## 1. Purpose

1.1. Cleveland Integrity Services Inc. performs services for clients/customers in workplaces where there is a potential for exposure to hydrogen sulfide (H2S). Consequently, the Company has designed and adopted this *Hydrogen Sulfide (H2S) Safety Program* to prevent injuries and death due to exposure to H2S at work locations.

1.2. Exposure potentials occur when Company operations are near places and situations where there can be releases and accumulations of H2S. Such operations include pipeline maintenance or repair, and any work performed near wells, tanks and production facilities. Other H2S exposure situations include: work near drilling operations or with drilling mud; water from sour crude wells; wells blowouts; tank gauging at production, pipeline or refining points; and during field maintenance or battery work at wells.

1.3. This program provides for training site supervisors and employees who have a potential for H2S exposure at work, giving them the required knowledge about and qualification for H2S hazard recognition, safety practices, work procedures, and response to a H2S emergency.

## 2. Physical Characteristics

2.1. Hydrogen sulfide ($H_2S$) refers to either the gaseous or liquid form of the compound. Under atmospheric conditions, it is a toxic, highly flammable and colorless gas.

2.2. Typically called "sour gas", hydrogen sulfide is soluble in water, crude oil or petroleum fractions, and is extremely corrosive. At low concentrations it has the odor of rotten eggs.

2.3. The gas can cause severe stress cracking of steel and other metals.

2.4. Hydrogen sulfide burns with a blue flame to form sulfur dioxide which is also a toxic gas.

2.5. Hydrogen sulfide has a density 1.2 times greater than that of air and tends to settle in low lying areas.

2.6. The gas can be dispersed by wind movement or air currents. Additional characteristics are provided in Appendix I in this program.

2.7. It is important to understand that the concentration of hydrogen sulfide can be measured or expressed in two ways:

2.7.1. Parts per million (ppm) of $H_2S$ in liquid, by weight ratio, and

2.7.2. ppm of $H_2S$ in the air, by volume ratio.

2.8. While both methods of measurement are utilized, there is a significant difference between a hydrogen sulfide concentration in air and that in liquid. The actual concentration measured in air (by volume ratio) is usually much higher, and can be 10 to 100 times higher than the same value measured in liquid by weight ratio.

For example, crude oil being discharged into a storage tank may contain only 70 ppm hydrogen sulfide in the liquid by weight. However, the concentration of hydrogen sulfide in the tank vapor space above the crude oil could exceed 7000 ppm hydrogen sulfide by volume. Unless otherwise specified, all following discussions refer to hydrogen sulfide concentrations based on ppm in air, by volume ratio.

## 3. Exposure Standards

3.1. The exposure standards provided are intended primarily for domestic operations. Where foreign operations are concerned, practices will be in accordance with the respective foreign government's regulations.

3.2. OSHA General Industry standards (29 CFR 1910.1000 Z-2 Table) establish a Permissible Exposure Limit (PEL) of 20 ppm (ceiling), with one exception. If no other measurable exposure occurs during the 8-hour work shift, exposures may exceed 20 ppm, but not more than 50 ppm (peak), for a single time period up to 10 minutes.

3.3. OSHA Construction Industry standards (29 CFR 1926.55 Appendix A) establish a PEL of 10 ppm, 15 mg/m3 TWA.

3.4. In addition to federal regulations and guidelines such as the Threshold Limit Values, some state governments such as California have enacted occupational health and safety legislation. In many cases, state regulations are a merging of the OSHA and ACGIH exposure limits.

For example, Cal-OSHA notes an 8-hour hydrogen sulfide exposure limit of 10 ppm. An excursion limit of 20 ppm may be experienced over one 20-minute period per 8 hours, and a ceiling limit of 50 ppm is not to be exceeded at any time.

Operations located in states having their own occupational health and safety regulations should reference the respective exposure limits with regard to exposure control and compliance.

3.5. The exposure limits for hydrogen sulfide are primarily based upon the irritant effects of the gas and resulting worker discomfort. The more significant concerns regarding the potential disabling or lethal capabilities of the gas at concentrations greater than 100 ppm are not primarily considered.

## 4. HEALTH EFFECTS FROM EXPOSURE

4.1. The effects associated with hydrogen sulfide exposure are primarily determined by the concentration of the gas in the individual's breathing zone, the length of the exposure period(s) and individual susceptibility to the contaminant.

4.2. Exposure effects at various hydrogen sulfide concentrations are provided in summary as Table I.

4.3. The health effects associated with hydrogen sulfide exposure are most often the result of sudden, excessive exposures experienced over a short time period. For example, a short-term exposure to hydrogen sulfide at a concentration of 600 ppm can result in death within minutes.

4.4. A most important characteristic of hydrogen sulfide gas is its ability to cause olfactory fatigue or a failure in the sense of smell. At concentrations approaching 100 ppm, exposure to hydrogen sulfide causes a loss of the sense of smell. This effect can result in an individual developing a false sense of security relative to the exposure conditions.

**HIGH CONCENTRATIONS OF HYDROGEN SULFIDE, ESPECIALLY THOSE CAPABLE OF CAUSING PHYSIOLOGICAL DAMAGE, CANNOT BE DETECTED BY THE SENSE OF SMELL.**

**Table I -- Potential Health Effects Of Hydrogen Sulfide At Various Concentrations**

| **$H_2S$ Concentration (ppm)*** | **Potential Effect** |
| --- | --- |
| 10 to 20 | eye irritation, especially in hyper-susceptible workers |
| 20 to 100 | inflammation, corneal blistering and the capacity of the eye, loss of the sense of smell, headache, cough, nausea |
| 100 to 300 | respiratory difficulty, pulmonary edema, respiratory depression and irritation (30 min - 8 hrs) |
| 300 to 600 | central and peripheral nervous system effects, e.g., tremors, weakness, numbness of extremities, unconsciousness and convulsions (several minutes - hrs) |
| 600 to 1000 | rapid breaths, unconsciousness resulting in death if emergency aid is not promptly administered |
| 1000 and greater | cessation of breathing (instantaneous) and death |

**Note:** Effects described at a specific concentration usually occur with increasing severity at higher concentrations.

* parts per million parts of air in breathing zone.

## 5. Work Practices

5.1. The incorporation of the specific work practices discussed below into routine operation and maintenance activities can help prevent overexposure to hydrogen sulfide. These work practices have proven effective in controlling hydrogen sulfide exposure in various Company operations.

5.1.1. *Ventilation*

5.1.1.1. When the potential for hydrogen sulfide exposure occurs during routine operation and maintenance activities, ventilation of the worker's breathing zone is extremely important. Hydrogen sulfide gas is 1.2 times heavier than air and does not readily dissipate. The gas accumulates in low lying and confined spaces and may remain for an extended time. Adequate ventilation, whether provided by natural winds, powered air or local exhaust, can prevent hazardous concentrations of hydrogen sulfide from accumulating.

5.1.1.2. Outdoor tasks involving potential exposure to hydrogen sulfide should not be conducted on calm days, when it is not practical to do so. Wind direction should be verified by a wind sock, streamer, or vane, prior to initiating work. If possible, workers should always remain upwind from the source of the gas during tasks. Wind conditions cannot be relied upon as a single means of controlling exposure.

5.1.1.3. Inside work, where hydrogen sulfide exposure may occur, should be conducted under a properly functioning laboratory hood or with local exhaust ventilation placed at the source of emission. Laboratory hoods should provide a minimum average face velocity of 125 linear feet per minute (fpm). Ventilation requirements for confined spaces are discussed separately.

5.1.2. *Monitoring*

5.1.2.1. Fixed or portable monitors will be used to detect the presence of H2S. Alarms will be preset to signal at the appropriate permissible exposure limit of 20 ppm when work being performed is regulated under OSHA General Industry 1910 standards; or 10 ppm when work being performed is regulated under OSHA 1926 Construction Safety standards.

5.1.2.2. Upon the sounding of an area or personal H2S monitor, evacuation of the area will begin immediately to a safe area upwind from the location. The evacuated area will not be re-entered except by trained and authorized personnel utilizing appropriate respiratory protection; or until the “all clear” is

sounded by personnel in charge of the work site and it is safe to re-enter the area.

5.1.2.3. Representative employees should be selected to wear personal monitors when such group tasks are to be performed. Portable monitors can be substituted for the personal type as long as it adequately samples the work area used by all employees with a potential for exposure.

5.1.2.4. Monitors should be utilized for the complete duration of work activity. If the alarm sounds, indicating a concentration at/or above this level, workers should immediately leave the area.

5.1.2.5. Workers should withdraw upwind to a position that is considered to be a safe distance from the source of the gas. The alarm will continue to sound until the detector-sensor is cleared of hydrogen sulfide.

5.1.2.6. Allowing workers to re-enter, and work in the area should be permitted only if they are wearing a full-face pressure-demand airline respirator with escape bottle, or an approved self-contained breathing apparatus (SCBA).

5.1.2.7. This procedure should be followed until it has been established that the area is safe from hydrogen sulfide. Depending on the type of monitor and the concentration of the gas, this can take several minutes, even though the monitor is removed to a hydrogen sulfide free atmosphere.

5.1.2.8. Continuous fixed area monitors can be permanently installed in locations where the sudden release of hydrogen sulfide is possible. The monitor sensors should be placed in proximity to potential sources of a hydrogen sulfide release. Several sensors may be necessary at points of possible gas emission, and should be connected to a central monitor. The monitor's warning device, audible and visual, should be located so that the alarm can be easily recognized throughout the facility. Employees should be instructed to follow established response procedures in the event an alarm is activated.

5.1.2.9. Both personal and area monitors must be routinely calibrated and properly maintained. Procedures should be established to carry out these functions. The individual or group responsible for this activity should be identified and should keep a log book for recording calibration and maintenance.

## 6. Respiratory Protection

6.1. Supplied-air (airline or SCBA) respiratory protection against hydrogen sulfide exposure is required in the following situations:

6.1.1. When routine or maintenance work tasks involves exposure to $H_2S$ concentrations of 20 ppm or greater.

6.1.2. When a fixed monitor alarms, and re-entry to the work area is required to complete a job.

6.1.3. When confined spaces are to be entered without knowledge of $H_2S$ levels present, or if initial measurements are to be taken of $H_2S$ levels.

6.1.4. During rescue of employees suspected of $H_2S$ overexposure.

6.1.5. For specific tasks identified with significant exposure potential and outlined in local program guidelines.

6.2. All respiratory equipment for hydrogen sulfide must be of the supplied-air type, equipped with pressure-demand regulators and operated in the pressure-demand mode only. This is the only type of respiratory protection recommended for hydrogen sulfide application. Equipment should be approved by NIOSH/MSHA or other recognized national authority as required. If airline units are used, a five-minute egress bottle should also be carried.

6.3. Gas masks or other air-purifying respirators *MUST NEVER BE USED FOR HYDROGEN SULFIDE* due to the poor warning properties of the gas.

6.4. Use of respiratory protection should be accompanied by a written respiratory protection program.

## 7. Confined Space

7.1. Work conducted in low lying areas and confined spaces where hydrogen sulfide may be present require specific precautions beyond those described above. These conditions may be encountered during excavation and line repair or tank (vessel) maintenance and inspection.

7.2. Prior to beginning work, these tasks require that the excavated area or vessel be thoroughly tested with a direct reading hydrogen sulfide instrument, as well as tested for sufficient oxygen and the absence of flammable atmospheres. These measurements should be included as an integral part of an entry procedure. Furthermore, where entry permits are required these measured levels should be noted on the permit.

7.3. Combination hydrogen sulfide detectors which also measure combustible gas and oxygen are available. *CARE SHOULD BE TAKEN TO DETERMINE THE*

*HYDROGEN SULFIDE CONCENTRATION THROUGHOUT THE COMPLETE AREA*. Particular attention should be given to measuring hydrogen sulfide in the bottom of tanks, vessels, or open pits, and on the top of floating roof tanks, where the gas is likely to concentrate. *IF ENTRY IS REQUIRED ON THE TOP OF FLOATING ROOF TANKS TO PERFORM THIS INITIAL TEST, THEN RESPIRATORY PROTECTION, AS DESCRIBED PREVIOUSLY, SHOULD BE WORN BY THE TESTER*.

7.4. If hydrogen sulfide levels are determined to be above 20 ppm, entry into a confined space should require respiratory protection. Efforts should be made to ventilate the confined space prior to scheduled entry. When concentrations of hydrogen sulfide remain above 20 ppm, additional forced air venting is recommended before entry, when time permits.

7.5. If entry is necessary under the above condition, respiratory protection should consist of a pressure-demand airline respirator with an egress bottle or an SCBA. A standby person, also equipped with proper respiratory protection, should be outside the vessel and in constant audio or visual contact with the worker inside. This precaution is necessary to ensure that rapid rescue of the worker inside can be accomplished.

## 8. Location Controls and Warning Signs

8.1. Wind Indicators

8.1.1. Wind direction should be determined prior to performing outdoor tasks-where hydrogen sulfide may be encountered.

8.1.2. Work tasks which can be performed upwind from a hydrogen sulfide source can greatly reduce the potential for gas in the worker's breathing zone.

8.1.3. Wind socks, streamers, or vanes provide an indication of wind direction.

8.1.4. These wind indicators should be placed at a location and height to enable free movement and should accurately indicate wind direction.

8.1.5. The wind indicator should be easily visible from normal entrances to the work area and from all work locations.

8.2. Warning Signs

8.2.1. Consistent with Hazard Communication requirements, warning signs for hydrogen sulfide should be posted to remind employees of the potential hazard at each specific location.

8.2.2. Additionally, signs should indicate the need for monitors or respiratory protection in areas where such equipment is required.

8.2.3. Where applicable, warning signs should be posted at producing well sites, tank batteries, refinery units, and chemical facilities, etc.

8.2.4. In effect, signs should be posted on all units where the potential for a dangerous release of hydrogen sulfide exists.

8.2.5. Signs should be large enough to be easily visible.

8.2.6. Warning signs such as the following are recommended although variations in the wording may be used:

**WARNING HAZARDOUS AREA**
**HYDROGEN SULFIDE**
**HEALTH HAZARD**
**POTENTIALLY FATAL OR HARMFUL IF INHALED**

## 9. Automatic Tank Gauges

9.1. Automatic Tank Gauging instruments have been used successfully in some operations to control potential hydrogen sulfide exposures. These devices can be installed on crude, produced (RECOVERED) water, and chemical product storage tanks to reduce the need for conventional manual tank gauging and the subsequent potential for gauge exposure. They enable measurement of storage tank volume and require only occasional manual gauging to check for proper operation.

9.2. When tanks equipped with automatic gauges require manual gauging and contain hazardous concentrations of hydrogen sulfide, the tank gauge should use pressure demand supplied air respiratory protection.

9.3. Respiratory protection should be utilized until the hydrogen sulfide concentration is determined to be within acceptable levels as measured by appropriate monitoring equipment.

## 10. Emergency Procedures

10.1. The prompt performance of specific rescue and emergency first aid procedures can very often result in the full recovery of victims overcome by hydrogen sulfide. These victims should be immediately removed from the contaminated atmosphere by a rescuer wearing full-face pressure-demand supplied air respiratory protection, e.g., SCBA or supplied air with egress unit.

10.2. *RESCUE SHOULD NEVER BE ATTEMPTED WITHOUT APPROPRIATE RESPIRATORY PROTECTION*! Many such attempts have resulted in the rescuer also becoming a victim.

10.3. Respiratory protection equipment should be located on-site for rescue purposes and/or carried on Company vehicles, depending on practicality and need. Full-face, pressure-demand self-contained breathing apparatus (SCBA) is most appropriate for rescue.

10.4. Respiratory protection designed specifically for safe egress may be appropriate for some limited locations. Egress equipment differs significantly in design and application from standard SCBA and airline respiratory equipment. This equipment can be placed at visible and easily reached points or carried by employees in areas where the sudden release of hydrogen sulfide is possible.

10.5. Egress equipment is primarily suited for areas where exit is restricted and either personal or area monitors are in use. Egress equipment should provide full-face protection and 5 to 15 minutes of air supply. The number of such devices should be determined according to the number of workers commonly in the area. *EGRESS EQUIPMENT IS DESIGNED FOR ESCAPE ONLY AND IS NOT INTENDED FOR RESCUE OR ROUTINE RESPIRATORY PROTECTION PURPOSES*!

## 11. **Emergency Aid**

11.1. Once the victim is safely removed from the contaminated atmosphere, the rescuer should begin artificial respiration or administer oxygen if breathing has ceased. *FRESH AIR SUPPLIED TO THE VICTIM'S LUNGS THROUGH ONE OF THESE METHODS IS THE MOST IMMEDIATE NEED*. Back pressure artificial respiration may be applied initially to clear the victim's lungs of the toxic gas before mouth-to-mouth artificial respiration is administered. NOTE: Follow the Company's first aid procedures.

11.2. Caution should be taken during the application of artificial respiration not to inhale air directly from the victim's lungs. This could also result in the rescuer being overcome. Depending on the length of exposure and concentration of hydrogen sulfide, heart failure may occur within 4 to 6 minutes should the exposure be major. If the victim's heart has stopped, cardiopulmonary resuscitation (CPR) must be started immediately. *RECOVERY FROM OVEREXPOSURE TO HYDROGEN SULFIDE IS USUALLY COMPLETE IF THIS AID IS ADMINISTERED PROMPTLY*.

11.3. If the victim does not respond to emergency aid, emergency medical aid should be summoned to the scene, and the individual should be taken, as soon as possible, to a hospital for further treatment. *REGARDLESS OF APPARENT CONDITION, OVEREXPOSURE VICTIMS SHOULD RECEIVE APPROPRIATE MEDICAL ATTENTION AS SOON AS POSSIBLE*.

11.4. Plans for obtaining emergency medical care and transportation of victims should be prearranged such as with contingency plans. Notification lists or contingency plans should be prominently posted or available to individual employees. This list should include the names and phone numbers of local medical facilities, ambulance services, and Company supervisory personnel to be contacted. Local medical facilities should be prepared to handle victims of hydrogen sulfide exposure. Therefore, they must be notified so they can make necessary arrangements to be able to handle such incidents.

12. **Contingency Plans**

12.1. Another part of the contingency plans should be developed for evacuation of employees and local residents where the potential exists for a significant and hazardous hydrogen sulfide release. Employees should be familiar with these plans and with their specific responsibilities in the event that the plan is activated. The plans should be developed in accordance with local, state, and federal environmental and public safety agency requirements.

13. **Training**

13.1. All employees who may encounter H2S as part of routine or maintenance work should receive thorough training on the hazards associated with hydrogen sulfide. Refresher training should be conducted annually.

13.2. The training should include:

13.2.1. The hazards of hydrogen sulfide;

13.2.2. Proper work practices to reduce the potential for exposure;

13.2.3. The hydrogen sulfide exposure conditions in the employees' work areas;

13.2.4. The proper use and limitations of hydrogen sulfide monitors and respiratory protective equipment; and

13.2.5. Rescue and emergency aid procedures in assisting hydrogen sulfide overexposure victims.

13.2.6. Site-specific operational, contingency and emergency plans, including host employer and general contractor requirements.

13.3. Employees performing jobs that require respiratory protection should receive training specific to the use and limitations of the equipment. Also, employees designated to perform maintenance and inspection of respiratory protective equipment should receive adequate training in these aspects as well.

13.4. New or transferred employees should receive instruction regarding hydrogen sulfide and respiratory protection prior to their full release to the new work location.

14. **Required Written Programs**

14.1. Standard Operating Procedures (SOPs) should be written by each job site supervisor if the potential for significant hydrogen sulfide exposure exists during routine tasks, maintenance activities, and confined space entry. These SOPs should be brief, and stated in such a manner that they can be easily understood.

14.2. A written respiratory protection program is required by OSHA when respiratory

protection is utilized. Such a program is also recommended for Company operations outside OSHA jurisdiction. Written respiratory protection programs should include instruction on proper maintenance, inspection, use, and cleaning of respiratory protection equipment.

14.3. The program should also indicate the individual responsible for these activities, and the time at which these various functions are to be carried out. Requirements for training and subsequent refresher training should also be specified.

14.4. Routine work operations for Company employees ***DO NOT*** include entering confined spaces to perform work. This includes confined spaces that may contain an accumulation of H2S. In the event that a work assignment should require entering what is identified as a confined space, entry will be performed in accordance with the Company's written Confined Space Entry program; and only by personnel who have been trained and authorized to perform this type of hazardous duty. All such work assignments will be specifically authorized in advance by the Site Supervisor and the Company Safety Representative.

## 15. Medical Surveillance

15.1. Employees subject to potential exposure to hydrogen sulfide can be included in a medical surveillance program.

15.2. Pre-placement physical examinations should review work histories to determine the significance of any previous exposure to hydrogen sulfide.

15.3. The employee ability to use pressure-demand respiratory protection and /or aid in emergency rescue should be determined.

15.4. The physical examination should place particular attention on symptoms related to the eyes, central nervous, cardiovascular and respiratory systems.

## APPENDIX I

## Physical and Chemical Properties of Hydrogen Sulfide

| | |
| --- | --- |
| Molecular Formula | H2S |
| Density compared to air (air-1.0) | 1.2 (gas @ 15NC, 1 atm) |
| Auto ignition temperature | 260NC (500NF) |
| Flammable range in air | 4.3-45% (by volume in air) |
| Appearance of gas | Colorless |
| Solubility in Water (Fresh or Salt) | Highly soluble |
| Solubility in Oil | Highly soluble |
| Odor | "Rotten eggs" |
| Odor threshold | 0.02 ppm* |
| Olfactory fatigue level | 100 ppm* (may vary) |

* parts of H2S per million parts air