REFERENCE DATA SHEET ON SEWER GAS(ES)

(Hydrogen Sulfide, Carbon Dioxide, Methane, Ammonia, Biological Agents)

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Potential Exposure Sources and Conditions:

- Sewer & Sewer Access Points
- Wastewater Treatment Facilities
- Underground Vaults
- Swamps/ Wetlands
- Activated Sludge Reactors
- Sewage Digesters
- Manure Pits
- Leather Tanning
- Trenches/ Excavations Near Sewer Lines
- Landfills
- Wet & Dry Wells
- Septic Tanks & Systems
- Anaerobic Conditions
- Methane Fermentation Reaction
- Lift Stations
- Certain Soils
- Petroleum & Natural Gas

SELECTED PHYSICAL DATA

Sewer gas is a generic name for the collection of gases and airborne agents that often accompany sewage and the natural processes and reactions associated with sewage processing and the decomposition of organic materials. The major components of sewer gas can include: nitrogen (N_2), hydrogen sulfide (H_2S), carbon dioxide (CO_2), methane (CH_4), ammonia (NH_3), biological organisms, water vapor, and other chemicals discharged to the effluent stream.[1,2] The presence and concentration of any of these components can vary with time, composition of the sewage, temperature, and pH.

- **Nitrogen** accounts for about 78% of the earth's atmosphere, and generally is not released from normally expected sewage reactions. It is not generated from the sewage, but its concentration in sewer gas may be effectively increased by the removal or consumption of oxygen through other means (i.e., rusting, other forms of oxidation or biological activity).

- **Hydrogen sulfide** is formed by biological and chemical processes in the liquid phase and is released to the headspace above the solution; its concentration in the gas phase is dependent upon its concentration in the liquid phase and ambient equilibrium conditions. At non-toxic levels, H_2S has the familiar odor of rotten eggs. At acutely toxic levels, H_2S quickly paralyzes an individual's ability to detect its odor, and will rapidly render a victim unconscious. Due to its relatively high toxic potential while at dilute concentrations, and normally expected air currents, the molecular gas density of H_2S is often of secondary importance in predicting its movement or stratification.[3] H_2S gas is also flammable at concentrations which are well above toxic levels (Lower Explosive Limit 4.35%, Upper Explosive Limit 46%).

- **Carbon dioxide and methane** have little or no odor characteristics and have a saturated gas density approximately 1.5 and 0.6 times that of air, respectively. Their relative gas densities compared to air and potential for elevated concentrations may cause some gas stratification. Since both of these gases are generated while in solution, there may be higher concentrations at the liquid-air surface.

- **Methane** is extremely flammable, has a wide explosive range, and a low flash point. These characteristics result in a substantial fire and explosion hazard. Methane will also react with some oxidizers spontaneously. It is also possible to have other flammable gases in sewers that originate from spills and leaks of flammable liquids.

- **Ammonia** has a distinct, strong odor with good warning characteristics which are present well before attaining toxic levels. Exposure to elevated levels of ammonia also may act as an eye and mucus membrane irritant. It is unlikely that acutely toxic levels of this material would be present from common sewage reactions.

All of the above gases are colorless at the concentrations commonly encountered in sewage systems.

- **Natural biological organisms and pathogens** from sewage can become airborne, primarily through agitation, or other physical actions on the accompanying liquid, but generally these microbes are short-lived when suspended in air.

Implications:

The materials which may occupy these locations may be variable mixtures of liquids, gases and mists. There may be little perceptible indication of decreased oxygen levels; there may be no warning odors for the most toxic gas; and there may be a possibility for a fire or explosion hazard. Exposure to airborne biological contaminants often requires the generation of mists containing these materials.

HEALTH EFFECT AND HAZARD DATA

The major adverse health effects and hazards from exposure to sewer gases are:

1. Poisoning from H_2S, Asphyxiation from displaced or consumed oxygen,
2. Decreased vigilance or fatigue due to reduced oxygen levels (from CO_2 and CH_4),
3. Biological contamination, and
4. Fires and explosions from methane gas, H_2S or other flammable gases.

Hydrogen sulfide has been reported as the leading cause of sudden death in the work place.[4] At concentrations in air of approximately 300 ppm, H_2S can be immediately deadly. It is absorbed primarily through the lungs, but can also be adsorbed to a limited extent through the skin and mucous membranes. Chronic health effects caused by repeated exposures have not been established. Common symptoms to non-acute exposure levels include eye irritation, fatigue, headache, and dizziness.

Carbon dioxide is a simple asphyxiant (displaces oxygen) and a stimulant for the respiratory system. A concentration of 5% may produce headaches and shortness of breath. Background concentrations of carbon dioxide in air range from 300 to 400 ppm.

Methane is a simple asphyxiant (displaces oxygen), but does not itself cause significant physiological responses.

Table 1 contains more information on the exposure criteria for the gaseous materials.

Common biological agents found in sewer systems may be bacteria, viruses, or parasites. Table 2 lists a few of the diseases and viruses that are associated with inhalation exposure from waste water operations.

TABLE 1 - SELECTED PROPERTIES OF SEWER GASES

Compound	Vapor Density (air = 1.0)	ppm Odor Threshold	PEL ppm [5]	STEL ppm [6]
Hydrogen Sulfide	1.19	0.01	20 (ceiling)	50 (10 mins.only)
Carbon Dioxide	1.53	-	5,000	-
Methane	0.55	-	-	-
Ammonia	0.59	17	50	-

TABLE 2 - SELECTED WASTEWATER RELATED DISEASES AND VIRUSES (inhalation)[7]

• Tuberculosis	• Poliomyelitis	• Common cold
• Histoplasmosis	• Adenovirus	• Echovirus
• Coxsackie A & B	• Bacillary dysentery	• Rotavirus

Implications:

The presence of sewer gas at significant concentration levels may result in dangerous conditions due to its toxic nature, its suppression of life supporting oxygen levels, and its potential explosive nature. Some components of sewer gas may result in detectable odors, but the odor warning characteristics alone may be insufficient to cause exposed individuals to leave the area. Biological contaminants can become airborne and accompany mists released from sewage-related operations.

CHEMICAL FORMATION/GENERATION

Hydrogen sulfide is formed from the bio-chemical reduction reaction of naturally occurring sulfate ions in water or from the decomposition of organic matter that contains sulfur under anaerobic conditions,[8] and from reactions of metal sulfides and strong acids.[9] Hydrogen sulfide generally will not form if there is an abundance of available oxygen. There is a potential for the continued biological oxidation of the hydrogen sulfide to form weak concentrations of sulfuric acid (H_2SO_4) or the formation of ferrous sulfide (FeS), a blackish solid residue, if iron is available. If sufficient dissolved oxygen is present, H_2S will not be generated.[10]

Carbon dioxide is the natural product of respiration, including that from microbial activity, and is primarily harmful due to the consumption and displacement of oxygen that accompanies its generation. This gas can also be produced under some circumstances from the reaction of some acids and the carbonates in concrete. This set of reactions is usually restricted due to such mass transfer limitations as the presence of slime and accumulation of a precipitate layer. There also is a water-carbonate system that will naturally dissolve or release CO_2 from ground and surface waters.[11]

Methane in sewers and similar structures generally occurs from biological activities or chemical reactions of certain organic materials. [12] Usually its concentration is below the lower explosive limit, and at that concentration range will only decrease the available oxygen concentration one percent for every five percent methane. Methane can add to the explosive vapors that may be present from other flammable and explosive chemicals that have been discharged to the system. The presence of elevated levels of nitrogen and carbon dioxide may alter the flammability limits normally published for methane in air.

The production of these and other gases may be altered by the presence of other chemicals, changes in temperature, and pH. The rate of gas generation may significantly affect the final concentration.

Implications:

There are several chemical pathways for the formation of these gases. Their concentration may be limited by reaction kinetics, mass transfer considerations, or by dilution effects. There are several sinks and sources for these materials. These kinds of controlling factors may substantially change the potential for exposure.

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