Hydrogen Sulfide: Take It

Before the invention of hollow plastic eggs filled with candy, most people hid boiled eggs at Easter. Sometimes the eggs were hidden indoors and occasionally an egg was not accounted for at the end of the hunt. A week or two later, a foul odor would lead someone to the missing egg. That odor was hydrogen sulfide (H_2S) produced from the natural decay of the egg.

A decaying egg in someone's home is a short-term annoyance that is easily remedied with no long-term concerns related to the incident. However, in industries where H_2S is manufactured or is produced as a by-product of other processes, H_2S is much more than a nuisance and should be taken seriously. The rendering process that results in valuable and useful consumer products often generates H_2S gas at concentrations that can be harmful and sometimes fatal. The decaying or cooking of organic material such as blood, feathers, hair, meat, and offal generates H_2S. Equipment or areas often associated with H_2S include blood tankers, meat trailers, raw product bins, cookers, presses, blood centrifuges, confined spaces, and wastewater treatment processes.

Properties and Health Effects

H_2S, also known as sewer gas, hydrosulfuric acid, sulfureted hydrogen, and the more descriptive stink damp, is a naturally occurring, colorless gas that is commonly described as smelling like rotten eggs. At room temperature it is slightly heavier than air and will tend to concentrate in low-lying areas if there is little air movement. It is slightly soluble in water and can be flammable at a high concentration (43,000 parts per million (ppm) or 4.3 percent).

The primary concern related to H_2S is the sudden inhalation (exposure) of high concentrations of the gas by an unsuspecting individual. H_2S is considered a broad-spectrum poison, meaning that it can poison several different systems in the body. Table 1 summarizes the health effects that may occur at various levels of exposure.

Table 1. Summary of Health Effects from Exposure to H_2S

H_2S Concentration (ppm)*	Health Effect
20-50	Noticeable eye irritation
100	Loss of ability to smell in 3-15 minutes
200	Loss of ability to smell quickly; stings eyes and throat
250	Pulmonary edema (fluid in lungs) with prolonged exposure
500	Dizziness; breathing ceases in a few minutes
700	Rapidly produces unconsciousness; breathing stops rapidly
>1,000	Single breath can cause collapse, coma, and death

*Values listed are approximations and individual variation is an important consideration.

When H_2S is inhaled, it enters the bloodstream through the lungs where it is metabolized in the liver to sulfate ions and eliminated from the body in urine. This process occurs rapidly and when the airborne H_2S concentration remains at a low enough level, the body is capable of prohibiting its buildup in the bloodstream. However, when a sudden exposure to a high concentration of H_2S occurs, the body is unable to metabolize it at a rate sufficient to prevent its accumulation in the blood. H_2S binds to hemoglobin in red blood cells and interferes with oxygen transport from the red blood cell to other cells. This can ultimately result in oxygen-deprived tissue, even though blood flow is adequate. An additional effect of a high exposure to H_2S is a rapid paralysis of the respiratory center of the brain leading to respiratory arrest (cessation of breathing) often referred to as "knockdown."

Another critical effect that increases the hazard of H_2S is olfactory fatigue. If a person is continuously exposed to H_2S concentrations above 20 ppm, he or she will temporarily lose their ability to smell it and may continue to work in a high concentration that could result in more serious health effects.

Overexposure Measures

When any overexposure to H_2S occurs, the most important step that should be taken is removal of the individual to fresh air. Accounts of H_2S related accidents are typically similar in nature – a rescue attempt of an overcome worker fails when the rescuer also is overcome. For this reason, proper emergency rescue procedures should be established and followed for any rescue attempt.

In addition, if a worker experiences health effects more severe than minor eye or throat irritation, a medical evaluation should be considered. A rule of thumb used in the oil fields is that if an overexposure occurs that results in the individual dropping to at least one knee without losing consciousness, medical attention should be sought.

Regulations and Guidelines for Exposure

To help protect workers in industries where H_2S is present, the U.S. Occupational Safety and Health Administration (OSHA) has established exposure limits for H_2S that shall not exceed 20 ppm (acceptable ceiling) with the following exception: if no other measurable exposure occurs during the eight-hour work shift, exposures may exceed 20 ppm, but not more than 50 ppm (maximum peak) for a single time period up to 10 minutes.

The American Conference of Governmental Industrial Hygienists (ACGIH), a non-regulatory organization whose members work primarily in state, local, and federal government, has also established worker exposure guidelines. The ACGIH exposure limits are as follows:

- Threshold Limit Value-Time Weighted Average, or

Seriously

By S. Brett Tarkington, MS, CIH, CHMM, and Paul Barton
Center for Toxicology and Environmental Health, LLC

TLV-TWA, of 10 ppm expressed as an average concentration over an eight-hour work shift.

• Short Term Exposure Limit, or TLV-STEL, of 15 ppm expressed as a 15-minute average concentration that should not be exceeded at any time during the work shift.

To protect workers from overexposure to H_2S, OSHA requires employers to identify potential sources of H_2S, evaluate the severity of the potential risk to workers, develop methods to ensure that workers are not overexposed (i.e., control methods), and inform workers of these activities.

H_2S Management Program

A program to manage exposure to H_2S in a rendering facility should include the following elements:

• Identify sources (areas and processes)

• Quantify the H_2S concentrations at and near these sources

• Engineering controls (local exhaust and general ventilation)

• Install stationary H_2S monitors with visible and audible alarm capability

• Use of personal H_2S monitors

• Housekeeping

• Restrict access to areas around sources

• Install warning signs and labels (hazard communication)

• Standard operating and emergency procedures

• Training for workers, managers, visitors, and contractors

Some of the processes and materials that often generate H_2S have already been mentioned. However, to fully characterize the sources of H_2S in a rendering facility, a qualified person will need to perform a comprehensive assessment. This means taking an H_2S survey instrument to each of these areas/processes, seeking out sources of the gas, and quantifying the concentrations.

An additional aspect of the assessment is personal monitoring. Workers wearing a personal H_2S monitor that is set to alarm at a level well below the OSHA exposure limit will know within seconds if they enter an area with an elevated H_2S concentration and will be able to better protect themselves and others from injury. In addition, many of these devices have the ability to record the average exposure and peak concentration during the shift (data log). These data can be downloaded, stored, and analyzed to provide a better understanding of H_2S concerns. Another key advantage of these devices is that they do not suffer olfactory fatigue and will continue to alarm until the individual is no longer in an environment with elevated H_2S levels.

Areas identified as having higher potential for elevated H_2S concentrations should have restricted access, signs or labels placed at entrances, and stationary H_2S monitors with visible and audible alarms to warn personnel of high H_2S levels.

For any type of airborne health hazard, there is a simple way of thinking about how to control worker exposures. First, there has to be a source (raw product cooker); second, a pathway (air); and finally, a receiver (worker). If the hazard is controlled at any of these points, the worker is not overexposed. The obvious best option for controlling the hazard is at the source, and this is where engineering controls such as local exhaust ventilation (LEV) can be used. LEV captures the H_2S at the point of generation and exhausts it safely out of the facility before it can be released into the plant. If H_2S is allowed to enter the work environment, general ventilation can be used to dilute the H_2S laden air with cleaner air so that if it reaches a worker, it is at a level that will not cause any adverse health effects.

A less obvious engineering consideration is the plumbing of process water or water draining from raw product bins directly into a drain. Water that has been in contact with raw material can contain H_2S and contribute to worker exposure. It is also important to clean up spilled raw materials as soon as possible to prevent their contributing to elevated H_2S concentrations.

If high levels of H_2S are not controlled at the source and are allowed to reach the receiver (worker), the last and least desirable control method is respiratory protection. A complication of using this control method is that at a H_2S concentration somewhere above 20 ppm, olfactory fatigue may occur and a worker will temporarily loose the ability to smell H_2S even when it is still present. For this reason, OSHA requires the use of air-line respirators or a self-contained breathing apparatus for use in environments with H_2S. The bottom line is that respiratory protection is not an attractive option for continuous rendering plant workers.

A document that clearly outlines the requirements and procedures for working around H_2S under normal operating conditions and during emergencies will serve as a tool for plant workers and managers to follow. If the first eight elements of the H_2S management program have been completed and everyone at the facility has been trained and understands the hazards and how to minimize the potential for exposure, a standard operating procedures manual will take any guesswork out of their daily activities related to H_2S overexposures.

Experience in the rendering industry has shown that H_2S has always been and will continue to be present. As responsible members of the rendering community, managers, industrial hygienists, and safety professionals at all levels of an organization need to take the lead in ensuring that all personnel working in a rendering facility are not overexposed to H_2S. ❖