

Recommended Practice

**Installation, Operation,
and Maintenance of
Hydrogen Sulfide
Detection Instruments**



ANSI/ISA-RP12.15, Part II — Installation, Operation, and Maintenance of Hydrogen Sulfide Detection Instruments

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Preface

This preface is included for informational purposes and is not part of ISA-RP12.15, Part II.

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CAUTION: HYDROGEN SULFIDE IS AN EXTREMELY TOXIC GAS, AND EXPOSURE MAY RESULT IN A LOSS OF CONSCIOUSNESS OR DEATH.

1 Purpose

ISA-RP12.15, Part II, establishes user criteria for the installation, operation, and maintenance of hydrogen sulfide gas detection instruments.

Its companion standard, ISA-S12.15, Part I, Performance Requirements for Hydrogen Sulfide Detection Instruments, has been prepared to provide minimum requirements for the performance of hydrogen sulfide gas detection instruments.

2 Scope

2.1 This recommended practice applies to all hydrogen sulfide gas detection instruments that satisfy the performance requirements in ISA-S12.15, Part I.

2.2 Reference Section 3 of ISA-S12.15, Part I, for definitions of terms as used herein. Reference Appendix D of this document for definitions of terms not specifically related to hydrogen sulfide gas detection instruments but of general interest to the users of such equipment.

2.3 References useful in the installation, operation, and maintenance of hydrogen sulfide gas detection instruments are listed in Appendix C. These references are not considered to be part of this document except for those specific sections of documents referenced elsewhere in this recommended practice.

3 General requirements

To assure that the instrument is suitable for the application and is compatible with its operating environment,

- a) the user should provide the potential supplier with detailed information on the conditions that exist in the area(s) in which the instrument is to be used;
- b) the instrument must meet the requirements of the applicable regulating agency having jurisdiction; and
- c) the instrument must be compatible with the environmental conditions (e.g., relative humidity, temperature, atmospheric contaminants, etc.) in which the instrument is to operate. A typical "Environmental and Application Checklist" is included as Appendix A and is intended to aid users in properly specifying requirements for their specific applications.

4 Unpacking

4.1 Unpack the shipping carton(s) and determine whether the order is complete "as received" (check for main assembly, accessories, spare parts, and instruction manual).

4.2 In the event of shipment damage, or for purposes of future correspondence, record the following:

- 1) User's purchase order number and manufacturer's order number and their respective dates
- 2) Carrier waybill number and date received (in case of transit claim)
- 3) Instrument serial number and user identification (ID) number (if assigned)

5 Storage

5.1 When storing hydrogen sulfide gas detection instruments, leave them in their original containers or provide suitable protective covers.

5.2 Select a location that is in accordance with the manufacturer's recommendations. Store hydrogen sulfide gas detection instruments where environmental conditions (temperature, humidity, etc.) are within the manufacturer's storage specifications.

5.3 Before storage, inspect the instruments and remove any internal batteries that could cause corrosion. If the instruments have rechargeable or "permanent" batteries, consult the manufacturer's instructions for battery maintenance during this period.

6 User record keeping

It is recommended that the user:

- a) assign an equipment identification (control) number to each instrument, and
- b) maintain complete records—including periodic performance, calibration, and maintenance checks (see Appendix B).

7 Maintenance

7.1 To maintain the reliability of hydrogen sulfide gas detection instruments, it is recommended that the user assign responsibility for their initial inspection and subsequent use (including maintenance) to a specific qualified individual or group.

7.2 It is important that the Checkout Procedures (see [Section 10](#)) be performed by qualified personnel—trained in the operation, maintenance, and repair of hydrogen sulfide gas detection instruments—and that the group responsible for maintenance be defined clearly.

7.3 The user should establish responsibility for obtaining the gas mixture recommended by the instrument manufacturer for calibrating and testing.

NOTE: Calibration and testing should be performed in accordance with the manufacturer's recommendations (flow rates, concentrations, procedures, etc.).

7.4 It is recommended that when instruments are first put into use, the calibration be checked on a routine basis as prescribed by the manufacturer. If experience shows minimal calibration deviation, then the period between calibration checks may be extended. Likewise, if routine checks indicate an increasing need for calibration, the period should be shortened, and the cause should be investigated.

8 Preparing instruments for use

8.1 Read and understand the manufacturer-provided Instruction Manual. Particular attention should be paid to the locations and functions of all controls and readout devices.

8.2 A shop calibration test of the type described in [Section 13.7](#) is recommended before the initial use of any hydrogen sulfide gas detector instrument.

9 Installation of stationary instruments

It is extremely important that the equipment manufacturer-provided Instruction Manual be read thoroughly and followed completely.

9.1 If instruments or ancillary components are installed in a hazardous (classified) location, these instruments or components must be approved for the area in which they are installed and clearly marked. Hazardous (classified) locations in the United States are defined by the National Electrical Code, NFPA 70, Article 500. Markings required by ISA-SI2.15, Part I, Section 6, should be visible to the operator. Installation of intrinsically safe systems shall be in accordance with ISA-RP12.6, Installation of Intrinsically Safe Instrument Systems in Class I Hazardous Locations.

9.2 Detector Locations. While many factors are involved in detector head quantity and location selection, and industry standards and/or applicable regulations may dictate quantities and general or specific locations, the following should be considered:

- 1) Density of gases to be monitored. Hydrogen sulfide gas is 20 percent heavier than air and tends to settle. However, air movement and elevated temperatures may cause hydrogen sulfide to rise.
- 2) Air movement, air velocity, and direction influence the dispersion of vapors/gases to be monitored.
- 3) Potential sources. The location and nature of the potential hydrogen sulfide sources (e.g., pressure, amount, source temperature, and distance) need to be assessed.
- 4) Ambient temperature. Reference [Section 9.8](#).
- 5) Vibration. Reference [Section 9.7](#).
- 6) Accessibility. Detector head locations should consider future maintenance and calibration requirements.
- 7) Structural arrangements. Structural arrangements (such as walls, troughs, or partitions) could allow hydrogen sulfide to accumulate.
- 8) Mechanical damage and contamination. Detectors should be installed in locations to preclude mechanical damage from normal operations (e.g., cranes, traffic, exhausts, and wash-downs).
- 9) Potential for personnel exposure.
- 10) Possible sources of electromagnetic interference/radio frequency interference (emi/rfi).

9.3 Detector heads must be connected to their respective control units as specified by the manufacturer (observing maximum loop resistance, minimum wire size, isolation, etc.) and using a cable, wire and conduit system, or other system suitable and approved for the purpose and the area classification.

9.4 Equipment required to be connected to ground in order to provide protection from electrical shock hazards shall be connected effectively with the general mass of the earth through a grounding system. The grounding system shall have sufficiently low impedance and shall have a current-carrying capacity sufficient at all times, under the most severe conditions that are likely to arise in practice, to prevent any current in the grounding conductor from causing a potential of 30 V rms or 42.4 V peak to exist between accessible conductive parts of the equipment and adjacent accessible conductive surfaces within a 12-foot radius. Where wet contact may occur, the maximum potential is reduced to 15 V rms or 21.2 V peak, respectively. This grounding system performance shall remain effective under all conditions.

9.5 To minimize electromagnetic interference (emi), it is recommended that properly grounded, shielded interconnecting cables (or wire and conduit) be used and enclosures (if of conductive material) be adequately grounded. It is recommended that cable shields be grounded at one point only, the controller end, unless otherwise specified by the manufacturer. It is recommended that splices in sensor wiring be properly soldered.

9.6 Lubricate all threaded connections, but ascertain that the lubricant used contains no substance that might be deleterious to the sensors.

9.7 Mount all instruments and detector heads in a manner to minimize vibration.

9.8 Mount all detector heads and instruments in areas that ensure compliance with the manufacturer's operating temperature specifications.

9.9 Adequate drainage should be incorporated into the system design to minimize moisture and condensation in the instrument, detector head, and interconnecting cable/conduit system.

9.10 Any potentially flammable or toxic gases introduced into sampling systems should be vented in a safe manner.

9.11 When interconnecting ancillary devices, maximum current and voltage ratings of the instrument's outputs (e.g., interposing relay contacts) must be observed.

10 Equipment checkout procedures

10.1 Portable instruments

10.1.1 With reference to the Instruction Manual, perform the following where applicable and necessary:

- 1) With the power OFF, reset the mechanical zero of any analog meters.
- 2) Ascertain that all electrical connections are properly tightened (remote detector head, power supply, etc.).
- 3) Check the battery voltage and/or battery condition, and make any required adjustments or battery replacements (according to the Instruction Manual).
- 4) With the power ON, allow adequate warm-up time (in accordance with the Instruction Manual.)
- 5) Check for sample line leaks and proper flow (sample-draw instruments only).
- 6) Check for clogged or dirty flame-arresting systems.
- 7) Perform a test of the failure (malfunction) circuit(s).

10.1.2 Place the detector head (integral or remote) or the sample draw assembly in an atmosphere free of any gas to which the instrument responds, aspirate a large enough sample to purge the lines (applicable only to sample-draw instruments), and adjust the electrical output to indicate zero.

10.1.3 Check the response of the instrument using a known hydrogen sulfide gas mixture as recommended by the manufacturer for the selected range concentration for which the instrument is indicated to be used. If the test results are not within 2 ppm or 10 percent, whichever is greater, of the applied gas concentration, recalibrate the instrument.

The concentration of the test gas mixture used must be greater than the highest alarm set point, and all alarms must actuate.

10.1.4 If an instrument fails this procedure and suggested corrective action does not solve the problem, instruments should be referred to the responsible maintenance individual or group.

10.2 Stationary instruments

10.2.1 With reference to the Instruction Manual, perform the following when applicable and necessary:

- 1) With the power OFF, reset the mechanical zero of any analog meters.
- 2) Ascertain that all electrical connections are properly tightened (remote detector head, power supply, etc.).
- 3) Verify that all explosion-proof enclosures are provided with the correct number of proper bolts/fasteners and all required conduit/cable seal fittings. Verify that bolts/fasteners are tightened/secured to manufacturer's specifications and that seal fittings are properly poured.
- 4) Apply power to the system and verify that all indicators operate properly (in accordance with the Instruction Manual).
- 5) Allow the system to warm up for an adequate time (in accordance with the Instruction Manual).

10.2.2 With the sensor in an atmosphere free of any gas to which the instrument responds, verify proper operation of all alarm set points using the "zero" control to offset the display up-scale (or other methods as recommended by the manufacturer). Before proceeding, reset the meter to zero if it was moved.

10.2.3 Check the response of the instrument using a known hydrogen sulfide mixture as recommended by the manufacturer for the selected range concentration for which the instrument is indicated to be used. If the test results are not within 2 ppm or 10 percent, whichever is greater, of the applied gas concentration, recalibrate the instrument.

10.2.4 If an instrument fails this procedure and suggested corrective action does not solve the problem, instruments should be referred to the responsible maintenance individual or group.

NOTE 1: Some instruments may incorporate multiple remote detector heads. Output response from multiple heads may be singular (discrete channels) or additive, depending on the manufacturer's design. These characteristics must be taken into account when conducting response and alarm checks.

NOTE 2: When calibrating for initial equipment checkout, possible contaminating, desensitizing, and interfering agents should be considered. (See 3(c), 11.1(6), 11.3, Appendix A, and Paragraph 6.2.1 of S12.15, Part 1).

11 Special operating considerations

CAUTION: HYDROGEN SULFIDE IS AN EXTREMELY TOXIC GAS, AND EXPOSURE MAY RESULT IN A LOSS OF CONSCIOUSNESS OR DEATH.

11.1 General

When using hydrogen sulfide gas detectors, the following precautions should be observed (when applicable):

- 1) For sample-draw instruments, pumping time must be sufficient to draw the sample to the sensing element, and transport time should be considered. Long sample lines will introduce time delays in detection. Time delays should be determined, and good engineering judgment should define acceptable limits for specific applications.
- 2) In areas where gases or vapors may be stratified rather than uniformly mixed, checks should be made at different elevations.
- 3) When sampling over liquids, the end of the sample line or detector head should not touch the liquid.
- 4) Vapor condensation may cause errors when the atmosphere to be tested is at a higher temperature than the atmosphere surrounding the gas-sensing element. Therefore, the temperature of the sampling assembly and instrument should be essentially the same as, or higher than, the temperature of the atmosphere under test unless the vapors will remain fully vaporized at the lower temperature near the gas-sensing element.
- 5) To avoid sampling losses, only sample lines recommended by the manufacturer or known to the user as being compatible with hydrogen sulfide should be used. Many materials (e.g., certain rubbers and polyvinyl chlorides) are absorbent and/or adsorbent in varying degrees to hydrogen sulfide. Some materials are sensitive to certain other gases and may deteriorate with time.
- 6) Detection instruments within the scope of this recommended practice may not be specific to hydrogen sulfide. That is, the presence of other (interference) gases, including flammable and nonflammable gases, may influence readings. Reference the manufacturer's Instruction Manual for a listing of known interference gases.
- 7) Erratic meter readings typically indicate power problems or instrument malfunctions and should be reported to the maintenance group.
- 8) Steam, other vapors, aerosols, or other materials may coat flame arresters, impeding or blocking sample flow to the sensor.
- 9) Certain materials, although otherwise suitable for sample lines, may deteriorate from sunlight or other environmental conditions.
- 10) To enhance safety, suitable instruments should be provided to detect other toxic or flammable gases and vapors that may be present.
- 11) Unless stated otherwise by the manufacturer, units should be recalibrated after exposure to concentrations exceeding instrument range.

11.2 Atypical mixtures

Most, but not all, instruments are calibrated and intended for hydrogen sulfide detection in air that contains approximately 21 percent oxygen by volume. For a description of system safety and instrument response expected under deficient or enriched oxygen conditions, consult the Instruction Manual, or contact the manufacturer for a recommendation.

11.3 Desensitizing agents

Some materials may have a poisoning, desensitizing, or inhibiting effect on some types of detectors, resulting in a loss of sensitivity. If desensitizing materials could be present in the atmosphere being monitored, instrument sensitivity should be checked frequently using a gas mixture of a known concentration. For some applications, it may be possible to detect hydrogen sulfide gas in the presence of desensitizing agents; for such special applications, the

manufacturer should be consulted. Reference the manufacturer's Instruction Manual for a listing of known desensitizing agents.

11.4 Entering atmospheres potentially containing hydrogen sulfide

Any atmosphere that potentially contains hydrogen sulfide should be tested first from outside the area to establish safe levels before entry. In addition to testing for hydrogen sulfide, tests for oxygen deficiency and/or combustibility may be required by the user and/or regulatory agency. Oxygen deficiency may alter the readings of hydrogen sulfide detectors (Paragraph 11.3). It may be prudent to test for oxygen content BEFORE testing for hydrogen sulfide. Operators should always wear suitable breathing apparatus when entering an unknown atmosphere. Optional attachments for portable devices that allow the users to manually draw samples from remote locations inherently prevent continuous monitoring of the local environment and, therefore, fall outside the scope of this document. While such equipment cannot be certified under Part I of this standard, it can provide useful information (such as concentrations within confined spaces before entry). Users should consult the manufacturer's Instruction Manual to determine the proper number of bulb strokes for drawing samples when such attachments are used. The attachments should be removed after use to restore the instrument to continuous monitoring.

11.5 Use of appropriate accessories

Safety and accuracy of hydrogen sulfide gas detection instruments may be improved in certain environments through the use of appropriate accessories. Any/all such accessories must be installed and used in accordance with the manufacturer's Instruction Manual.

- 1) If there is a danger of electrical shock while using a portable unit with a conductive sample probe, the conductive assembly should be replaced with a nonconductive sample probe.
- 2) A nonabsorbent coarse filter may be available for sampling in an atmosphere containing dust.
- 3) A probe with a special tip and/or a liquid trap inserted in the sample line may be available to reduce the chance of liquids being ingested by instruments requiring a drawn sample.
- 4) Dilution assemblies are often available to permit the testing of atmospheres where concentrations are above the normal range of the instrument.
- 5) Where long sample lines to the instrument are required, it may be desirable to install a sample valve or cock near the instrument to facilitate access to fresh air for "zero" checks.
- 6) Accessories are often available and may be desirable to improve the accuracy and reliability of detectors installed in areas of high air velocity and/or liquid spray/wash-down.

NOTE: Response time may be lengthened by the use of such accessories.

- 7) Remote calibration accessories are often available and may be desirable for detector heads installed in locations difficult to access.

NOTE: The manufacturer's recommendations must be followed for installation and calibration for optimum accuracy. Periodic physical inspections of detector heads and transport lines are recommended.

11.6 Electromagnetic Interference (EMI)

Some hydrogen sulfide gas detectors are susceptible to EMI, especially radio frequency interference (RFI), which can cause malfunctions, false alarms, and/or zero drift. Where EMI is anticipated, suitable apparatus resistant to such interference should be selected. Reference also [Section 9.5](#).

11.7 Maintenance schedule

A regular maintenance schedule conforming to the manufacturer's Instruction Manual and any regulatory requirements should be adopted. This maintenance schedule should be the responsibility of a designated and qualified individual or operating group. Refer to Appendix B for recommended typical maintenance records.

12 Operational Checks

Certain minimum operational checks are necessary during the use of the instrument. These checks should include the following:

- 1) Visual check
 - a) Check the instrument for abnormal conditions such as malfunctions, alarms, or non-zero readings.
 - b) Assure that the detector head assembly is free of obstructions or coatings that could interfere with gas reaching the sensing element. Assure that the sample draw is proper for sample draw systems; reference [Section 13.4](#).
 - c) For sample draw systems, inspect flow lines and fittings. Cracked, pitted, bent, or otherwise damaged or deteriorated flow lines or fittings should be replaced with those recommended by the manufacturer.
- 2) Response (sensitivity) check
 - a) Assure that the instrument indicates zero when zero gas is present. When the reading is stable, adjust the instrument if necessary (according to the manufacturer's Instruction Manual).
 - b) Following the manufacturer's instructions, apply a known concentration calibration gas to the detector head. If the reading is not within specifications, adjust or recalibrate according to the Instruction Manual (or return the instrument to the group or individual responsible for such adjustments/recalibrations.)
 - c) For sample-draw systems, calibration gas periodically should be introduced through transport lines and the results (accuracy and response time) compared to calibration results when the calibration gas is introduced directly to the sensor calibration port. This check is to verify that the transport lines, filters, etc., are not contaminated. Refer to [Section 11.1](#)(15).
 - d) Complete the maintenance records; refer to Appendix B for a typical maintenance record.

If an instrument fails this procedure, and suggested corrective action does not solve the problem, the instrument should be referred to the maintenance group or individual responsible for repair.

13 Maintenance procedures

13.1 General

13.1.1 Maintenance procedures should be undertaken only by qualified personnel trained in the operations, maintenance, and repair of hydrogen sulfide gas detection instruments.

13.1.2 If the maintenance facility is not adequately equipped and/or qualified personnel are not available to perform the manufacturer's recommended checkout and maintenance procedures, the user should contact the instrument manufacturer or other qualified outlet for repair.

"Qualified" implies not only the ability to perform recommended procedures but also knowledge and understanding of ISA-S12.15, Part I; ISA-RP12.15, Part II; and the requirements of any applicable regulatory authority.

13.1.3 Complete and explicit instructions for testing and checkout of replaceable instrument components may be obtained from the manufacturer. Suitable parts lists and schematics are provided in the Instruction Manual.

13.1.4 After all defective operations are corrected (repaired or replaced in accordance with the Instruction Manual), a full Shop Calibration Test (as described in [Section 13.7](#)) should be conducted.

13.2 Preliminary checkout

NOTE: Given the variety of instruments available, it is not practical for this recommended practice to tabulate each maintenance, repair, and calibration step in full detail. What follows is a listing of the principal items that all maintenance procedures should include.

13.2.1 If an instrument is in the shop for scheduled maintenance, the full maintenance procedure should be conducted. If specific instrument failure is a cause for return, the complaint should be noted, the instrument repaired, and applicable checkout tests conducted. All instruments, however, should undergo a full calibration test before being returned to service.

13.2.2 The Instrument Maintenance Record (see Appendix B for a typical maintenance record) for the instrument should be reviewed for previous service history.

13.2.3 When a failed instrument is received, it should be determined if the instrument's power supply (including any voltage regulation stages and/or battery chargers supplied) is the primary cause for failure before proceeding further.

An independent, commercially available, regulated and filtered DC power supply should be used, where applicable, to:

- a) provide a constant source of DC voltage for instruments subject to battery drain during servicing, and
- b) permit removal and isolation of the instrument's power supply for further testing, replacing, or recharging.

Detailed instructions for determining acceptable operation of the hydrogen sulfide gas detector's power supply may be obtained from the manufacturer.

13.2.4 After checking the power supply, repair personnel should proceed with the checkout of sensors, flow systems, readout devices, and alarm devices, identifying and correcting all deficiencies. The manufacturer's instructions should be followed when deciding whether to replace an assembly or repair it by replacing a component part. If components are replaced, the replacement components must meet the specifications and tolerances of the original components.

13.2.5 The following criteria should be considered for a scheduled maintenance procedure:

- 1) Test instrument response with a known concentration hydrogen sulfide test mixture. Readout operation, operation of controls, switches, the flow system, etc., should be observed.
- 2) External potentiometric controls should be checked by rotating the shafts back and forth and feeling for variations in contact surfaces that might be a prelude to field failure.
- 3) Exterior housings should be examined for dents and distortions that could be a cause of nonfunctional readouts or intermittent electrical operation.
- 4) Circuit boards and wiring should be visually examined for burns, cracks, improper solder joint conditions (e.g., cold solder joints), and inadequate conformal coating. All wiring should be checked for shorting, improper termination, and poor connection integrity.
- 5) Fuses (current and voltage ratings and continuity) and fuse holders should be checked and replaced as necessary.

13.3 Sensor

13.3.1 Depending on the time interval since the last sensor replacement, anticipated field usage, and response to the gas mixture during calibration, good maintenance practice suggests automatic sensor evaluation/replacement at service intervals recommended by the manufacturer. Also, unless specifically stated as unnecessary by the manufacturer, it is recommended that sensors be calibrated and be evaluated in accordance with the manufacturer's instructions after exposure to high concentrations of hydrogen sulfide.

Sensors must be replaced if the readout cannot be electrically zeroed, if the instrument cannot be adjusted to read a known hydrogen sulfide concentration, or if the calibration gas readout is erratic.

13.3.2 If a flame arrestor is part of the sensor assembly, it should be checked for proper attachment and fit and signs of corrosion, dirt, or moisture. Any necessary cleaning or replacement should be in accordance with the manufacturer's instructions.

13.4 Flow system

13.4.1 This section is applicable only to those instruments utilizing aspirated sampling.

13.4.2 The flow system must be checked for leakage, restrictions, and proper pump operation. Any necessary cleaning, repair, or replacement should be in accordance with the manufacturer's instructions.

13.4.3 All filters, traps, and flame-arresting assemblies should be emptied, cleaned, or replaced in accordance with the manufacturer's instructions.

13.4.4 The flow system and sample chamber should be examined for deposits of foreign material and steps taken to prevent future accumulations.

13.4.5 All flow connections should be tightened in accordance with the manufacturer's instructions.

13.4.6 All valves and moving pump parts should be lubricated but only according to the manufacturer's recommendation.

13.4.7 Sample-draw systems should be adjusted to correct flow rate values using recommended test instruments.

13.4.8 The loss of flow trouble signals required by ISA-S12.15, Part 1, Section 5.4.2, should be checked for proper operation.

13.5 Readout devices

13.5.1 If the instrument incorporates a meter, perform the following procedures:

- 1) Inspect the meter for broken or cracked lens.
- 2) Inspect analog meters for defects — e.g., bent pointers, loose dials, loose up-scale and down-scale stops, etc.
- 3) Inspect digital meters for defects — e.g., missing segments, faded segments, etc.
- 4) Conduct other electrical and mechanical meter tests that the instrument manufacturer deems necessary to assure proper performance.

13.5.2 Other readouts (e.g., solid state) and outputs (e.g., alarm outputs) that may be incorporated should be tested (electrically) at specified test points according to the manufacturer's instructions.

13.6 Alarms

Check all alarms for proper alarm operation by offsetting the electrical zero (or by other methods as recommended by the manufacturer) until the alarm(s) is actuated. Check failure (malfunction) circuits by disconnecting components (or other actions recommended by the manufacturer) and observing whether or not the failure alarm is actuated.

13.7 Shop calibration test

13.7.1 The instrument shall be calibrated in accordance with this recommended practice using the manufacturer's calibration equipment and specified calibration procedure. A known concentration hydrogen sulfide test mixture, preferably near mid-scale (hereafter known as "calibration mixture"), in sufficient quantity and accuracy for shop use, can be purchased commercially. Hydrogen sulfide mixtures are unstable and their shelf life should be confirmed with the supplier. All "calibration mixtures" and associated calibration apparatus should have the following characteristics to ensure reliable results:

- 1) Calibration mixtures should be certified or analyzed to be accurate to at least 1 ppm or 5 percent, whichever is greater, of the actual labeled concentration.
- 2) A regulator assembly of sufficient sensitivity and stability should be used to reduce compressed cylinder pressures. The regulator should be suitable for this service and incorporate appropriate connections.
- 3) A direct-reading flow rate indicator, preset regulator, expandable bladder, or other flow-controlling element should be installed in the calibration mixture supply line to permit adjustment of flow rate to the instrument manufacturer's specified value of range and accuracy.

- 4) All calibration system components should be resistant to absorption and adsorption of, and corrosion by, the calibration mixture.

13.7.2 For the calibration test, the mixture of gas recommended by the instrument manufacturer (and for which the instrument is factory calibrated) should be used.

13.7.3 All tests should be conducted in a manner to ensure safe venting of calibration mixtures.

13.7.4 Instruments should be allowed to stabilize at operating temperature. Then, operating controls should be adjusted in accordance with the Instruction Manual.

13.7.5 The calibration system should be connected to the instrument and the stabilized reading noted. The calibration span (gain) potentiometer should be adjusted, if necessary, so the output reading equals the concentration of the calibration mixture. The calibration mixture should be removed, and it should be ascertained that the instrument returns to "zero." This procedure may require repeating if the instrument zero and span adjustments interact.

13.7.6 Ascertain that all alarms are actuated when the set point(s) is reached, following the manufacturer's recommendations.

13.7.7 The calibration test as herein described shall be the last test conducted before an instrument is released from the shop. It is recommended that the calibration data be recorded on the Maintenance Records; refer to Appendix B for a typical maintenance record. The Maintenance Record (or comparable document) should be updated before returning the instrument to service.

14 External power supply systems

14.1 General

Stationary gas detection systems require reliable external power supply systems, either AC or DC. A DC system may be preferred in some applications for reasons given below. Whether an AC or DC supply is required depends on the specific instrument utilized.

Any peripheral external power supply equipment provided must be suitable and approved for the area where it is to be used (for environmental conditions and for the area classification).

14.2 AC supplies

14.2.1 When reliable AC power is available, units are often furnished AC power directly. When continuous power is required, however, the AC supply usually is provided with a battery charger/inverter system. In such a system, the inverter provides standby power from batteries in the event of failure of the normal power source.

14.2.2 It is recommended, for most installations where standby power is required, that DC-powered equipment be utilized directly.

14.3 DC supplies

14.3.1 General. It usually is desirable to utilize external DC supplies for one or more of the conditions discussed below.

14.3.2 Controls. It generally is recommended (and frequently required) that electrical controls

for safety systems such as gas detector systems be "normally energized" ("fail-safe"). This means that power is supplied continuously during normal operations to devices (such as solenoid valves) that provide equipment shutdown or other "corrective action" if gas concentrations corresponding to specific alarm set point(s) are reached. Under these conditions, interruption of power due to either deliberate safety device actuation or accidental loss of power will initiate equipment shutdown (or other "corrective action"). If continuous power is not supplied, nuisance shutdowns would result from even momentary power disruptions. Special consideration should be given to systems where unwarranted shutdowns (such as those caused by coil failure of an energized solenoid valve) could create potentially hazardous situations.

NOTE 1: It is desirable to provide a means that will allow the system to be tested (and calibrated) without initiating equipment shutdown (or other corrective action), but it should be evident to personnel that the system is in the test (bypass) mode.

NOTE 2: It may be desirable to provide an output of battery charger status to allow the installation of a remote trouble signal.

14.3.3 Buffer applications. DC power systems often are desirable to serve as buffers between AC power sources and gas detection systems to reduce the instrument's exposure to transients and short periods of time when AC power is off voltage and/or off frequency.

14.3.4 Standby power applications. It normally is desirable (and frequently required) that hydrogen sulfide gas detection systems remain operative for limited periods of time when AC power is not available. This feature is particularly attractive for systems installed at locations that are unmanned, remote, and/or subject to frequent AC power failures and is even more important if controls are installed normally energized ("fail-safe").

In addition to conventional AC-powered battery charger systems, users may wish to consider photovoltaic cells, thermoelectric generators and other nonconventional power sources. Environmental conditions (temperature, availability of sunlight, etc.) are influencing factors in choosing alternate power sources.

Appendix A — Environmental and application checklist for hydrogen sulfide gas detectors (typical)

1) Briefly describe the application in which hydrogen sulfide is to be sensed. (Address: sampling methods, special environments, and locations.)

2) If monitored points are separate from the control unit, what distances are involved?

3) List toxic gases and combustible gases and/or vapors that may be present and their approximate sample composition.

Gas Vapor Component*	Concentration	Special Considerations
<hr/>	<hr/>	<hr/>
<hr/>	<hr/>	<hr/>
<hr/>	<hr/>	<hr/>

*List also chemical name if possible.

If gases other than hydrogen sulfide are anticipated, indicate whether these gases or vapors will be present separately or in combination. _____

4) Is detection to be in normal (21% oxygen), oxygen-deficient, or oxygen-enriched atmospheres?

Estimated oxygen range of atmosphere to be sampled. _____

5) Required instrument measuring range(s):

6) Ambient temperature range in which the control unit is to be used:

_____ °C minimum to _____ °C maximum.

Nominal expected temperature: _____ °C.

7) Ambient temperature range in which the detector head is to be used:

_____ °C minimum to _____ °C maximum.

Nominal expected temperature: _____ °C.

8) Ambient humidity range of atmosphere to be monitored:

_____ % r/h minimum to _____ % r/h maximum.

9) Pressure range of atmosphere to be monitored:

_____ minimum to _____ maximum.

10) Velocity range at atmosphere to be monitored:

_____ minimum to _____ maximum.

11) Other pertinent conditions (presence of dusts, corrosives, fumes, mists, emi/rfi, etc.). Please state type and amount, if possible.

12) Potential desensitizing agents or other materials that can affect sensor performance:

13) Classification of the location in which the control unit is to be used:

Class: _____ Division: _____ Group: _____

Classification of the location in which the detector head is to be used:

Class: _____ Division: _____ Group: _____

14) Will electrical shock hazards exist in the vicinity to be tested for combustibles (requiring a nonconducting probe)?

15) Additional accessories required: _____

Appendix B — Instrument maintenance record for hydrogen sulfide gas detectors (typical)

Manufacturer _____
 Date Purchased _____
 Serial No. _____
 Calibration Gas Concentration _____
 Source of Calibration Gas _____

Model No. _____
 Date Placed in Service _____
 User ID No. _____
 Location _____

Maintenance Other Than Routine Calibration						
	Date	Check One		Returned By	Serviced By	Nature of Service and Parts Replaced
		Sched. Maint.	Failure			
1						
	Comments ¹					
2						
	Comments ¹					
3						
	Comments ¹					
4						
	Comments ¹					

¹ Include modifications, adjustments, etc.

Calibration Records		
	Date	Comments ²
1		
2		
3		
4		
5		

² Include calibration difficulties, reading, and ppm H₂S applied prior to calibration, etc.

Appendix C — Reference publications

This appendix is included for informational purposes and is not part of this standard.

A) *American Petroleum Institute (API)*

- 1) API RP 14C-1984, Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms.
- 2) API RP 14F-1985, Recommended Practice for Design and Installation of Electrical Systems for Offshore Production Platforms.
- 3) API RP 49-1987, Recommended Practices for Safe Drilling of Wells Containing Hydrogen Sulfide.
- 4) API RP 55-1983, Conducting Oil and Gas Production Operations Involving Hydrogen Sulfide.
- 5) API RP 500A-1982, Recommended Practice for Classification of Locations for Electrical Installations in Petroleum Refineries.
- 6) API RP 500B-1987, Recommended Practice for Classification of Locations for Electrical Installations at Drilling Rigs and Production Facilities on Land and on Marine Fixed and Mobile Platforms.
- 7) API RP 500C-1984, Recommended Practice for Classification of Locations for Electrical Installations at Pipeline Transportation Facilities.

B) *British Standards Institute*

- 1) BS.5345, Code of Practice in Selection, Installation, and Maintenance of Electrical Apparatus for Use in Potentially Explosive Atmospheres (Other Than Mining Applications for Explosive Processing and Manufacture). Parts 1-9.

C) *Canadian Standards Association (CSA)*

- 1) CSA Standard C22.2, No. 0.4, Bonding and Grounding of Electrical Equipment (Protective Grounding).
- 2) CSA Standard C22.2, No. 152, Combustible Gas Detection Instruments.

D) *Factory Mutual Research Corporation*

- 1) Approval Standard Class Number 3610, October 1988, Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous (Classified) Locations.
- 2) Approval Standard Class Number 3611, April 1986, Electrical Equipment for Use in Class I and II, Division 2, and Class III, Divisions I and 2 Hazardous Locations.
- 3) Approval Standard Class Number 3615, March 1989, Explosionproof Electrical Equipment General Requirements.

- 4) Approval Standard Class Number 3810, March 1989, Electrical and Electronic Test, Measuring, and Process Control Equipment.
- 5) Approval Standard Class Number 3600, March 1989, Electrical Equipment for Use in Hazardous (Classified) Locations General Requirements.
- 6) Approval Standard Class Number 6310, 6320, December 1989, Combustible Gas Detectors.

E) Institute of Electrical and Electronics Engineers (IEEE)

- 1) IEEE Std. 142-82, Recommended Practice for Grounding of Industrial and Commercial Power Systems.
- 2) IEEE Std. 315-75, Graphic Symbols for Electrical and Electronics Diagrams.

F) ISA

- 1) ANSI/ISA-S5.5-1984, Instrumentation Symbols and Identification.
- 2) ISA-S12.1-1960, Electrical Instruments in Hazardous Atmospheres.
- 3) ISA-S12.4-1970, Instrument Purging for Reduction of Hazardous Area Classification.
- 4) ANSI/ISA-RP12.6-1987, Installation of Intrinsically Safe Instrument Systems for Class I Hazardous Locations.
- 5) ANSI/ISA-S12.13, Part I, Performance Requirements, Combustible Gas Detectors.
- 6) ANSI/ISA-RP12.13, Part II, Installation, Operation, and Maintenance of Combustible Gas Detection Instruments.
- 7) ISA RP-12.15, Part II, Installation, Operation, and Maintenance of Hydrogen Sulfide Detection Instruments.
- 8) ANSI/ISA-S51.1-1979, Process Instrumentation Terminology.
- 9) ANSI/ISA-S71.04-1985, Environmental Conditions for Process Measurement and Control Systems; Airborne Contaminants.
- 10) ANSI/ISA-S82.01, S82.02, and S82.03, Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment.
- 11) Schaeffer, M. J., "The Use of Combustible Detectors in Protecting Facilities from Flammable Hazards," *ISA Transactions*, Vol. 20, No. 2., Research Triangle Park, N.C.
- 12) Bossert, John A., "Performance Certification of Combustible Gas Detectors," presented at ISA International Symposium, 1976.

G) International Electrotechnical Commission (IEC)

- 1) IEC Pub. 654-1 (1979), Operating Conditions for Industrial-Process Measurement and Control Equipment, Part I: Temperature, Humidity and Barometric Pressure.

H) National Association of Corrosion Engineers (NACE)

- 1) Corrosion Data Survey, Metals Section.
- 2) MR-01-75, Sulfide Stress Cracking Resistant Metallic Materials for Oil Field Equipment.

I) National Fire Protection Association (NFPA)

- 1) NFPA No. 70-1987, National Electrical Code.
- 2) NFPA No. 493-1978, Intrinsically Safe Apparatus for Use in Division I Hazardous Locations.
- 3) NFPA No. 496-1986, Standard for Purged and Pressurized Enclosures for Electrical Equipment.

J) Underwriters Laboratories, Inc. (UL)

- 1) UL 913-1979, Intrinsically Safe Apparatus and Associated Apparatus for Use In Class I, II, and III, Division 1, Hazardous Locations.

K) United States Coast Guard (USCG)

- 1) 46 CFR 154.1345 and 1350, U.S. Coast Guard Regulations for Gas Detection and Gas Detection Systems on Self-Propelled Vessels Carrying Bulk Liquefied Gases.

L) United States Code of Federal Regulations

- 1) Title 29, Part 1910, Occupational Safety and Health Standards, Subpart S, Electrical.
- 2) Title 30, Parts 250 and 256 (April 1, 1988), Oil and Gas and Sulphur Operations in the Outer Continental Shelf.

M) Miscellaneous

- 1) Threshold Limit Values for Chemical Substances in the Work Environment Adopted by ACGIH for 1984-1985.
- 2) SAMA PMC 33.1-1978, Electromagnetic Susceptibility of Process Control Instrumentation. (Under revision as potential ISA Standards; currently designated as ISA-dS71.05, ISA-dS71.06, and ISA-dS71.07.)
- 3) Criteria Documents on Hydrogen Sulfide and Sulfur Dioxide, National Institute for Occupational Safety and Health (NIOSH).
- 4) "Occupational Health Guideline for Hydrogen Sulfide," DHHS (NIOSH) Publication No. 81-123, *Occupational Health Guidelines for Chemical Hazards*, Jan., 1981, pp. 1-5.

Appendix D — Definitions

NOTE: Reference ISA-12.15, Part I, for definitions specifically related to hydrogen sulfide gas detection instruments. The definitions below are not directly related and are not considered part of this document but are given only for the convenience of the reader.

Immediately Dangerous to Life and Health (IDLH) represents the maximum level from which one could escape within 30 minutes without escape-impairing symptoms or any irreversible effects.

Threshold Limit Value — Time Weighted Average (TLV-TWA) is the time-weighted average concentration for a normal 8-hour work day and a 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day.

Threshold Limit Value — Short Term Exposure Limit (TLV-STEL) is a 15-minute, time-weighted average exposure that should not be exceeded at any time during a work day, even if the 8-hour time-weighted average is within the TLV. Exposures at the STEL should not be longer than 15 minutes and should not be repeated more than four times per day. There should be at least 60 minutes between successive exposures at the STEL.

Threshold Limit Value (TLV) is the maximum value that nearly all workers may be repeatedly exposed to day after day without any adverse effects.

Appendix E — Occupational health guidelines for hydrogen sulfide

E.1 Introduction

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

E.2 Substance identification

- Formula: H_2S
- Synonyms: Sulfuretted hydrogen; hydrosulfuric acid; hepatic gas
- Appearance and odor: Colorless gas with a strong odor of rotten eggs. The odor of this gas should not be used as a warning, since its presence may deaden the sense of smell. Hydrogen sulfide can also exist as a liquid at low temperature and high pressure.

E.3 Permissible Exposure Limit (PEL)

The current OSHA standard for hydrogen sulfide is a ceiling level of 20 parts of hydrogen sulfide per million parts of air (ppm) or a maximum allowable peak of 50 ppm for 10 minutes once, if no other measurable exposure occurs. NIOSH has recommended that the permissible exposure limit be reduced to 15 mg/m (10 ppm) averaged over a 10 minute period, and that work areas in which the concentration of hydrogen sulfide exceeds 70 mg/m be evacuated. The NIOSH Criteria Document for Hydrogen Sulfide should be consulted for more detailed information.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

E.4 Health hazard information

- Routes of exposure

Hydrogen sulfide can affect the body if it is inhaled or if it comes in contact with the eyes, skin, nose or throat. It can also affect the body if it is swallowed.
- Effects of overexposure
 - 1) Short-term exposure: Inhalation of high concentrations of hydrogen sulfide vapor may cause loss of consciousness and death. Inhalation of lower concentrations may cause headache, dizziness, and upset stomach. Exposure to hydrogen sulfide can cause temporary loss of the sense of smell, and irritation of the eyes, nose, or throat.
 - 2) Long-term exposure: Not known.

3) Reporting signs and symptoms: A physician should be contacted if anyone develops any sign or symptoms and suspects that they are caused by exposure to hydrogen sulfide.

- Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to hydrogen sulfide at potentially hazardous levels:

1) Initial medical examination:

- a) A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the eyes and lungs should be stressed.
- b) Eye disease: Hydrogen sulfide is a severe eye irritant and may cause tissue damage. Those with pre-existing eye problems may be at increased risk from exposure.
- c) 14" x 17" chest roentgenogram: Hydrogen sulfide may cause human lung damage. Surveillance of lungs is indicated.
- d) FVC and FEV (1 sec): Hydrogen sulfide is a respiratory irritant. Persons with impaired pulmonary function may be at increased risk from exposure. Periodic surveillance is indicated.

2) Periodic medical examination: The aforementioned medical examinations should be repeated on an annual basis, except that an x-ray is considered necessary only when indicated by the results of pulmonary function testing, or by signs and symptoms of respiratory disease.

- Summary of toxicology

Hydrogen sulfide gas is a rapidly acting systematic poison which causes respiratory paralysis with consequent asphyxia at high concentrations. It irritates the eyes and respiratory tract at low concentrations. Inhalation of high concentrations of hydrogen sulfide, 1000 to 2000 ppm, may cause coma after a single breath and may be rapidly fatal; convulsions may also occur.

Exposure to concentrations of hydrogen sulfide above 50 ppm for one hour may produce acute conjunctivitis with pain, lacrimation, and photophobia; in severe form this may progress to keratoconjunctivitis and vesiculation of the corneal epithelium. In low concentrations, hydrogen sulfide may cause headache, fatigue, irritability, insomnia, and gastrointestinal disturbances; in somewhat higher concentrations it affects the central nervous system, causing excitement and dizziness. Prolonged exposure to 250 ppm of hydrogen sulfide may cause pulmonary edema. Prolonged exposure to concentrations of hydrogen sulfide as low as 50 ppm may cause rhinitis, pharyngitis, bronchitis, and pneumonitis. Repeated exposure to hydrogen sulfide results in increased susceptibility, so that eye irritation, cough, and systemic effects may result from concentrations previously tolerated without any effect. Rapid olfactory fatigue can occur at high concentrations.

E.5 Chemical and physical properties

- Physical data
 - 1) Molecular weight: 34.08
 - 2) Boiling point (760 mm Hg): -60°C (-76°F)
 - 3) Specific gravity (water = 1): Liquid = 1.54
 - 4) Vapor density (air = 1 at 15°C (59°F)): 1.189
 - 5) Melting point: -82.4°C (-116°F)
 - 6) Vapor pressure at 25°C (77°F): 20 atm
 - 7) Solubility in water, g/100 g water at 20°C (68°F): 2.9(slight)
 - 8) Evaporation rate (butyl acetate = 1): Not applicable
- Reactivity
 - 1) Conditions contributing to instability: Elevated temperatures may cause containers to burst.
 - 2) Incompatibilities: Contact with strong oxidizers and oxidizing materials may cause fire explosions. Hydrogen sulfide attacks many metals, which results in the formation of sulfides.
 - 3) Hazardous decomposition products: Toxic gases and vapors (such as sulfur oxides) may be released in a fire involving hydrogen sulfide.
 - 4) Special precautions: Liquid hydrogen sulfide will attack some forms of plastics, rubber, and coatings.
- Flammability
 - 1) Hydrogen sulfide is a flammable gas
 - 2) Autoignition temperature: 260°C (500°F)
 - 3) Flammable limits in air, % by volume: Lower 4.3; Upper 46
 - 4) Extinguishant: Alcohol foam, carbon dioxide
- Warning properties
 - 1) Odor threshold: According to the AIHA Hygienic Guide, hydrogen sulfide can be recognized by the "sense of smell" at low concentrations. Odor not reliable at high concentrations, and olfactory fatigue occurs quickly Threshold is 0.13 ppm. Faint but readily perceptible at 0.77 ppm. Easily noticeable at 4.6 ppm. Strong, unpleasant, but not intolerable at 27 ppm. The Hygienic Guide also states that "olfactory fatigue can occur with(in) 2 to 15 minutes at 100 ppm."
 - 2) Eye irritation level: Grant states that "effects of hydrogen sulfide on the eyes are notable only at sublethal concentrations, so low that they have no discernible systemic effect Typically, workmen exposed to low concentrations of hydrogen sulfide gas... have no sensation of irritation or discomfort for at least several hours, or sometimes for several days while working in the presence of low concentrations. Ocular symptoms generally start after several hours of exposure and may not appear until the patient has finished his work for the day. There is then gradual onset of a scratchy, irritated

sensation in the eyes with tearing and burning Experimentally it is demonstrable that at a concentration of 100 ppm in air an immediate irritation of the eyes and respiratory tract is produced, but conditions responsible for the vast majority of cases of hydrogen sulfide keratoconjunctivitis are those in which the concentration is too low to cause immediate irritation and has toxic effect only after several hours or days of exposure. However, in industries where the concentration is regularly kept below 10 ppm in air, it is rare to have any irritation of the eyes."

The Hygienic Guide states that "50 to 100 ppm causes slight conjunctivitis and respiratory tract irritation after 1 hour."

- 3) Evaluation of warning properties: Since olfactory fatigue occurs at high concentrations, and since the irritant effects are delayed, hydrogen sulfide is treated as a material with poor warning properties.

E.6 Monitoring and measurement procedures

- Eight-hour exposure evaluation

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- Ceiling evaluation

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of hydrogen sulfide. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totaling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- Peak above ceiling evaluation

Measurements to determine employee peak exposure should be taken during periods of maximum expected airborne concentration of hydrogen sulfide. Each measurement should consist of a 10-minute sample or a series of consecutive samples totaling 10 minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- Method

Sampling and analyses may be performed by collection of hydrogen sulfide in an impinger containing an alkaline suspension of cadmium hydroxide, followed by chemical treatment and spectrophotometric analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure hydrogen sulfide may be used. An analytical method for hydrogen sulfide is in the NIOSH Manual of Analytical Methods, 2nd Ed., Vol. 6, 1980 available from the Government Printing Office, Washington, D.C. 20402 (G.P.O.) No. 017-033-00369-6.

E.7 Respirators

- Good industrial hygiene practices recommended that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators also may be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

E.8 Personal protective equipment

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent the skin from becoming frozen from contact with liquid hydrogen sulfide or from contact with vessels containing liquid hydrogen sulfide.
- Any clothing which becomes wet with liquid hydrogen sulfide should be removed immediately and not reworn until the hydrogen sulfide has evaporated.
- Employees should be provided and required to use splash-proof safety goggles where liquid hydrogen sulfide may contact the eyes.

E.9 Common operations and controls

The following list includes some common operations in which exposure to hydrogen sulfide may occur and control methods which may be effective in each case:

Operation	Controls
Liberation from pockets during underground mining operations near sulfide ores	Local exhaust ventilation; respiratory protective devices
Liberation during refining of high-sulfur petroleum	Concentration and recovery of H ₂ SO ₄
Liberation from accumulations of decaying organic matter in sewers and waste waters and tanneries, glue factories, fat-rendering plants, and fertilizer plants	Provide continuous water discharge to sewer and cover and vent waste drains
Liberation as a by-product of dehairing and vent and tanning process	Provide separate sewage lines and cover and waste drains; add neutralizing agents (CaCl ₂) as appropriate; local exhaust ventilation
Liberation during manufacture of viscose rayon	Local exhaust ventilation

Liberation during production of sulfur dyes, carbon disulfide, sulfur, oleum, and thioprene

Local exhaust ventilation or process enclosure

Liberation during vulcanization of rubber during manufacture of coke from coal having high gypsum content

Local exhaust ventilation or process enclosure

Liberation during excavation projects

Respiratory protective equipment

Liberation in closed containers containing organic matter

Respiratory protective equipment

E.10 Emergency first aid procedures

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- Eye exposure

If liquid hydrogen sulfide gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

- Skin exposure

If liquid hydrogen sulfide gets on the skin, immediately flush the contaminated skin with water. If liquid hydrogen sulfide penetrates through the clothing, remove the clothing immediately and flush the skin with water.

If irritation is present after washing, get medical attention.

- Breathing

If a person breathes in large amounts of hydrogen sulfide, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

E.11 Spill and leak procedures

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

- If hydrogen sulfide is spilled or leaked, the following steps should be taken:

- 1) Remove all ignition sources.
- 2) Ventilate area of spill or leak to disperse gas.
- 3) If in the gaseous form, stop flow of gas. If source of leak is a cylinder and the leak cannot be stopped in place, remove the leaking cylinder to a safe place in the open air, and repair the leak or allow the cylinder to empty.
- 4) If in the liquid form, allow to vaporize.

RESPIRATORY PROTECTION FOR HYDROGEN SULFIDE

Condition	Minimum respiratory protection* required above 10 ppm
<i>Gas Concentration</i>	
300 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 300 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive mode. A combination respirator which includes a Type C supplied-air respirator with a full faceplate operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
<i>Fire Fighting</i>	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
<i>Escape</i>	Any gas mask providing against acid gases or hydrogen sulfide. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

E.12 References

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