Lewis Energy Group®

STANDARD OPERATING PRACTICE

Hydrogen Sulfide

Lewis Energy Group
Version 1.4
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Acronyms and Abbreviations

BU	Business Unit
CFR	Code of Federal Regulations
H_2S	Hydrogen Sulfide
IDLH	Immediately Dangerous to Life or Health
LEG	Lewis Energy Group
LRM	Lewis Resource Management
NACE	National Association of Corrosion Engineers
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
PPM	Parts per million
ROE	Radius of Exposure
SCBA	Self Contained Breathing Apparatus
SOP	Standard Operating Practice
SO_2	Sulfur Dioxide
STEL	Short Term Exposure Limit
SWR-36	Statewide Rule 36
TRRC	Texas Railroad Commission

1.0 Purpose and Policy Statement

Lewis Energy Group (LEG) Team Members and contractors who have the potential for occupational exposure to Hydrogen Sulfide (H_2S), must be informed on the hazard levels of H_2S, the requirements for working safely in these environments, and what to do in an H_2S emergency. All Team Members and contractors will receive training if they are working at LEG facilities and properties where H_2S is present. Team Members must adhere to the Hydrogen Sulfide Standard Operating Practice (SOP).

2.0 Applicability

This Standard Operating Practice (SOP) applies to all LEG Team Members and Contractors conducting work at LEG locations and facilities.

3.0 Requirements

3.1 TESTING PROCEDURES

LEG needs to know the H_2S concentration and volume at any given point in their system. A typical well has two sample points- the tubing and the casing. The tubing is the preferred sampling point if there is free gas available. The casing represents an easy sample point in a well without a packer because there is normally free gas available. However, this may not be a valid concentration for flow-line calculations because the casing can behave similarly to a storage tank and concentrations can vary. The casing can be a good sample point, if the well is producing little or no gas through the tubing and the casing produces gas continuously. After each well is tested, the concentration in each flow line is calculated. Be sure to recalculate at any point where flow lines are connected. When possible, take samples off the hairpin or flow line. Another sampling option is off the crown or swab valve. Measure each storage tank when the tank is at least three quarters full.

All tests should be field tests, as H_2S may impregnate sample containers (i.e. Glass, Plastic, Stainless Steel, etc.). Industry-accepted color metric tubes are approved for storage tanks only**.** The testing instructions vary for various tubes and are provided with each box of test tubes. However, since these tubes are not to be force-fed, it is a good idea to run the gas supply into an open jar or bottle and pull the sample from the bottle at atmospheric pressure. Color metric tubes are not an acceptable means of sampling when calculating the radius of exposure.

3.2 FORM H-9 CERTIFICATE OF COMPLIANCE

A certified operator will comply with the provisions of SWR-36.

1. H-9's are not transferable, each operator must test each lease/gas well or system and file H-9.
    - In triplicate with the district office
    - 30 days prior to commencement of drilling
    - Within 30 days after P-4 certificate of transfer
2. New/amended H-9 filed if change in public exposure.

3. Signed by a person trained, experienced, and qualified to make the certification.

3.3 MATERIALS AND EQUIPMENT

Sulfide stress cracking is a result of metals subjected to high stress levels in a corrosive environment where H_2S is present. The metal will often fail catastrophically in a brittle manner. This phenomenon is a function of metal chemical composition and hardness; heat treatment and microstructure; and pH, H_2S concentration, stress, and temperature. It is also a function of material handling, new construction, or modification of facilities (including materials and equipment used in drilling and workover operations. Therefore, the metal components shall be those metals selected and manufactured to be resistant to H_2S stress cracking under the operating conditions for their intended use, provided they satisfy requirements described in the latest editions of the National Association of Corrosion Engineers (NACE) Standard MR-01-75 and American Petroleum Institute (API) RP-14E, Sections 1.7(C), 2.1(C), 4.7.

Materials that are not susceptible to sulfide stress cracking (i.e. fiberglass and plastics) may be used in H_2S service if such materials have been manufactured and inspected to satisfy the latest published and applicable industry standard specifications or recommended practices.

3.4 RADIUS OF EXPOSURE

A radius of exposure (ROE) will be determined for all facilities, other than storage tanks, that have a concentration of 100 parts per million (ppm) or greater. The ROE, defined in SWR-36, is the distance surrounding a possible or potential leak site where the concentration of 100 ppm or 500 ppm (depending on which radius is being calculated) will remain at a constant level for a 24-hour period by way of continuous emission.

For wells drilled, completed, recompleted, worked over, or serviced in an area with insufficient data (but could reasonably be expected to have H_2S concentrations over 100 ppm), a 100 ppm ROE equal to 3,000 feet is assumed.

3.5 CONTROL AND SAFETY

According to SWR-36, if there is a 100 ppm ROE in excess of 50 feet that penetrates a public area, or a 100 ppm ROE equal to or greater than 3,000 feet, an automatic leak-detecting device or safety procedure is required. The rule does not specify the type or number of equipment required. Operators should comply with the intent of SWR-36 to prevent the undetected, continuous escape of H_2S, using safety control, monitors, or safety procedures. Each system is subject to evaluation by the appropriate TRRC district office. If a release of H_2S gas occurs and the area has been evacuated, location entry and re-entry will require air sampling and monitoring.

3.6 WARNING AND SECURITY

The signs and fencing requirements of SWR-36 reside under Section (c) (6) (A) and Section (c) (6) (B) of the TRRC regulations. For facilities that have a 100 ppm ROE in excess of 50 feet, there must be warning signs at the facility and on all access roads.

The sign must say **"CAUTION"** and **"POISON GAS"** and it must comply with the standards as indicated in the rule. The standard requires the coloring on the sign to be **black** and **yellow** and the size of the lettering to be large enough to read from a reasonable distance.

An unattended facility must also be fenced and locked if it is within city limits or within a quarter mile of a dwelling, place of business, hospital, church, school, government building, school bus-stop, public park, city, town, village, or similarly populated area. Specific fencing requirements will be satisfied on a case-by-case basis as determined by the TRRC district office.

Storage tanks that contain an H_2S concentration in excess of 500 ppm are subject to SWR-36. Storage tanks do not require an ROE calculation; however, a warning sign must be posted within 50 feet of the facility indicating a potential danger.

During drilling or workover operations, display work condition signs and/or flags at the lease entrance depicting the status of any danger associated to H_2S.

3.7 CONTINGENCY PLAN

Applicable Business Units (BUs) will develop a contingency plan (Appendix B – sample) for alerting, responding to, and protecting the public, following a release of potentially hazardous volume of H_2S gas. The plan is required for any operation with an H_2S concentration of 100 ppm ROE in excess of 50 feet includes any public area, an H_2S concentration of 500 ppm ROE greater than 50 feet that includes any public road, or an H_2S concentration of 100 ppm ROE greater than or equal to 3000 feet. Contingency Plans must be available to all personnel on location. All Team Members at the work location must become familiar with the plan and sign an acknowledgement form (Appendix B). The plan must include actions taken prior to a planned release of H_2S, gas or an unexpected detected release by H_2S gas detection equipment. The plan must also include:

1. Emergency contact numbers
2. The location of public areas in the ROE
3. Personnel accountability
4. Escape routes which are drawn on location maps and diagrams
5. Control measures
6. Supervisor notification
7. Public official notification (made by management)

3.8 RAILROAD COMMISSION NOTIFICATION

The BU Manager will make immediate notification to the appropriate TRRC district office if any accidental release of H_2S gas of sufficient volume presents a hazard or if any H_2S gas related accident has injured an employee or a member of the public. In addition, a 12-hour advance notification of an intentional release, or as soon as possible after an unplanned intentional release in an emergency, is required should the contingency plan be activated. A written report must be sent to the appropriate TRRC district office within 10 days of the incident.

3.9 WORKING IN H_2S ENVIRONMENTS

All personnel who work or enter an H_2S location will receive training which must be kept current (within 1 year). During training, discuss the following safe work practices and enforcement:

1. No smoking, except in designated areas.
2. Immediately dangerous to life or health (IDLH) environments (100 ppm or greater) require a buddy system.
3. All personnel will receive medical approval to wear a respirator, fit tested, and demonstrate proficiency when using emergency breathing equipment.
4. A contingency plan outlining the requirements, procedures and instructions at an H_2S location.
5. Worker permissible exposure limit (PEL) is 10 ppm per 8-hour workday.
6. Worker short-term exposure limit (STEL) is 15 ppm for 15-minute, 4 times per day during an 8-hour workday must be 1-hour between each 15-minute exposure.
7. Regular equipment inspections: valves, flare systems, connections, monitoring instrumentation.
8. Planned escape routes will have at least 2 routes of escape (preferably roads). Escape crosswind then upwind from the H_2S source.
9. There should be at least one person on location at all times with CPR/First Aid certification (recertification every two years).
10. Visitors must provide proof of current H_2S training prior to entering an H_2S location.
11. Awareness of wind direction (windsocks), personal gas monitoring devices, briefing areas, and fixed H_2S alarms.
12. Confined space entry procedures must be defined (must meet Occupational Safety and Health Administration (OSHA) 1910.146 requirements); all personnel who enter confined spaces will be properly trained.

3.10 PERSONAL PROTECTIVE EQUIPMENT (PPE)

Only a positive-pressure, self-contained breathing apparatus (SCBA) or positive-pressure airline unit with an emergency egress bottle will be used in any known or suspected H_2S gas environment of 10 ppm or greater in the breathing zone. LEG prohibits the use of canister-type, air-purifying respirators when working in H_2S environments.

Respirator wearers requiring corrective eyewear will be fitted with spectacle kits according to the respirator manufacturer at no expense to the employee. Respirators and their components shall not be interchanged. Each respirator wearer will complete Respiratory Protection training and a Respirator Fit Test after receiving a medical clearance and before entering any H_2S gas location.

4.0 Responsibilities

The BU Managers and Supervisors responsibilities include:

1. Adhere to the H_2S contingency plan(s)
2. Provide the appropriate H_2S gas monitors for Team Members
3. Ensure H_2S gas monitoring is being conducted

4. Ensure feasible engineering controls are being utilized (i.e. metallurgy, flare systems, etc.)
5. Ensure H_2S source identifying surveys are conducted
6. Require LEG Team Members and contractors to meet training requirements
7. Ensure Team Member compliance with the program
8. Require H_2S gas monitoring equipment to be inspected and calibrated
9. Ensure all H_2S locations have signage to alert personnel and wind socks to indicate wind direction

The LEG Team Members responsibilities include:

1. Comply with the procedures outlined in this SOP and the required training

Note: Verify these responsibilities during a BU audit.

4.1 TRAINING

Personnel who work in areas where potential for H_2S exposure exists shall receive training that includes the following topics:

1. Hazards, characteristics, properties, and sources of H_2S and Sulfur Dioxide (SO_2)
2. Proper use of H_2S gas detectors and monitoring equipment
3. Symptoms of overexposure to H_2S gas
4. First aid administration for H_2S victims
5. Proper selection, use, and maintenance of respiratory protection equipment
6. Safe work procedures and precautions
7. Wind direction awareness and routes of egress
8. Job hazards identification
9. Effects of H_2S exposure on equipment (corrosion, hydrogen embrittlement, etc.)
10. Confined space entry procedures
11. Emergency procedures

Note: A comprehensive examination administered after the training class is mandatory.

5.0 Recordkeeping

Maintain records of training, equipment calibration, H_2S Concentration surveys, exposure monitoring, and notification to affected personnel (in accordance with applicable laws/regulations and manufacturer recommendations):

1. Training – signed documentation of annual training by the Safety Department, filed in Skill-soft
2. Equipment calibration and inspection – documentation of equipment calibration and inspection at the BU field office
3. H_2S concentration surveys – documented when a well is drilled, at gas delivery point prior to sales, and hazard assessment at facilities where H_2S is present

4. Exposure Monitoring - documentation of exposure monitoring of personnel at the Safety Department. Records retained 30 years following the duration of employment of individuals monitored.

Note: When personnel no longer work for LEG, records may be stored off-site, for archive purposes.

6.0 Document Control

Version	Change Date	Change Description	Changed by	Approved by	Approval Date
1.1	10/9/19	Update H2S PS and add new title page	Colin Clark	Ken Phillips	10/9/19
1.2	10/17/19	• Update TOC • Change Attachment to Appendix • Add Header	Colin Clark	Ken Phillips	10/17/19
1.3	10/22/19	• Changes per Wes Sharples: • 2.0 to all TMs and Contractors • 3.3 add therefore • 4.0 #6 correct to TM/Contractors • 5.0 add in accordance	Colin Clark	Ken Phillips	10/22/19
1.4	5/29/24	Review Only – No Changes	Colin Clark	Ken Phillips	

NOTE: A Sub-Committee will review all changes to this document and the Executive Safety Committee will make final approval. Add all document revisions to the Document Review Change Log. Keep this form current to maintain audit compliance.

7.0 Definitions

Acute Exposure – an acute exposure usually refers to single incident of short duration exposure with effects that are immediate and severe.

Administrative Controls – focus on reducing worker exposure and reducing hazards through training, planning and scheduling, information sharing, policies, procedures, work instructions, safe work practices, and environmental and medical surveillance.

Breathing Zone – a space forward of the shoulders with a radius of 6 to 9 inches.

Buddy System – an individual trained and qualified for rescue and retrieval to provide "stand-by service" for individuals working in IDLH atmospheres.

Bump Test – the process that verifies the performance of the gas detector and ensures that sensors are responding to their target gas.

Calibration – an instrument's measuring accuracy relative to a known traceable concentration of test gas.

Chronic Exposure – prolonged exposure to toxic substances gradually introduced in to the body by means of absorption through the skin, inhalation by the mucous membranes, or ingestion (swallowing) of food and/or drink inadvertently contaminated by physical handling.

Contingency Plan – an organized plan of action for alerting and protecting the public within an area of exposure prior to an intentional release or following the accidental release of a potentially hazardous volume of H_2S gas.

Engineering Controls – remove hazards by applying methods that eliminate, substitute, isolate and ventilate.

Flaring – the burning of natural gas that cannot be processed or sold. Flaring disposes of gas, but can also emit other gases into the atmosphere during the combustion process.

Gas Detection – a means to detect the presence of gases in an area, often as part of a safety system. This type of equipment can detect a gas leak or other emissions and can interface with a control system to shut a process down. A gas detector can sound an alarm to personnel in the area where the leak is occurring, giving them an opportunity to leave.

H-9 Certificate of Compliance – certify that operator has complied, or will comply, with applicable provisions of SWR-36. The certificate of compliance shall certify existing operations subject to this rule to be in compliance, will be in compliance as specified in an attached schedule, or for new or modified facilities, will be in compliance upon completion.

Hydrogen Sulfide (H_2S) – a colorless, extremely poisonous gas that has a very disagreeable odor, much like that of rotten eggs at low concentrations, but deadens the sense of smell at higher concentrations. In dangerous concentrations, it is extremely corrosive and poisonous, causing damage to skin, eyes, breathing passages, and lungs and attacking and paralyzing the nervous system, particularly that part controlling the lungs and heart. H_2S gas is flammable; in an excess of air it burns to form SO_2.

Immediately dangerous to life or health (IDLH) – an atmospheric concentration of any toxic, corrosive, or asphyxiate substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individuals' ability to escape from a dangerous atmosphere. The IDLH for H_2S gas is a concentration of 100 ppm.

Parts per Million (ppm) – parts of vapor or gas per million parts of contaminated air by volume

Permissible Exposure Limit (PEL) – the maximum exposure amount or concentration of a chemical or agent for workers. The PEL can be based on either a time-weighted average (8 hours), or the maximum exposure limit described by the regulation.

Personal H_2S gas monitor – personal H_2S gas monitors alarm at predetermined set points–one at a low level and another at a high level. The monitor alarm level must be low enough to satisfy the strictest applicable safety standard. Personal H_2S gas monitors have an audible and visual alarm.

Personal Protective Equipment (PPE) – any barrier worn on the body to reduce or control a hazard and determined by specific job and potential hazard. PPE is required when engineering or administrative controls fail to mitigate the hazard.

Public Area – a dwelling, place of business, church, school, hospital, school bus stop, government building, public road, all or any portion of a park, city, town, village, or other similarly populated area

Radius of Exposure (ROE) – the distance surrounding a possible or potential leak site where the concentration of H_2S gas is 100 or 500 ppm (depending on which radius is calculated) that will remain at a constant level for a 24-hour period by way of a continuous emission. For a well drilled, completed, recompleted, worked over or serviced in an area where insufficient data exists to calculate a radius of exposure, but where H_2S can be present in concentrations in excess of 100 ppm in the gaseous mixture, assume a 100 part per million (ppm) radius of exposure equal to 3000-feet.

Self-Contained Breathing Apparatus (SCBA) – air supplied to a full-face mask from a cylinder worn by the worker which gives greater movement than an airline respirator. The air supply is limited.

Short Term Exposure Limit (STEL) – the exposure limit that is acceptable for a short time-period, typically 15 minutes. This limit represents the maximum concentration for worker exposure over the time-period without incurring health or safety risks.

Venting – the process of discharging a material to the atmosphere through a series of piping and/or venting devices to facilitate the proper and safe dispersion of toxic materials and to minimize personnel exposure

APPENDICES

APPENDIX A - CHARACTERISTICS OF H_2S

APPENDIX B - PHYSICAL EFFECTS OF HYDROGEN SULFIDE

APPENDIX C - TOXICITY OF VARIOUS GASES

APPENDIX D – COMPLIANCE REQUIREMENTS DRILLING AND PRODUCTION

APPENDIX E – SAMPLE CONTINGENCY PLAN AND ACKNOWLEDGEMENT FORM

APPENDIX A - CHARACTERISTICS OF H2S

1. Colorless gas at room temperature
2. Boiling point = -76˚F (-60˚C)
3. Soluble in liquid
4. Density = 1.19 X Air (Heavier than air)
5. Ignition temperature = 500˚F (260˚C)
6. Flame is practically invisible
7. One combustion by-product is SO_2, which is also toxic
8. Explosive at mixtures between 4.3% and 46%
9. Noxious at low concentrations (smells similar to rotten eggs)
10. Corrosive to high carbon steel

APPENDIX B - PHYSICAL EFFECTS OF HYDROGEN SULFIDE*

Concentration			Physical Effects
Percent (%)	**PPM**	**Grains/100 std. ft3****	
0.001	10	.65	Obvious and unpleasant odor. Safe for 8 hours exposure
0.01	100	6.48	Kills smell in 3 to 15 minutes; may sting eyes and throat.
0.02	200	12.96	Kills smell shortly; stings eyes and throat.
0.05	500	32.96	Dizziness; breathing ceases in a few minutes; need prompt respiration.
0.07	700	45.36	Unconscious quickly; death will result if not rescued promptly.
0.10	1000	64.80	Unconscious at once; followed by death within minutes.

***Caution:** Hydrogen sulfide is a colorless and transparent gas and is flammable. It is heavier than air and may accumulate in low places.

****At** 15.00 psia and 60˚F

APPENDIX C - TOXICITY OF VARIOUS GASES

Common Name	Chemical Formula	Specific Gravity	Threshold Limit[1]	Hazardous Limit[2]	Lethal Concentration[3]
Hydrogen Cyanide	HCN	0.94	10 ppm	150 ppm per hour	300 ppm
Hydrogen Sulfide	H_2S	1.19	10 ppm[4] 20 ppm[5]	250 ppm per hour	600 ppm
Sulfur Dioxide	SO_2	2.21	5 ppm		1,000 ppm
Chlorine	CL_2	2.45	1 ppm	4 ppm per hour	1,000 ppm
Carbon Monoxide	CO	0.97	50 ppm	400 ppm per hour	
Carbon Dioxide	CO_2	1.52	5,000 ppm	5%	10%
Methane	CH_4	0.55	90,000 ppm	Combustible above 5% in air	

Threshold Limit[1] — Concentration that all workers may be repeatedly exposed day after day without adverse effects.

Hazardous Limit[2] — Concentration that may cause death.

Lethal Concentration[3] — Concentration that will cause death with short-term exposure.

APPENDIX D: COMPLIANCE REQUIREMENTS

Rule 36 Compliance Requirements – Drilling & Production			
Provision	**Case 1**	**Case 2**	**Case 3**
H_2S Concentration Test	X	X	X
H-9 Certification of Compliance	X	X	X
Training	X	X	X
District Office Notification	X	X	X
Drill Stem Tests Restricted	X*	X*	X
BOP Test	X*	X*	X
Materials		X	X
Warning and Marker		X	X
Security		X	X
Contingency Plan			X
Control and Equipment Safety			X
Monitors		X**	X**
Mud (ph control or Scavenger)			X*
Wind Indicators		X**	X
Protective Breathing Equipment		X**	X
Choke manifold, Secondary Remote Control, and Mud-gas separator.			X
Flare Stacks			X*

Case 1: 100 ppm ROE is < 50'

Case 2: 100 ppm ROE ≥ 50' but < 3,000' & No Public Area.

Case 3: 100 ppm ROE ≥ 50' & Public Area; or 500 ppm ROE contains a public road; or 100 ppm ROE ≥ 3,000'.

*Requirements for District 5&6 only.

**Requirements for Drilling and Workover Operations.

APPENDIX E: SAMPLE CONTINGENCY PLAN

Business Unit:	**Date:**
Facility/Location:	**H_2S Concentration:**

Objective:

Individual Responsibilities

All personnel:

1. Responsible for his/her assigned safety equipment.
2. Responsible for familiarizing himself how to use safety equipment.
3. Responsible for reporting any indications of H_2S to those in the area and to a supervisor

Location Supervisor:

1. Responsible for controlling the scene and preventing entry by nonessential personnel.
2. Responsible for implementing all phases of this contingency plan.
3. Responsible for minimum personnel on the location during expected hazardous operations.
4. Responsible for coordinating all site operations and communications in the event that an emergency condition develops.
5. Responsible for ensuring that all essential visitors receive an H_2S orientation, maintain a log for all personnel on the location.

Location Layout:

A. The location of at least two pre-determined safe areas to assemble at in the event of an emergency. These locations should be located 180 degrees to one another, and adjusted to direction of the prevailing winds.

Safe Area location: Safe Area Location:

B. **H_2S monitors**:

Type: Location:

Type: Location:

C. Respiratory Protection:

Type: Location:

Type: Location:

D. Windsocks:

Location: Location:

E. Safety Equipment:

1.
2.
3.
4.

F. Communications:

G. Warning Signs:

Operating Conditions:

A. **Normal Operating Conditions**
Potential Danger, Operations Under Control

Characterized by: Normal operations and test operations in areas which contain, or may contain H_2S. No detectable gas present.

General Action:

(1) Know location of safety equipment.

(2) Check safety equipment for proper function. Keep it available.

(3) Be alert for a condition change.

(4) Follow instructions of the supervisor.

B. Potential to Moderate Danger to Life

Characterized by: H_2S gas present. Concentration less than 10 PPM.

Probable Cause(s):

C. Moderate to Extreme Danger to Life

Characterized by: H_2S present in concentrations at or above 10 PPM. Critical operations.

Probable Cause(s):

General Emergency Action(s):

1. Put on respiratory protection. Move to **"SAFE BRIEFING AREA"** and remain there if not working to correct the problem.
2. Follow instructions of Supervisor.
3. The Supervisor will initiate emergency action(s) provided in the contingency plan and as appropriate to the actual conditions.
4. The Supervisor will conduct any necessary operations with an absolute minimum of personnel. All persons in the immediate area will wear respiratory protection. All other personnel will restrict their movements to those directed by the supervisor.
5. Ignition of H_2S gas produces SO_2, which is toxic.

Emergency Procedures:

1. Instructions/procedures for alerting public/safety personnel:

2. Procedures for requesting assistance to evacuate public:

3. Call List:

- Railroad Commission District 1,2: Wesley Dresch 210-227-1313
- Railroad Commission District 4: Rick Silguero 361-242-3113
- Residents in Radius of Exposure:
- Life Flight/Hospital:
- Sheriff's Department:
- Contract Companies:
- Department of Public Safety:

Plat Detailing Area of Exposure:

Provisions for Advance Briefing of the Public:

Person Completing Contingency Plan:

Acknowledgement Form:

By my signature below, I acknowledge that I have read and understand the contingency plan for _____ facility/location.

Print Name	Signature	Company/Department	Date