 ppm, and a 15-minute STEL of 5 ppm.

Chlorine

Chlorine (Cl₂) is a pervasively common industrial chemical. According to the OECD, 30.8 million pounds of chlorine are produced and used per year in the United States. Water treatment, the pulp and paper industry, chemical plants, and many other industries are all major users of this chemical. The most widely recognized standards for Cl₂ reference an 8-hour TWA limit of 0.5 ppm, and a 15-minute STEL of 1.0 ppm. For many individuals, these concentrations may be too low to detect by smell. The corollary is that if you can smell the odour of chlorine, you are probably at or above the exposure limit for the substance.

The consequences of a major leak or release leak can be catastrophic. On 6 May 1991, a massive liquid chlorine leak from a chemical plant in Henderson, Nevada produced a cloud that drifted over the town, causing more than 200 injuries, at least 30 very serious, and the evacuation of approximately 7,000 nearby residents. Thankfully, there were no fatalities. The number of injuries and likelihood of fatalities would have been much greater if not for the fact that plant employees were equipped with emergency escape respirators and direct reading chlorine detectors. In an emergency situation, planning, training, and on-hand personal protective equipment make all the difference.

Ammonia

Ammonia (NH₃) is even more common, with an estimated 40.6 million pounds produced and used per year. Ammonia is commonly used in many industries, including petrochemical, pulp and paper, fertilizer and the oil industry to name but a few.

Anhydrous ammonia is also very widely used as a coolant in large industrial refrigeration systems. While ammonia refrigeration has long been a standard in the food/beverage industry, it is also now found in pharmaceuticals production, in air-conditioning equipment for many public buildings and in electric power generation plants.

Ammonia is a highly toxic gas, and proper safety monitoring procedures and equipment must be in place at all times to avoid serious accidental injury or death. The most widely recognized exposure limits for ammonia are an eight-hour TWA of 25 ppm, with a 15-minute STEL of 35 ppm. Besides its toxic properties, ammonia is also an explosively flammable gas, with a lower explosion limit (LEL) concentration of 16% volume.

On 21 September, 2001, an ammonia / ammonium nitrate explosion at a fertilizer plant in Toulouse, France killed 30, and injured 2,500 more workers and nearby residents. According to the government investigation, as horrific as the accident was, it could have been much worse if intervening buildings had not broken the force of the explosion, preventing the potential detonation of 20 more railroad tank cars full of anhydrous ammonia.

Carbon dioxide

While many safety managers continue to view CO₂ primarily as a simple asphyxiant, carbon dioxide is a toxic gas. The most widely recognized standards for CO₂ specify an 8-hour TWA of 5,000 ppm, and a 15-minute STEL of 30,000 ppm. Carbon dioxide is a strong cerebral vasodilator. Inhaling high concentrations can cause rapid circulatory insufficiency leading to coma and death.

As awareness of CO₂ as a toxic hazard increases, regulations are beginning to require direct measurement as part of confined space monitoring programs. In Germany, confined space regulations now include direct measurement of CO₂ as a mandatory requirement.

Carbon dioxide is usually measured by means of a non-dispersive infrared (NDIR) sensor. NDIR sensors detect gas by measuring the absorbance of infrared light. Specific molecules (like CO₂) absorb infrared radiation at precise wavelengths. NDIR sensors include a source of infrared light, which is filtered to provide a narrow range of wavelengths. As the infrared radiation passes through the sensing chamber, only those wavelengths that match the contaminant being measured (in this case CO₂) are absorbed. The rest of the light is transmitted through the chamber without hindrance. The amount of light absorbed is proportional to the amount of CO₂ present.

Volatile Organic Compounds (VOCs)

VOCs are organic compounds characterized by their tendency to evaporate easily at room temperature. Familiar substances containing VOCs include solvents, paint thinner, nail polish remover, as well as the vapors associated with fuels such as gasoline, diesel, heating oil, kerosene and jet fuel. The category also includes many specific toxic substances such as benzene, butadiene, hexane, toluene, xylene, and many others. In the past, since most VOCs are combustible at higher concentrations, the tendency has been to monitor them by means of the percent LEL combustible sensor included in most multi-sensor instruments. Unfortunately, we know today that many VOCs present a toxic hazard when present at much lower concentrations.

In 2002 the ACGIH™ adopted a new, very tough exposure limit for diesel vapor. The ACGIH™ TLV™ specifies an eight-hour TWA for total diesel hydrocarbons (vapor and aerosol) of 100 mg/m³. This is equivalent to approximately 15-ppm diesel vapor. This concentration limit is far too low for detection by means of a standard LEL range combustible sensor. Photoionization detectors capable of PPM range measurement, or PPM range capable combustible gas sensors are the most widely used techniques for TLV™ range measurement of this hazard.



Zero maintenance personal H₂S detectors are compact, weather resistant, and last up to two years without requiring battery replacement or calibration adjustment.

Photoionization detectors (PIDs) use high-energy ultraviolet (UV) light from a lamp housed within the detector to remove an electron from neutrally charged VOC molecules. This produces a flow of electrical current proportional to the concentration of contaminant. Photoionization detectors are non-specific, that is, they provide a "broad range" indication of all detectable molecules present in the atmosphere being monitored. PIDs can only detect certain gases and vapors. Nonvolatile liquids and solids, particulates, and many toxic gases and vapors cannot be detected at all.

Look for it

The only way of being sure that toxic contaminants are not present in dangerous concentrations is to look for them with an atmospheric monitor designed for their detection.

Gas detectors used to monitor for the presence of toxic gases are increasingly compact, rugged, easy to use and much less expensive than ever before. There is an instrument with the features and pricing to fit every atmospheric monitoring program and budget. Given the prevalence, dangers and human costs associated with toxic gas accidents, use of gas detection instruments should be an integral part of every workplace safety program where these hazards are potentially present.

About the author

Robert Henderson is Vice President, Business Development for BW Technologies. Mr. Henderson has been a member of the American Industrial Hygiene Association since 1992. He is a current member of the AIHA Gas and Vapor Detection Systems Technical Committee. He is also a current member and past chair of the AIHA Confined Spaces Committee. He is also a past chair of the Instrument Products Group of the Industrial Safety Equipment Association.