"Ignorance of Safety, or No Ostrich Zone. "

In the safety world hazard recognition plays a vital role in keeping your people safe from unsafe behaviors and/or conditions. Some hazards are easily recognized, for example an employee climbing up a 20 foot ladder with tools held in both hands. (This is a fall hazard by the way.) Common sense right? The safety guy who taught me safety had a great response to this attitude, "Few people have any sense (read knowledge) in common (read shared alike)". So while some safety hazards are immediately recognizable others require training to spot and avoid. Training is a key method in avoiding the "Ostrich Zone". One such hazard is Hydrogen Sulfide. You don't want to bury your head facing this hazard. (Won't do much good anyway, Hydrogen Sulfide is heavier then air!)

Hydrogen sulfide (H2S) is a clear gas, dangerous to human health/life, extremely flammable, corrosive and sometimes has a detectable odor of rotten eggs. It can be produced in nature (bogs, swamps, volcanos and hot springs). (1) It can also be produced by industrial activities (oil and gas, natural gas pipeline transmission, refineries, fertilizer manufacturing, sewage treatment plants, vacuum trucks, tanneries, food processing plants, manholes, standing water, grain silos, silage pits and manure pits just to name a few.) Whether a natural or industrial source it is the result of bacterial decomposition of organic material. Just out of curiosity how many of the potential sources of H2S just listed were recognizable to you before reading this paragraph? (See, the Ostrich Zone is fading already.)

What's the H2S hazard? A very low level exposure can result in serious illness or death. (IDHL is 100 ppm. 1% = 10,000 ppm. That's a *very* low level.) And as just mentioned there exist locations one would not necessarily associate with this hazardous gas. (A 25 year old waste hauling service worker died in an underground manure waste pit. The access opening was fitted with a removable stainless steel cover. There was no ventilation or gas monitor in use.) (2) NIOSH lists multiple instances of H2S deaths occurring on farms and sanitation facilities involving enclosed/confined spaces harboring this deadly gas. In none of these sad instances was a gas monitor used to alert the presence of this gas. (3) What makes H2S so deadly?

H2S is an inhalation, flammable/explosive and contact hazard. Inhalation symptoms at low level exposures include headache, dizziness, sleep disturbances, upset stomach, changes in appetite at 20 ppm. (Remember sentence above, 1% = 10,000 ppm! This is a *very* small exposure.) Exposure of 100 ppm is IDLH (NIOSH) and symptoms include altered breathing and drowsiness after 15-30 minutes at this level. Death may occur after 48 hours and exposures ranging to 500 to 700 ppm will likely result in staggering, collapse and death after 30-60 minutes. 1000-2000 ppm nearly instant death. (4)

H2S is also a corrosive and will act on skin and eyes. Exposure levels of 50-100 ppm will give rise to eye irritation and marked conjunctivitis and respiratory track irritation after an hour at 200-300 ppm. (4 above.) Acute exposure can cause painful conjunctivitis, photophobia (sensitivity to light), corneal abrasions and blindness. (5) H2S is classified as a chemical asphyxiate similar to carbon monoxide and cyanide gasses. It inhibits cellular respiration up take of oxygen causing biochemical suffocation. (6)

How does one go about recognizing this hazard and how do you protect yourself? Training.
There are several levels of H2S training selection of which is dependent upon the anticipated action expected of the employee/trainee. For example, if an employee's work will rarely result in exposure to H2S and is expected to immediately evacuate a site upon the detection of H2S than awareness training and training on use and care of gas monitor is likely adequate. If the employee works in a setting where H2S is likely, say manure pits or oil and gas processing plant handling H2S involved gas/products then

training must include a more advanced training including special evacuation criteria, use of respiratory PPE and gas monitor use/care, first aid, expectations of employees in an exposure/release event (evacuate only or rescue) and nature of work (confined space), exercises and drills, schedule for refresher training (annual), site specific safe work practices, properties/characteristics of H2S, detection methods, care/use of PPE (full face respiratory protection) and rescue techniques and first aid procedures. (For more detail on training content refer to ANSI/ASSE Z390.1-2006 (R2010) ANSI's standard is too long to recite here but is comprehensive and is a must when putting together H2S training.

For sites/work where H2S could be present, such as manure pit, sewer type operations, gas/oil processing, etc. a Contingency Plan is required. Briefly, Contingency Plans, are written plans addressing site specific issues relating to H2S such as air flow directions, safe muster points, type of PPE/respiratory equipment, training drills, emergency procedures, worker responsibility, phone numbers/communication methods and nearby residences/schools/businesses, flag ratings (green, yellow and red), locations of fixed gas monitors, etc. If you are on a site where a Contingency Plan exists read it. It will be invaluable and may save your life.

Remember the No Ostrich Zone theme at the beginning of this article? H2S is corrosive. It will dissolve/weaken steel, brass, bronze and copper (though not some stainless steels). Plants/equipment exposed to H2S can experience degradation of steel structures like ladders, anchor points for fall protection, etc. Training for employees on sites where H2S has been exposed to steel parts of the plant a good practice includes periodic structural evaluations/examinations. Using proper ladder climbing techniques are ineffective if the ladder one is using is structurally compromised and fails.

Working in confined spaces such as storage tanks or manure pits training on how to safety test such atmospheres is a must. (Note: Leaning over a pit/tank with monitor in hand to check for H2S is NOT safe. There are techniques to test such situations keeping the tester safely distant from potential H2S exposure. Such techniques must include classroom *and* practical training.)

Detection. Regardless of the rotten egg smell believing one can detect H2S using sense of smell is dangerous. Why? The sense of smell does not identify the level of H2S exposure. 0.13ppm level offers a slight detection by sense of smell. But H2S deadens the sense of smell so you may only detect a momentary whiff of the gas before losing your sense of smell. The fact the odor seems to go away does *not* mean the gas is gone! OSHA standard limits for exposure is 10 ppm. (REL NIOSH) (4) Short Term Exposure Limit (STEL) is 15 ppm for 15 minutes per ACGIH. 100 ppm is considered Immediately Dangerous to Life and Health (IDLH). So how does one detect H2S? Use gas monitors but first a couple of points to consider.

Observe your surroundings. Signage. If working in the oil and gas industry look for H2S Danger Signs posted upon approach/ site entrance. Wind indicators. Look for wind socks or streamers which are also indicators of potential hazardous gas on site. What direction are the windsocks/streamers flowing? As you walk/work around the site periodically look to see the direction of wind flow per the windsocks/streamers. If the site has fixed H2S gas monitors know what their alarm does, i.e. flashing lights and type of sound. (If you are new to the site ASK the supervisor/employee he/she can tell you if H2S is present, what to look out for and nature of the alarm system and evacuation points/directions. Contingency Plan will also answer these questions.) Finally, there may be colored flags onsite. Green means possible danger, Yellow means moderate danger (this color would indicate it's time to leave or use PPE) and Red for extreme danger (leave immediately to save your life and use PPE). Remember

though, pay attention to the direction of the flag/windsock/streamers and move perpendicular and then upwind from the H2S source for evacuation purposes. Your direction of evacuation should be the shortest distance to safety.

Next, you should view the plant and surrounding terrain. H2S is heavier than air. So any topography containing dips, low spots, or plant configuration like vaults, pits, etc. could accumulate the gas. H2S can dissolve in liquids (water and hydrocarbons) and can then release if the liquid is agitated, depressurized, heated, circulated, pumped, flowed or swabbed into tanks. This gas can be found at the tops of open tanks, gauge hatches, vent lines as well as likely places identified in the second paragraph above. (Remember, that list is not all inclusive). (5) Do you recall the sad fatality of the waste worker mentioned above? The entry point hatch was stainless steel. Here is a tip. H2S is very corrosive and will dissolve iron, copper, brass, bronze, cast iron, types 1010 and 1020 carbon steel, lead and Monel but not stainless steel. (6) The presence of stainless steel, usually unaffected by H2S corrosivity, is a potential indicator of its presence. The tip here is to pay attention to the metals comprising mechanical devices, piping and storage facilities. If you see stainless steel be on notice that H2S is may be present. In all instances have your gas monitor with you and switched on. (Gas monitors are more effective when on.)

Now on to gas monitors. An effective means of detecting H2S is through the use of a gas monitor. (Other methods of detecting H2s such as Lead acetate strips or colorimetric tubes are mentioned here only for awareness.) Some sites will have fixed H2S monitors. Fixed monitors sample air in their vicinity and are typically placed where H2S is likely found. But only the personal gas monitor will alert you if you've walked into a pocket of gas that is beyond the sensing range of the fixed monitor. Therefore it is safer for you to have your own personal gas monitor with you at all times. Have the gas monitor placed about 6-9 inches from your face (breathing zone). Fashion tip: Gas monitors have been seen clipped to the back of hard hats, waist belts and on work boots. Don't be "cool". Be alive. Clip the gas monitor so it is 6-9 inches in the breathing zone. Save the fashion statements for the local mall. The gas monitor must be on to detect H2S. If you work in any of the industries mentioned in the first paragraph it is prudent to have a personal gas monitor with you at all times. (Note: Some personal gas monitors can be attached to a tube of several feet in length. The tube end can be lowered into a tank or vault to check atmospheric presence of H2S while keeping you at a distance from potential exposure during testing.)

But let's add some additional food for thought regarding recognizing the hazard via gas monitor. When should you turn on the gas monitor? The monitor should be on as you approach an area where H2S could exist and not as you stop and park at the site. When I was working in the O & G industry I turned on my monitor the moment I left for the field. It stayed on until I was home for the night.

Pointers regarding gas monitor care. Gas monitors need be set specifically to detect H2S. Gas monitors will detect only those gases for which they are set. If your work may expose you to H2S make sure the gas monitor you employ is set up to detect it. Caring for a gas monitor includes periodic bump testing and calibration according to schedules recommended by the manufacturer. (Some monitors are set up to "self-bump test" with the press of a button.) Conduct these tests religiously. If a monitor fails to properly bump test presume the monitor is not working properly. Second guessing a possibly malfunctioning gas monitor around H2S is definitely not prudent. Make sure the batteries are charged. Some gas monitors have low battery indicators so check the battery status before heading to the field and during use. Keep the monitor in its charging station unless it's with you in the field.

Setting detection limits for gas monitor. An accepted limit by OSHA is 10 ppm. However the ACGIH has recently issued a new Threshold Limit Value (TLV): 1 ppm. (7) What are others in the oil and gas industry doing gas monitor threshold wise? 39% use 10ppm and 15ppm; 35% use 5ppm and 10ppm; 15% use 10ppm and 20 ppm. (8)

Point to ponder: while this ACGIH standard is not a "legal" standard given the dangerous nature of H2S failure to follow this standard could produce unexpected results. (Injury, fatality, legal liability.) That said, OSHA references ACGIH's new standard in its Oil and Gas Well Drilling and Servicing E Tool, Appendix A. (7)

Acute exposure symptoms include affects the nervous, pulmonary systems and olfactory nerves (means, no longer smelling the odor?) lungs, brain, respiratory control center and eyes. Symptoms can include nausea, burning sensation in the eyes, coughing, dizziness, difficulty breathing, accumulation of fluid in the lungs, headache, nausea, vomiting, staggering and excitability. The symptoms displayed depend on exposure level and length as well as physical condition. (11) Once any of these symptoms is exhibited a dangerous level of exposure has already occurred. A properly functioning gas monitor will detect the presence of H2S long before symptoms display and/or detection by sense of smell.

Unsure of incurring the cost of changing the gas monitor settings? OSHA holds a Recommended Exposure Limited (REL) to be of less than 10 ppm but with a 15 minute ceiling at 15 ppm (STEL). (9) (10) Say the nature or lack of personal protective equipment (PPE) (we'll get to PPE in a second) available/used in the field combined with the work environment creates an evacuation travel time greater than 15 minutes. (This assumes the actual exposure is a maximum of 15 ppm.) Is the employee truly able to timely evacuate? Does a lower trigger threshold for gas monitors make sense given the character of the work site and time needed to safely evacuate? Factor in your work environment and site conditions when reasoning through the monitor H2S detection/alarm level you want to set the gas monitor threshold. No Ostrich Zone continues.

Escape/rescue. So now your monitor is on and with you, you have visually inspected the physical condition/situation of the site. The gas monitor starts alarming. What do you do? Immediately check the wind direction by looking at the windsocks/streamers. Next start moving. As you move tell others nearby about the alarm. Absent respiratory protection do your best to hold your breath as you evacuate. (Hard to hold your breath while shouting a warning to others, polite hand gestures are acceptable.) Conventional wisdom calls to move upwind. But what if the source of H2S is directly upwind of from you? Move perpendicular and then upwind. If your car is parked downwind DON'T head toward it thinking it's the fastest means of escape. You cannot outrun H2S. You can only run away!

What if you see a person down and not moving? Leave them. Unless specially trained as a rescuer and possess the necessary PPE any action other than immediate evacuation will likely result in two people down. (Two thirds H2S victims are rescuers!)

What does rescue involve? 1) Proper PPE; SCBA or supplied air positive pressure and full face mask. Rescuers must also have an auxiliary self-contained air supply. (OSHA Fact Sheet, Hydrogen Sulfide (H2S), https://www.osha.gov/OshDoc/data_Hurricane_Facts/hydrogen_sulfide_fact.pdf) Protective clothing such as gloves/fire and acid proof covering/clothes. Contact with liquid H2S can result in freezing. 2) Proper unconscious person moving techniques as the down person could have fallen,

sustained some injury so proper movement is techniques must be known/trained/practiced. 3) First aid training. H2S hazard is primarily inhalation but also presents skin, eye hazards as well as potential frost bite from liquid contact. Rescue need include preparation to remove clothing, need quick drench capability for skin/eyes and clothing contact situations (NIOSH 2003). In instances where respiratory assistance is called for use mechanical devices and NOT mouth to mouth. (Victim lungs may contain H2S and hence dangerous to rescuer using mouth to mouth.)

Let's discuss the types of PPE suitable for H2S. There are short term air bottle fed systems for escape use (sufficient air for about 5-8 minutes.) Next are SCBA (Self Contained Breathing Apparatus) systems designed for long term use (30 -45 minutes) and then supplied air systems for long term use. Full face respirators with the appropriate cartridges are *strictly* for escape use. Some conversations I've heard from field folks is cartridge face masks are OK for other than escape use. This is *wrong*. Remember the Ostrich factor. If H2S contacts the body rinse with water for 15 minutes. (See any SDS on H2S). Clothing will need be washed before reuse and removed immediately after exposure. This means you may be driving home dressed differently than when you arrived at work.

Any person exposed or thought to have been exposed to H2S must seek immediate medical evaluation. There are tests available which can determine if an event resulted in exposure. Some of these tests need be conducted within several hours of the exposure to ascertain a medical event. (15) It is important to tell the medical providers of any medicines (prescribed or recreational) by the exposed person as H2S effects may be aggravated by certain drugs.

H2S is very corrosive, most air supply systems consist of metal parts so any PPE/supplied air system exposed to H2S must be carefully inspected to assure no damage has occurred due to the exposure.

A final comment. Some petroleum processing sites flare H2S. When burned it produces a blue flame. The gas produced from burning H2S is Sulfur Dioxide which in itself is toxic. Has many H2S characteristics, such as heavier than air, will produce similar symptoms (irritation of throat, burning eyes, etc.) and can likewise produce serious/fatal results. The sole difference from H2S is that sulfur dioxide is not flammable.

Can working around H2S locations be done safely? Absolutely. Does understanding the hazards of H2S make a difference? Absolutely. Do many folks work safely around H2S and go home safe and sound each day? Absolutely. But they do so because of their knowledge, precautions and preparation. Remember working with H2S is a no Ostrich Zone.

(1) EPA Report to Congress on Hydrogen Sulfide Air Emissions Associated With the Extraction of Oil and Natural Gas, Report No. 453R93045, (1993) United States Environmental Protection Agency, Office of Air Quality, Planning and Standards, Research Triangle Park, NC 27711, EPA-453/R-93-045, October 1993, Air Report to Congress on Hydrogen, EPA Sulfide Air Emissions Associated with the Extraction of Oil and Natural Gas

(2) https://www.osha.gov/SLTC/hydrogensulfide/hydrogensulfide_found.html

(3) http://www.cdc.gov/niosh/topics/hydrogensulfide/

(4) OSHA, Safety and Health Topics, Hydrogen Sulfide https://www.osha.gov/SLTC/hydrogensulfide/hazards.html: And Canadian Center of Occupational Health and Safety, Hydrogen Sulfide, http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/hydrogen_sulfide.html)

(5) Canadian Center of Occupational Health and Safety, Hydrogen Sulfide, http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/hydrogen_sulfide.html)
(6) http://el.erdc.usace.army.mil/workshops/04jun-wots/kaluschue.pdf)
(7) Hydrogen Sulfide - Health Effects, Detection and Exposure Prevention, Hilton E. Kalusche, Industrial Hygienist, Safety and Environmental Management, http://el.erdc.usace.army.mil/workshops/04jun-wots/kaluschue.pdf
(8) https://www.wtstc.org/PDF/H2S%20in%20the%20Oilfield%20Eng.pdf
(9) Canadian Center for Occupational Health and Safety, CHEMINFO Chemical Profiles by CCOHS, http://www.ccohs.ca/products/databases/samples/cheminfo.html#TOC7
(10) Professional Safety Journal of the American Society of Safety Engineers, Supplement to "Safety Matters", Professional Safety, November,2013, http://www.asse.org/professionalsafety/docs/DragerASSE_whitepaper.pdf
(11) https://www.osha.gov/SLTC/etools/oilandgas/general_safety/appendix_a.html
(12) Source: NIOSH Recommended Exposure Limit (REL): 10 ppm, 10-minute ceiling. Concentration considered immediately dangerous to life and health (IDLH): 100 ppm, https://www.osha.gov/SLTC/hydrogensulfide/standards.html
(13) OSHA, Hydrogen Sulfide in Workplace Atmospheres, https://www.osha.gov/dts/sltc/methods/inorganic/id141/id141.html
(14) OSHA Fact Sheet Hydrogen Sulfide (H2S)
(15) Exposure, medical follow-up, with short time after exposure, use thiosulfate as a urinary biomarker of H2S exposure. (Science Direct, Hydrogen Sulfide (H2S) and sour gas effects on the eye. A Historical Perspective. Lambert, Goodwin, Stefani, Strosher, Rice of the Total Environmental 367 (2006) 1`-22, May 18, 2005. http://www.calgaryhealthregion.ca/publichealth/envhealth/risk_assessment/publications/H2S_Eye.pdf)

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