

# ANSI/ASSP Z390.1-2017

## Accepted Practices for Hydrogen Sulfide Safety Training Programs

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**ANSI/ASSE Z390.1 – 2017**

**American National Standard**

**Accepted Practices for  
Hydrogen Sulfide (H<sub>2</sub>S) Training Programs**

Secretariat

**American Society of Safety Engineers**  
520 N. Northwest Highway  
Park Ridge, Illinois 60068

**Approved June 30, 2017**

**American National Standards Institute, Inc.**

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## Foreword

(This Foreword is not a part of American National Standard Z390.1-2017.)

The charter of the American National Standard Committee Z390 on Hydrogen Sulfide (H<sub>2</sub>S) Training was accredited by the American National Standards Institute (ANSI) on January 1, 1993. This standard grew out of the recognition of a need for specialized training dealing with this toxic chemical, above and beyond conventional hazard communications training, due to numerous fatal accidents involving victims and their would-be rescuers succumbing to the effects of hydrogen sulfide.

Historically, H<sub>2</sub>S training issues have been addressed by only a few industries, and the consistency of the training criteria varied greatly from one organization to another. For these reasons, the standard addresses the individual training criteria that should be incorporated into a comprehensive training course. These criteria were developed by combining accepted practices in numerous affected industries. Most significantly, emphasis has been given to the qualifications and proficiency of individual H<sub>2</sub>S safety instructors, as well as student performance-based competency and qualifications.

The guidelines presented in this document are designed to provide workers the fundamental knowledge to protect themselves from H<sub>2</sub>S exposure. This document does not include the information necessary to satisfy the requirements of the ANSI/ASSE Z88.2, *Practices for Respiratory Protection*, and OSHA Respiratory Protection 29 CFR 1910.134. In addition, this document does not provide the site-specific information necessary to work at a particular facility.

Governmental regulations (see OSHA Hazard Communication 29 CFR 1910.1200) specify mandatory requirements for the training of personnel working with or around hazardous chemicals. As a voluntary consensus standard, this document complements those regulations. However, compliance with this standard does not assure compliance with governmental regulations, and vice versa.

The Z390 Committee solicits public input that may suggest revisions to the standard. Such input should be sent to the Secretariat, American Society of Safety Engineers, 520 N. Northwest Highway, Park Ridge, Illinois 60068.

**Revisions:** The Z390 Committee welcomes proposals for revisions to this standard. Revisions are made to the standard periodically (usually every five years from the date of the standard) to incorporate changes that appear necessary or desirable, as demonstrated by experience gained from the application of the standard. Proposals should be as specific as possible, citing the relevant section number(s), the proposed wording, and the reason for the proposal. Pertinent documentation would enable the Z390 Committee to process the changes in a timely manner.

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Only the Z390 Committee (through the Z390 Secretariat) is authorized to provide any interpretation of this standard.

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**Appendices:** Appendices are included in most standards to provide the user with additional information related to the subject of the standard. Appendices are not part of the approved standard.

**Committee Meetings:** The Z390 Committee meets on a regular basis. Persons wishing to attend a meeting should contact the Secretariat for information.

**Standard Approval:** This standard was developed and approved for submittal to ANSI by the American National Standards Committee on H<sub>2</sub>S Training, Z390. Committee approval of the standard does not necessarily imply that all members voted for its approval. At the time of its approval, the Z390 Standards Committee had the following members:

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# AMERICAN NATIONAL STANDARD Z390.1 ACCEPTED PRACTICES FOR HYDROGEN SULFIDE (H<sub>2</sub>S) TRAINING PROGRAMS

## 1. Scope, Purpose and Application

### 1.1 Scope

This standard sets forth accepted practices for hydrogen sulfide (H<sub>2</sub>S) safety training and instruction of affected personnel to include, but not be limited to, the following:

- minimum informational content of the course
- recommended exercises and drills
- properties and characteristics of H<sub>2</sub>S
- sources of H<sub>2</sub>S and areas of potential exposure
- typical site-specific safe work practices associated with H<sub>2</sub>S operations
- detection methods for H<sub>2</sub>S
- engineering/mitigation controls
- properties, characteristics and safe work practices of sulfur dioxide (SO<sub>2</sub>)
- selection, use and care of personal protective equipment appropriate for atmospheres containing H<sub>2</sub>S concentrations above the applicable occupational exposure limit
- rescue techniques and first aid procedures for victims of H<sub>2</sub>S exposure
- H<sub>2</sub>S Safety Instructor qualifications

### 1.2 Purpose

The purpose of this standard is to establish minimum requirements for H<sub>2</sub>S safety training programs that will enhance safety in occupational settings where H<sub>2</sub>S is present, or is recognized as being potentially present, above the applicable occupational exposure limit.

### 1.3 Application

This standard is recommended for voluntary application in occupational settings where personnel have the potential to be exposed to concentrations of H<sub>2</sub>S in excess of the applicable occupational exposure limit. The applicable occupational exposure limit is determined by the employer or facility referencing consensus standards, regulations and health safety and environmental (HSE) professionals.

## 2. Definitions

### 2.1 Acute Exposure

Exposures to high concentrations over a short period of time.

### 2.2 Chronic Exposure

Exposures to low concentrations over a long period of time.

### 2.3 Contingency Plan

A site-specific written document that provides an organized plan for alerting and protecting workers and the public within an area of exposure following the accidental release of a potentially hazardous atmospheric concentration of H<sub>2</sub>S.

## 2.4 Designated Rescuer

An individual or individuals who are responsible for recovery and providing resuscitation and first aid to H<sub>2</sub>S victims

## 2.5 Emergency Action Plan

A part of a broader and more comprehensive contingency plan that outlines the immediate steps and actions that would be taken in the event of a major release of toxic material. The emergency procedures plan includes, but is not limited to, such items as:

- the responsibilities of personnel;
- the immediate action plan, telephone numbers and communication methods;
- the location of nearby residences, businesses, schools, churches, medical facilities and emergency response personnel, safety equipment and supplies available; and
- evacuation routes.

## 2.6 Flaring

The controlled combustion of the flammable gases and vapors discharged from vent piping systems.

## 2.7 Immediately Dangerous to Life and Health (IDLH)

Any atmosphere that poses an immediate hazard to life, impairs ability for self-rescue, or poses immediate irreversible debilitating effects on health.

## 2.8 Instructor

An individual who has successfully completed a course in H<sub>2</sub>S instructor training from an institution or organization offering such courses or possess significant past experience in instructing in this field. (See Section 5 Instructor Qualification and Proficiency.)

## 2.9 May

Indicates a permissive statement.

## 2.10 Non-Essential Personnel

Those individuals who are not required to engage in activities to control the hazardous conditions associated with H<sub>2</sub>S during an emergency.

## 2.11 Parts Per Million (ppm)

As in parts of a vapor or gas per million parts of air, by volume.

## 2.12 Shall

Indicates a mandatory requirement.

## 2.13 Should

Indicates a recommendation which is advised, but not required.

## 2.14 Occupational Exposure Limit (OEL)

A health-based workplace standard to protect workers from adverse exposure (e.g., PELs, TLVs®, RELs, WEELs, etc.) adopted by the employer or facility owner.

## 2.15 Venting

The process of discharging a gas or vapor to the atmosphere, through piping and/or venting devices, to facilitate the proper and safe dispersion of toxic gas or vapor and to minimize personnel exposure.

## 2.16 Visitor

An individual who is visiting a job site for a short period of time, and who is not required to provide any of the operational or control activities at the site. Visitors are not exempt from the initial and annual H<sub>2</sub>S training.

## 3. Training Criteria for H<sub>2</sub>S Certification

### 3.1 H<sub>2</sub>S Certification

Designed for individuals who have the potential to be exposed to H<sub>2</sub>S in concentrations greater than the occupational exposure limit. Based on the instructor needs assessment, the length of the course may vary, however all of the objectives in Appendix C shall be met. This certification training should be a minimum of 3-4 hours in length. The certification is valid for a period of one year. The training shall be documented and a H<sub>2</sub>S certification card stating that the program conforms to ANSI/ASSE Z390.1 shall be presented to the attendee. Retraining shall include all of the information contained in 3.2. These personnel, who have received H<sub>2</sub>S certification and are subject to working under respiratory protection, shall also have successfully completed a respiratory protection training program, to include medical evaluation and fit-testing if they are to wear tight-fitting air supplied respirators in these hazardous atmospheres according to ANSI Z88 and/or OSHA 29 CFR 1910.134 or applicable local regulatory requirements.

### 3.2 Minimum Course Content

- the hazards, characteristics and properties of H<sub>2</sub>S and sulfur dioxide (SO<sub>2</sub>)
- sources of H<sub>2</sub>S and SO<sub>2</sub>
- safe exposure limits for H<sub>2</sub>S and SO<sub>2</sub> to include PEL and TLV
- regulations pertinent to workers on H<sub>2</sub>S jobsites
- proper use of H<sub>2</sub>S and SO<sub>2</sub> detection methods used at the workplace
- recognition of, and proper response to, the warning signals initiated by H<sub>2</sub>S and SO<sub>2</sub> detection systems in use at the workplace
- symptoms of H<sub>2</sub>S exposure; symptoms of SO<sub>2</sub> exposure
- rescue techniques and first aid to victims of H<sub>2</sub>S and SO<sub>2</sub> exposure
- proper use and maintenance of respiratory protection equipment for working in H<sub>2</sub>S and SO<sub>2</sub> atmospheres, usage instruction and hands-on practice, with demonstrated proficiency (29 CFR 1910.134)
- workplace practices and relevant maintenance procedures that have been established to protect personnel from the hazards of H<sub>2</sub>S and SO<sub>2</sub>
- wind direction awareness and routes of egress
- enclosed facility entry procedures
- emergency response procedures that have been developed for the facility or operations
- locations and use of safety equipment
- locations of safe briefing areas

### 3.3 Minimum Course Content for H<sub>2</sub>S Train the Trainer

Course content shall include sufficient instruction to assure competency with regard to the topics required in the H<sub>2</sub>S certification. Additionally, the student shall receive adequate

instruction on the following topics from ANSI/ASSE Z490.1, *Criteria for Accepted Practices in Safety, Health and Environmental Training*:

- training program administration and management
- training development
- training delivery
- training evaluation
- documentation and recordkeeping

### 3.4 Minimum Requirements for Site-Specific Orientation

In addition to the annual H<sub>2</sub>S certification training, a site-specific orientation is required for individuals who have the potential to be exposed to H<sub>2</sub>S in concentrations greater than the occupational exposure limit. At a minimum, personnel shall be briefed on:

- route(s) of egress
- use and location of wind indicators
- emergency assembly area(s)
- applicable warning signals
- how to respond in the event of an emergency
- use and location of personal protective equipment
- hands-on training with the specific H<sub>2</sub>S detector to be used in the field is required prior to use (see Appendix D)

## 4. Required Course Content

### 4.1 Physical and Chemical Properties of H<sub>2</sub>S

The physical and chemical properties of H<sub>2</sub>S, including but not limited to the following, shall be discussed as part of H<sub>2</sub>S training:

- **Synonyms:** sulfuretted hydrogen, sulfurated hydrogen, hydrosulfuric acid, H<sub>2</sub>S, disulfur hydride, sour gas, rotten egg gas, sulfane, sewer gas, swamp gas, sulfur ode hidrogeno, gas venenoso and others
- **Chemical Family:** inorganic sulfide
- **Chemical Formula:** H<sub>2</sub>S
- **Normal Physical State:** highly toxic, colorless gas, slightly heavier than air. Vapor density = 1.19 (air = 1.00). H<sub>2</sub>S may collect in low-lying areas or confined spaces.
- **Auto-Ignition Temperature:** 500 degrees F (260°C)
- **Flash Point:** -76.4 degrees F (-60.2°C)
- **Melting Point:** -117.2 degrees F (-82.9°C)
- **Flammable Limits:** 4.3% – 46% vapor by volume in air
- **Solubility:** soluble in water and oil; solubility decreases as the temperature of the liquid increases
- **Combustibility:** burns to produce SO<sub>2</sub>, a very irritating gas with a burnt match odor. SO<sub>2</sub> is a colorless gas appreciably heavier than air. Vapor density = 2.26 (air = 1.00)
- **Odor and Warning Properties:** H<sub>2</sub>S has an unpleasant odor, characteristic of rotten eggs, and may be easily detected at low concentrations. Due to the rapid onset of olfactory fatigue and paralysis (loss of the sense of smell), your sense of smell is not a reliable indicator for the presence of H<sub>2</sub>S.

## 4.2 Incompatibilities and Reactivities

- $\text{H}_2\text{S}$  can react violently with oxidizers and acids and may cause fire or explosions.
- When  $\text{H}_2\text{S}$  dissolves in water, it forms a weak acid that can dramatically increase corrosion and pitting of mild steel.
- Acids added to solutions/equipment containing  $\text{H}_2\text{S}$  and sulfides may cause an immediate release of toxic concentrations of  $\text{H}_2\text{S}$  gas.
- $\text{H}_2\text{S}$  may cause catastrophic failures of certain pipeline metals by some form of hydrogen stress cracking (refer to ANSI/NACE MR0175/ISO15156).
- $\text{H}_2\text{S}$  can react with iron oxide to form an iron sulfide that is pyrophoric when dry. Pyrophoric iron sulfide has caused fires in coke piles, rubbish bins and in operating equipment including strainer filters, demister pads, piping, exchanger tubes, compressors, spent catalyst, tanks and enclosed sulfur pits.

## 4.3. Sources of $\text{H}_2\text{S}$

Students shall be informed of the following sources of  $\text{H}_2\text{S}$ :

- **Natural Sources:**  $\text{H}_2\text{S}$  is produced in nature primarily through the decomposition of organic material by bacteria. It may develop in low oxygen environments such as bogs, swamps and polluted water. Also,  $\text{H}_2\text{S}$  occurs as a constituent of natural gas, crude oil, sulfur deposits, volcanic gases and sulfur springs.
- **Industrial Sources:** In industrial operations,  $\text{H}_2\text{S}$  is a co-product or raw material. Whenever possible, it is recovered and converted to elemental sulfur or sulfuric acid (see Appendix A for a listing of occupations with potential  $\text{H}_2\text{S}$  exposures).

## 4.4 Human Physiology and Medical Evaluation

### 4.4.1 Human Physiology Information

An overview of the respiratory system and the eyes shall be presented. The target organs and body structures subject to the effects of  $\text{H}_2\text{S}$  shall be identified. These include, at a minimum, the following:

- olfactory nerves
- lungs
- brain
- respiratory control center
- eyes

### 4.4.2 Signs and Symptoms of Acute Exposure to $\text{H}_2\text{S}$

The signs and symptoms of  $\text{H}_2\text{S}$  exposure associated with acute exposure shall be presented, these include:

- olfactory paralysis
- excitement (anxiety)
- eye irritation
- coughing
- headaches
- sneezing
- nausea
- irritation of the respiratory tract
- diarrhea
- dizziness

- confusion
- staggering gait
- sensitivity to light
- pulmonary edema (chemical pneumonia)
- brain damage
- respiratory arrest
- cardiac arrest

#### 4.4.3 Signs and Symptoms of H<sub>2</sub>S Exposure Associated with Chronic Toxicity

The signs and symptoms of H<sub>2</sub>S exposure associated with chronic exposure shall be presented, these include:

- eye irritation
- corneal blistering, pitting and opacity
- headaches
- nausea
- irritation of the respiratory tract
- pulmonary edema (chemical pneumonia)
- anorexia (loss of appetite)
- sleep disturbances

#### 4.4.4 Variables Affecting the Symptoms Associated with H<sub>2</sub>S Exposure

Information concerning variables that determine the symptoms associated with H<sub>2</sub>S exposure and the speed of their onset shall be presented. The primary variables are exposure concentration, exposure frequency, exposure duration and individual variables. Individual variables include:

- body mass
- overall physical condition
- age
- personal biochemistry

#### 4.4.5 Interaction of Drugs and Alcohol with H<sub>2</sub>S

Multiple toxins being filtered from the bloodstream by the liver may not be metabolized at their normal rate, therefore compounding their effects upon the body. The presence of alcohol, prescription medications and/or illicit drugs in the body may result in hypersensitivity to the effects of H<sub>2</sub>S shall be presented.

#### 4.4.6 Medical Evaluation

The need for a medical evaluation to determine whether or not respiratory protection can be used effectively shall be discussed (refer to 29 CFR 1910.134, *Respiratory Protection*).

#### 4.4.7 Hierarchy of Hazard Controls

The student shall be informed of the hierarchy of controls. This is intended to provide the student with an overview of a systematic approach to eliminating hazards, and reduce or control H<sub>2</sub>S risks. Each step is considered less effective than the one before it. It is usual to combine several steps to succeed in reducing the H<sub>2</sub>S risks to a level that is as low as reasonably practicable. The following examples are given to illustrate measures that can be implemented at each level:

- hazard elimination - avoiding risks, adapting work to workers
- substitution - replacing H<sub>2</sub>S with less dangerous or inherently safer material; combating the risks at the source; adapting to technical progress
- engineering controls - implement collective protective measures, e.g., isolation, ventilation systems, mechanical handling, specifying the appropriate materials of construction
- administrative controls - give appropriate instructions to workers, e.g., warning signs, lockout processes, safety equipment inspections, health and safety coordination with subcontractors' activities, induction, forklift driving licenses, rotation of workers
- personal protective equipment (PPE) - provide adequate PPE and instructions for PPE utilization and maintenance, e.g., safety shoes; safety glasses; self-contained and air supplied respirators

#### 4.4.8 Engineering Controls

Training shall include discussion regarding site-specific engineering controls. Students shall be familiarized with the following:

- design of worksites
- ventilation equipment
- materials of construction (metallurgical properties)
- burning, flaring and venting of H<sub>2</sub>S
- containment
- chemical treatment

#### 4.4.9 General Work Procedures

Workers involved in operations where H<sub>2</sub>S may be present shall understand that proper work procedures and practices can greatly reduce the potential for exposure and accidents. These workers shall be trained in proper safe work procedures.

Safe work procedures and practices should include but not be limited to:

- conducting site-specific safety meetings
- verifying that workers are properly trained
- maintaining compliance with permit requirements
- providing personnel qualified to perform rescue, first aid and CPR in a timely manner (if workers are exposed to IDLH environment, you shall provide standby rescue personnel and they shall be rigged and ready)
- providing personnel with appropriate supplied air respirators when there is a potential for exposure above the IDLH
- verifying that proper safety equipment is available, functioning properly, and is used
- checking and remaining aware of wind conditions and direction (stand on the upwind side whenever possible when working on equipment)
- performing a thorough check for personnel and ignition sources in the downwind area before starting any potentially hazardous work
- notifying supervisory personnel, when necessary, before initiating operations that could involve the release of H<sub>2</sub>S
- using the buddy system and never working alone in H<sub>2</sub>S areas above the IDLH concentration
- monitoring conditions through implementation of an H<sub>2</sub>S detection and/or monitoring strategy
- ventilating work areas, vents or purge lines on vessels before beginning work
- keeping non-essential personnel away from work areas