Direct Reading Gas Detectors
FOR TOXIC KILLERS

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

For carbon monoxide (CO) and hydrogen sulphide (H2S) are 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.

Industrial 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.

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 can 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 1,800 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.

Hydrogen sulphide (H2S) is a colourless gas that at low concentrations faintly 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 1,200 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.

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

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BW Technologies Article (P39-40)  7/19/04  3:40 PM  Page 39

GAS Detection

IET Buyers' Guide 2004 - 2005
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 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® TLV® 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 1.5 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 1300 nearby residents. Thankfully, there were no fatalities. The number of injuries and likelihood of fatality 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, training, planning, 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.

Ammonia is also 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 20, 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 adhesives, 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, 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 used 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.

Photometric 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. Nonpolar 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 Detector 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.