Hydrogen Sulfide (H2S)

1. **Introduction:**

Many in-construction, manholes, storm sewers or operating oil and gas fatalities involve situations where a closed or open system containing or has the potential to contain H2S is opened through a valve or pump either to perform construction, installation or maintenance work, vent by-products, or remove condensate. The hazards and potential for employee exposure inherent in these operations require the following:

1. Perform a hazard analysis that includes atmospheric testing to address the hazards of the process and engineering and other control measures to ensure worker safety, including a complete evaluation and assessment of process systems handling waste products, by-products, and/or un-reacted process components. Recommendations made, including recommended engineering changes, should be promptly implemented.

2. Assure that the system is locked and tagged out, including draining and purging of lines and equipment, prior to working on the system.

3. Assure that written procedures are clear and that they provide complete instructions for the safe performance of work activities.

4. Assure that employees, including contract employees, are trained in applicable procedures and safe work practices, and that the employees understand and adhere to the current operating procedures of the process.

5. All work performed where there is actual or potential H2S can only be performed under a safe work permit.

6. Atmospheric monitoring is required at all times, by way of personal and or static monitoring devices.
H2S
Hydrogen sulfide is a powerful and deadly gas which smells like rotten eggs at low concentrations and has a sweet smell at high concentrations. But workers should not rely on the smell as a warning. At high concentrations H2S may overcome one's sense of smell. The result could be instant death. Long exposure to low concentrations will also deaden the sense of smell.

What it is
H2S is explosive - it will ignite and explode when subjected to a spark or ordinary flame - in any concentration from 4% to 44% of the air. It is also soluble in water and oil, so it may flow for a considerable distance from its origin before escaping above ground or in an entirely unexpected place. Because the vapor (gas) is heavier than air, it may travel for a long way until ignited and then flash back towards the source.

Where is it found?
Hydrogen sulfide is found in large amounts in natural gas and petroleum. Any worker involved in extracting gas and petroleum from the ground or in storing, transporting, working in or near or processing gas is at risk from exposure to H2S. Hydrogen sulfide exists in solution in crude oil, and workers are exposed when the gas begins to "pass off" as it reaches the surface or comes into contact with air. This can occur at any point, including all stages of the refining operation, and it is accelerated by heat or hot weather.

H2S Sources
H2S is found widely in industry and few workers are warned of its dangers or their exposure. It is formed by the decomposition of organic materials, so it is found in natural gas and oil, in mines, wells, fertilizers, sewers, and cesspools. It is given off as a by-product in the manufacture of rayon, synthetic rubber, dyes and the tanning of leather.

While the risk of accidents cannot be entirely eliminated due to unintentional release, these procedures and practices will reduce the potential for accidental exposure to H2S.
2. **Engineering Controls:**

Systems containing H2S or that have the potential to contain must be completely assessed to assure that valves capable of releasing the H2S to the atmosphere are permitted to be opened only when absolutely necessary and are then vented to a safe location. The valves must also be capable of being locked out. Sewer systems for draining tanks or drums which present potential exposure to H2S should be constructed so that they are closed, vented to a safe location, or not open to the atmosphere. Alternatively, appropriate respiratory protection should be worn before these systems are used. A valve configuration on an industrial process should be such that only the valves used for routine use as part of the normal process are readily capable of being opened. If the valves are required to be opened for occasional shutdown operations, they must be locked and tagged in the closed position to preclude erroneous opening during routine operations. Valves that must remain available for immediate use in emergency operations should be clearly labeled as such so that they are not accidentally opened during operations.

3. **Monitoring and Detection Equipment:**

Working on units where there is potential exposure to H2S personnel need to be supplied with personal monitoring equipment. Alternatively, stationary monitors could be installed. Personal or stationary monitors must be capable of sounding an audible alarm and/or visual warning when the PEL 10 or 20 ppm respectively is reached.

4. **Training:**

All current and new employees should receive training in standard operating procedures covering all aspects of the job, with emphasis on safe work practices. Where appropriate, training should also include field observations (on-the-job training) by qualified supervisory personnel, including verification that workers have satisfied the training requirements. Training must include proper procedures for working around areas of potential exposure to H2S and include the hazards of exposure. While labeling of pipes cannot be required, the hazard communication standard does the hazards of unlabeled piping systems in a written hazard communication program and that the information is provided through training to workers.
5. **Respiratory Protection:**

Respirators must be provided when effective engineering controls are not feasible, or while they are being instituted, when such equipment is necessary to protect the health of the worker. The employer must provide respirators that are applicable for the purpose intended. Written procedures must be developed for the safe use of respirators during the performance of operations presenting a potential exposure to H2S. Under circumstances where individuals may be exposed to an unknown concentration of hydrogen sulfide or some other hazardous chemical, back-up personnel with appropriate respirators and emergency equipment must be present.

6. **Health Effects of H2S:**

Acute Exposure
First of all, and most important, H2S can kill you. The extent of acute poisoning danger depends on the concentration of H2S in the atmosphere.

When you breathe in H2S, it goes directly through your lungs and into your bloodstream. To protect itself, your body "oxidizes" (breaks down) the H2S as rapidly as possible into a harmless compound, if you breathe in so much H2S that your body can't oxidize all of it, the H2S builds up in the blood and you become poisoned. The nervous centers in your brain which control breathing are paralyzed. Your lungs stop working and you are asphyxiated - just as though someone had come up and put their hands around your neck and strangled you. A worker can be overcome by H2S and lose consciousness in a few seconds; luckily if he is rescued in time and is given artificial respiration within a few minutes, the worker may recover. Either artificial mouth-to-mouth or an oxygen supply system of resuscitation will work if it is done in time, because, with an adequate source of oxygen and no further H2S intake, the body will quickly break down the H2S still in the blood.

This is acute poisoning. It can occur with no warning at all, since even the sense of smell may be overcome, and it can be fatal within a few seconds.
Although acute poisoning is deadly if it is not caught in time, when caught and treated it is reversible and this is why rescue attempts with proper safety equipment are so important.

Recent evidence has shown irreversible brain damage from acute high doses.

Chronic Effects
H2S can also cause a wide range of sub-acute and chronic effects. At very low concentrations of 10-100 ppm headache, dizziness, nausea and vomiting may develop, together with irritation of the eyes and respiratory tract (the lungs and trachea and bronchi, or air pipes from the nose and mouth to the lungs). The eyes become red, sore, inflamed, and sensitive to light. Respiratory system effects include cough, pain in the nose and throat, and pain on breathing.

If exposure at low levels continues, the worker may develop a state of chronic poisoning. In addition to eye and respiratory tract irritation, there will be a slowed pulse rate, fatigue, insomnia, digestive disturbances, and cold sweats. More dangerous, if exposure at the level of 100 ppm (which results in eye and respiratory tract irritation and drowsiness after 15 minutes) lasts for several hours, it may result in death within the next 48 hours. Symptoms of chronic exposures at low levels are conjunctivitis (eye infections), headache, attacks of dizziness, diarrhea, and loss of weight.

Chronic hydrogen sulfide intoxication is marked by headaches, eye disorders, chronic bronchitis, and a grey-green line on the gums. Reports of nervous system disorders including paralysis, meningitis, and neurological problems has been reported, but not confirmed.

A study of workers and community residents of a California refinery engaged in extracting sulfur from crude oil, which is rich in H2S, complained of headaches, nausea, vomiting, depression, personality changes, nosebleeds and breathing difficulties. When compared to a non-exposed group of people, the exposed people showed abnormalities of color discrimination, eye-hand coordination, balance, and mood disturbances.

In rats, exposure to hydrogen sulfide has caused teratogenic effects.
7. **Permissible Exposure Level (PEL):**

The OSHA Permissible Exposure Limit (PEL) for a ceiling concentration is 20 ppm hydrogen sulfide, a level which may not ever be exceeded. The acceptable maximum peak, for 10 minutes only, once during an 8 hour day if there is no other measurable exposure, is 50 ppm.

There is no time-weighted average because H2S is so fast-acting that no fluctuations above 20 ppm are safe; only one peak per day is allowed.

This level is too high and recent recommendations are that it be lowered to 10 ppm. You should remember, however, that H2S is an invisible gas, floating freely and unpredictably, and a reading even below a 10 ppm Permissible Exposure Limit (PEL) may not guarantee your safety.

There are no particular medical exams for exposure to H2S.

8. **Confined Space and Emergency Procedures:**

Prior to entry of an area suspected of containing H2S emergency procedures should be covered with all personnel and emergency equipment should be properly inspected. Whenever you enter a confined space such as a tank, make sure that you follow strict work practices, including a permit system. Make sure that the Confined Space Entry Standard is followed, that the air is continually monitored for the presence of H2S, and that an attendant be stationed outside a confined space. All entrants should wear supplied air or SCBA and lifelines, and rescue equipment must be immediately available. In the event the alarm sounds or the monitor instructed personnel to vacate the area all personnel must comply and proceed to the established muster area. The monitor must ensure all personnel have vacated the space. If muster area is downwind of hazard the monitor will instruct personnel to an alternate location.