APPENDIX E

OPERATION, MAINTENANCE, AND INSPECTION PLAN

Operation, Maintenance, and Inspection Plan

The Big Still Oil Treatment Facility

Lea County, New Mexico

C-137 Surface Waste Management Facility Application

May 2025

Prepared for:

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OPERATION, MAINTENANCE AND INSPECTION PLAN
THE BIG STILL OIL TREATMENT FACILITY

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1.0 INTRODUCTION

The Moonshine Energy, LLC Big Still Oil Treatment Facility (Facility) is a proposed surface waste treatment facility which will be constructed and operated in accordance with New Mexico Oil Conservation Division (NMOCD) regulations as outlined and defined in 19.15.36 New Mexico Administrative Code (NMAC). The purpose of the facility will include processing tank bottoms, produced water, or other hydrocarbons from oil and gas operations to separate usable hydrocarbon material for sale and processing. No solid waste, contaminated media, or other hazardous materials will be accepted or processed at the Facility.

1.1 Purpose

The following document comprises the Operation, Maintenance, and Inspection Plan (OMI) for the Facility. This document is intended to comply with applicable requirements of 19.15.36 NMAC. This OMI presents site specific methods, best management practices (BMPs) and procedures by which the Facility will address, maintain, and document compliance and regulatory requirements applicable to the construction, operation, and maintenance of the Facility in a manner which ensures protection of fresh water, public health, and the environment in accordance with 19.36.15.8C(7) and 19.36.15.8C(14). This OMI should be used in conjunction with the current NMAC and NMOCD rules.

1.2 Facility Description

The proposed Facility will be located near mile marker 37.3 on New Mexico Highway 128, approximately 15 miles west of the City of Jal, New Mexico. The property is located within Township 24 South, Range 34 East, Section 25, and consists of a 5.4± acre parcel leased to Moonshine Energy, LLC. The facility will utilize the entire parcel, and will consist of a fenced, cleared and leveled area with caliche surface cover allowing for access and maneuvering of large trucks and equipment. Three tank batteries will be located on the facility for processing tank bottoms, hydrocarbons, or produced water delivered to the facility. Two tank batteries, located in the west-central portions of the property, will be used for the receipt of waste and for storage of reclaimed hydrocarbons prior to sale. Each of the two batteries will consist of ten (10) 500 barrel (bbl) (21,000 gallon) capacity steel frac tanks, situated within a secondary containment area constructed of 3-foot steel walls lined with a with a 40-mil High Density Polyethylene (HDPE) liner to prevent release of any spilled material. An additional tank battery consisting of four (4) 750 bbl (31,500 gallon) fiberglass tanks situated within secondary containment (also steel walls with a 40-mil HDPE liner) will be located on the southeast portion of the Facility and be utilized to store separated water until it is removed for disposal. The Facility will have two skid-mounted modular buildings to function as an office/gate house and personnel facilities. The Facility will be staffed by at least one operator during all periods of operation.

2.0 OPERATION PROCEDURES

This OMI presents site specific methods and procedures the Facility will maintain and document compliance, and address the regulatory requirements applicable to the construction, operation, and maintenance of the Facility. The OMI is developed in accordance with the requirements of 19.15.36 NMAC and will be updated as required to reflect current operations and regulations. All operations at the Facility will be conducted in accordance with this OMI, as well as other associated and referenced Plans specifically developed for the Facility, including:

- Emergency Contingency Plan
- H_2S Contingency Plan
- Waste Management and Exclusion Plan

2.1 Facility Process

The Facility will operate 24 hours a day/7 days a week, and is expected to receive approximately 6,000 bbls of material each day.

Waste at the facility will be managed utilizing the processes outlined in the Facility's Oilfield Waste Management Plan. Prior to acceptance, waste will be screened/tested and properly manifested for record-keeping and handling requirements. Waste delivered to the facility will flow through offload hoses directly into one of the ten (10) 500-barrel BS&W frac tanks located in the northern battery to begin the separation process. Fluid in the frac tanks will remain undisturbed for several hours to facilitate separation of water, oil, and emulsion. Once the separation process has been completed, the separated hydrocarbons/oil will be transferred via vacuum truck to one of the ten (10) 500-barrel oil frac tanks located in the southern frac tank battery. Separated water will be transferred via vacuum truck to one of the four (4) 750-barrel fiberglass tanks located on the southeast portion of the property. All material transfers, including any material delivered to frac tank or separated water tank batteries, will utilize transfer hoses equipped with secondary containment Pollution Control Corporation (PCC) connectors to minimize potential for spills or releases.

When sludge buildup in the tanks reaches 12 inches, the tanks will be emptied to remove the sludge. Sludge buildup will be measured using a rod or probe with thickness indicators that is placed into the tank during periodic visual inspections (Section 4.2, Table 3 below) which are conducted either monthly or after emptying of the tank Vacuum trucks will be used to remove the sludge from the tanks and will transport the sludge off-site to an approved waste management facility for disposal. All non-processed waste at the facility will be removed by licensed, permitted haulers for disposal at an appropriately permitted facility.

The use of secondary containment around all tank batteries and PCC secondary containment connectors for offloading hoses are best management practices (BMPs) which will help minimize the risk of a hydrocarbon release during unloading and transfer operations at the facility.

Secondary containment areas will be inspected on a daily schedule (see Table 3 below) to check for visible evidence of leaks and the presence of standing water. Standing water which does not readily evaporate will be removed via vacuum truck. Water with a visible sheen will not be discharged onto the ground surface and will be transported off the Facility via tanker or vacuum truck to be properly disposed of as oilfield exempt waste.

2.2 Waste Acceptance

The Facility will treat and or dispose of eligible Oil Field Wastes including tank bottoms and other hydrocarbon wastes generated in connection with the exploration, development, and production of oil or gas or geothermal resources. Other hydrocarbon wastes include, but are not limited to, pit hydrocarbons, skim oil, spillage, and leakage of crude oil or condensate from producing lease or pipeline storage tanks, and crude oil or condensate associated with pipeline ruptures and other spills. It is anticipated that the facility will accept 6,000-barrels of tank bottoms and other hydrocarbon wastes daily.

A shakeout test shall be conducted on all tank bottoms and other hydrocarbon wastes upon removal from any producing lease tank, pipeline storage tank or other production facility to determine crude oil content and lease condensate thereof. The shakeout test shall be conducted in accordance with the most current American Petroleum Institute (API) or ASTM International method.

Prior to receipt at the site, one grab sample from each 50 cubic yards of waste material from waste hauler truck yards, service companies, commercial oil and gas facilities, and reclamation plants shall be analyzed for either Total Organic Halides (TOX) or Extractable Organic Halides (EOX). Any load with a TOX/EOX reading of 100 ppm or greater will not be unloaded or processed at the facility.

Each load of incoming waste, other than water-based drilling fluids and associated cuttings, or oil-based drilling fluid and associated cuttings, shall be scanned for the presence of NORM using a scintillation meter with a sodium iodide detector. As detailed in 20.3.14.1403 NMAC, any load with a reading of 50 microroentgens per hour or greater will not be unloaded or processed at the Facility. If the waste generator is able to provide documentation of laboratory analysis that demonstrates that the waste does not exceed 30 picocuries per gram of Radium-226 combined with Radium-228, or 150 picocuries per gram of any other radionuclide, the Facility will then accept the waste. Current calibration records of all NORM screening devices shall be maintained on-site and made available to NMOCD personnel upon request.

2.3 Access Control and Requirements

In accordance with 19.15.36 NMAC, facility operators must prevent unauthorized access by the public and entry by large animals to the Facility's active portion through the use of fences, gates, locks, cattle guards, or other means that attain equivalent protections. The Facility has only one public access for the vehicle traffic located on the northeast portion of the facility boundary. The entrance gate is locked during non-operating hours to prevent illegal access to the Facility. At the entrance gate, a sign that is readable from a distance of 50 feet will be posted indicating the operator's name, the Facility permit number, the Facility location by unit (section, township, and range), and emergency telephone numbers.

The Facility will have an appropriately sized fence installed around the perimeter of the Facility to control unauthorized access. A manually locked gate will be located at the entrance of the Facility that can only be opened by Facility personnel and local Emergency Departments. Public traffic is prohibited from entering the Facility property boundary. A site plan with the facility layout is included as Figure 2.

All storage and processing tanks within the Facility are completely enclosed with no open tops. As such, no additional controls are proposed to protect migratory birds or other wildlife, as required by 19.15.36.13.I NMAC.

2.4 Traffic Control

To prevent unnecessary traffic in and around the Facility, trucks will be directed to the appropriate frac tank Facility personnel and will follow traffic routes indicated on Figure 2. It is anticipated that between 12-25 trucks will enter and exit the facility each day (24-hour operations).

Trucks will enter the facility from New Mexico State Highway 128, which is a 2-lane highway with no shoulder. No turning lane is present on NM-128 near the Facility. All truck will enter through the single access gate on the northeast portion of the Facility and then check in with the on-site operators at the Facility gate house/office. The operators will then direct the vehicle to the appropriate tank battery for unloading or loading. The vehicles will exit the property through the same entrance.

2.5 Personnel and Equipment Requirements

Facility personnel and their roles, as well as heavy equipment which will be utilized on site are summarized in Table 1 below. A trained Facility Operator will be present at the Facility at all times of operation. The Facility Training program which all personnel will be required to complete is summarized in Section 3.0.

TABLE 1. FACILITY PERSONNEL AND EQUIPMENT
Big Still Oil Treatment Facility

Personnel/Equipment	Quantity	Purpose
Personnel		
Operations manager / Supervisor	1	Complete the required paperwork associated with management of the Facility and assist operators as needed
Vacuum Truck/Equipment Operators	1	Perform operations of oil field waste receipt, including directing waste placement, operating vacuum trucks, and general facility maintenance
Equipment		
Vacuum Truck	1	Utilized to transfer materials between on-site tank storage

2.6 Litter, Odor, Noise, and Dust Control (Nuisance Avoidance)

To prevent the Facility from becoming a public nuisance or public health hazard, procedures will be implemented to ensure compliance with 19.15.36 NMAC. These procedures include dust and odor control, litter control, and general Facility maintenance which are implemented as BMPs to help maintain public health and the environment.

The Facility will only accept liquid, suspended, or emulsified waste which can be transferred through enclosed tanks and the use of hoses, and therefore does not expect to accept waste which can result in blowing litter. In the event litter becomes a problem on the site, temporary litter collection teams will be deployed to collect litter which has left the operations area.

Odor impacts are also expected to be limited as wastes accepted at the facility will be transferred directly from tanker trucks to covered frac tanks. The location of the Facility, away from potential receptors, will limit exposure to any odors resulting from H_2S or associated gases.

As with odor, impacts from noise are not expected as the Facility is located in an isolated area with no nearby residential or commercial receptors (i.e. the closest residence is over five miles away). Further, the general nature of Facility operations should not produce significant potential impacts outside of road noise already associated with State Highway 128.

Blowing dust is expected to be minimal – caliche will be placed in trafficked areas of the facility and all equipment within the facility will be traveling below 10 mph. In the event blowing dust from trucks or equipment becomes a problem, the Facility may treat the area with water from a water truck to minimize dust generation.

2.7 Emergency Fire or Spill Responses

Facility personnel will be trained to respond to emergencies, including fires, spills, or gas releases. A table of emergency contacts and response coordinators is included as Table 2.

TABLE 2. LIST OF EMERGENCY COORDINATORS
The Big Still Oil Treatment Facility

Primary Emergency Coordinator			
Name:	Calvin Brown		
Title:	Big Still Facility Manager	Mobile/Home Phone:	575-361-2730
Address:	491 Scarlet Ct., Canyon Lake, TX		
Alternate Emergency Coordinator			
Name:	Allen Mosig		
Title:	Facility Operator	Mobile/Home Phone:	432-241-7061
Address:	3206 Ma Mar Ave. Midland, TX 79705		
Alternate Emergency Coordinator			
Name:	Michael McCurdy		
Title:	Regional Manager	Mobile/Home Phone:	432-312-5251
Address:	2004 Humble Ave. Midland, TX 79705		

Releases and spills may occur from on-site tanks or from hoses/connections during loading/unloading operations. Details on proposed responses to fire, spills, or releases to soil, groundwater, or surface water are detailed the Facility Contingency Plan. Details on responses to a release of hydrogen sulfide gas (H_2S) are included in the H_2S Contingency Plan. All materials resulting from a cleanup will be disposed of at permitted facilities in accordance with the Facility Waste Management Plan.

Emergency Equipment, including fire extinguishers and spill response kits, are maintained at several locations throughout the Facility.

2.8 Groundwater or Vadose Monitoring

As no lined pits, ponds, or pools are utilized at the Facility and groundwater is present at a depth of approximately 165 feet as determined by nearby NMOSE well logs, no groundwater or vadose monitoring is proposed to be conducted at the Facility.

3.0 TRAINING PROGRAM

All employees working at the Facility will be required to attend training required for operation and emergency response at the Facility. All personnel will be required to attend training on the following topics:

- Facility Operations, Maintenance, and Inspection (this Plan)
- Waste Management and Exclusion Plan
- Contingency Plan for Emergencies, including:
    - Emergency Assessment
    - Fire Response
    - Spill Response
    - Releases to Air
    - Evacuation Procedures
    - Notification Requirements
- H_2S Contingency Plan, including:
    - Hazards and Characteristics of H2S
    - Proper use and maintenance of personal protective equipment (PPE)
    - Proper use and maintenance of H2S detectors, alarms, warning systems
    - Evacuation Procedures and Facility Operations
- Closure Care Plan (as applicable)
- Conditions specified in the Facility Permit

Training listed above will be completed by all personnel upon hire, and all personnel will be required to attend annual refresher training thereafter. Refresher training will be completed and documented annually in employee files and maintained in facility records for no less than five (5) years.

In addition to training, all facility personnel will be required to participate in quarterly H_2S emergency response drills involving a simulated release of H_2S which would require a facility evacuation.

4.0 FACILITY INSPECTIONS

In accordance with 19.15.36.13 NMAC, a site-specific inspection schedule for the Facility has been developed. Inspection of the Facility, operations, and waste will be carried out on a routine basis and will be conducted as part of the Facility's BMPs to ensure all equipment is operating properly and is in good condition to ensure protection of public health and the environment in accordance with 19.15.36.8.C(14). The inspection schedule will be used in conjunction with the Operation and Maintenance procedures.

4.1 Inspection Record Keeping

Inspections and any required corrective actions or remedy will be documented on the Operations Inspection Checklist Forms, which are provided in Attachment 1. Inspection Forms will be supplemented with photographs as necessary and will be maintained in the Permanent Operating Record (POR) system and will be available at the request of NMOCD. Records of inspection and documentation of any maintenance resulting from the inspections will also be recorded on Inspection Forms. The Inspection Forms will be modified as needed to include all pertinent information. All inspection records and documentation will be placed in the Facility POR.

4.2 Inspection Schedule

Inspections will be performed often enough to identify problems in time to correct them before they harm human health or the environment. Inspections also prevent malfunctions, deterioration, and operator error from affecting the performance of the Facility and operations. In addition to the standard frequency of inspections, the Facility will also be inspected following major storm events or natural disasters. Table 3 below details the inspection and maintenance schedule, and descriptions of inspections and maintenance activities are detailed in Sections 4.3-4.7 below.

TABLE 3. FACILITY INSPECTION SCHEDULE
Big Still Oil Treatment Facility

Site Component	Inspection Frequency	Form
Facility Operations & Infrastructure • Gate/Road Conditions • Presence of Standing Water • Tank Exterior and Tank Secondary Containment • Material Transfer Hoses • Air Quality Monitor Operation • Safety Equipment • Litter/Odors	Daily	Daily Facility Inspection Checklist
General Facility Condition • Fence & Gates Condition • Berm Condition • Road and ground conditions • Sign condition	Monthly or after major storm events	Monthly Facility Inspection Checklist
Tank Conditions & Waste Removal Needs • Secondary Containment & signs of staining • Tank and Transfer Hose Component Inspection • Quantity of solid waste in tanks	Every load removed or monthly if less than one load is produced in a four-week period	Monthly Facility Inspection Checklist
Monitoring & Emergency Response Equipment • Stationary H_2S Monitor Operation • Individual H2S Meters • Fire extinguishers • First aid kits • Spill Kits & PPE • 4-Gas Meter	Monthly Inspection or as needed	Monthly Facility Inspection Checklist See Contingency Plan

4.3 Facility Operations & Infrastructure

All equipment utilized in active facility operations, including exterior of tanks, hoses, secondary containment liners and walls, safety equipment, and ambient air monitors will be inspected daily to minimize the potential for releases, fire, or spills. The facility infrastructure, including roads, fences, and gates, as well as presence of standing water, will also be inspected. Facility personnel will also conduct inspections of the facility to ensure no litter, odors, or other nuisances are being generated.

4.4 General Facility Infrastructure and Condition

In addition to daily checks, more thorough inspections of the Facility's perimeter fencing, gates, locks, access roads, berms, and signage will be conducted monthly and any damages will be repaired as necessary. In the event of a major storm event, additional inspections will be conducted to ensure no damage to the facility infrastructure.

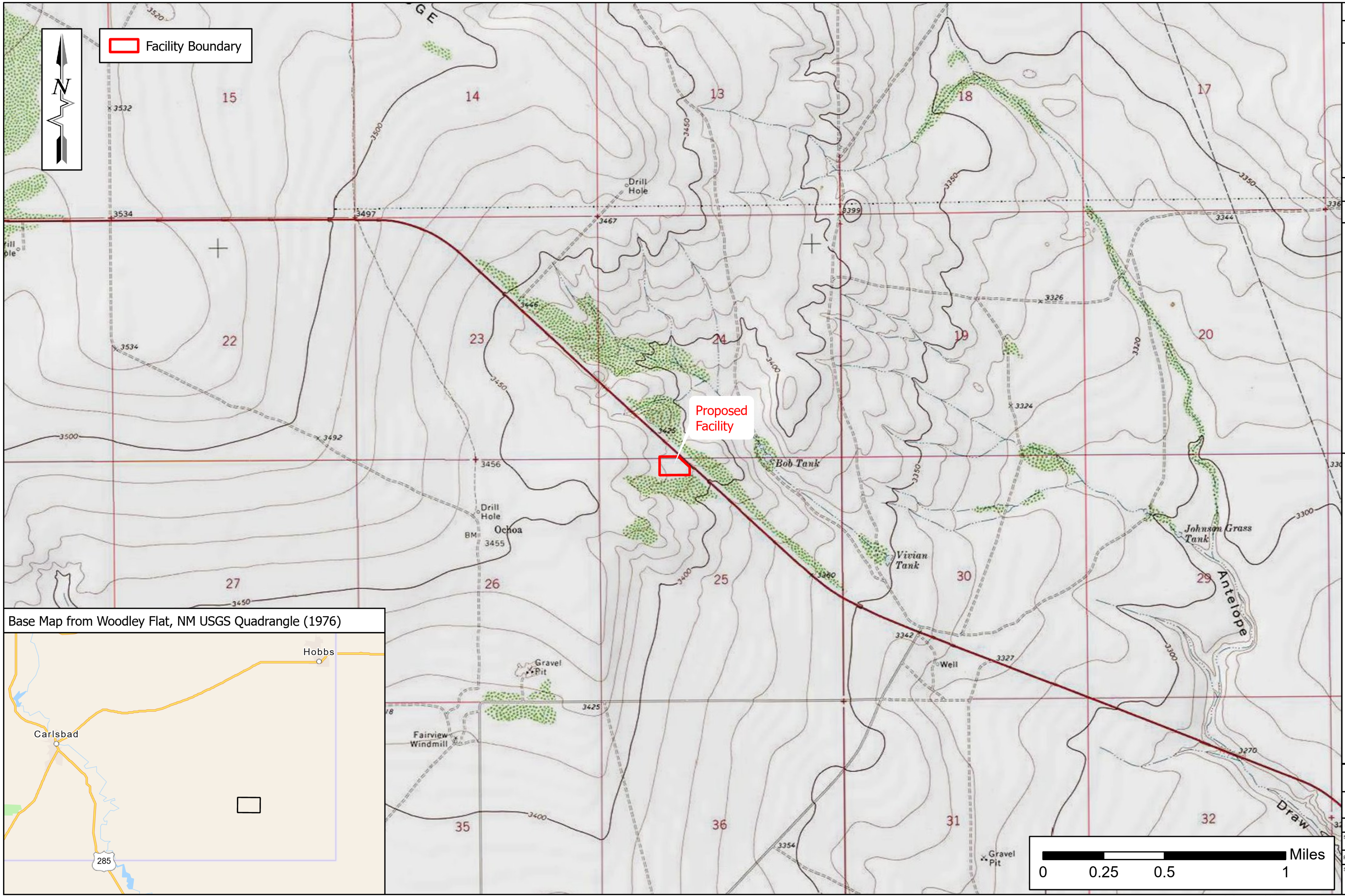
4.5 Tank Conditions and Waste Removal Needs

In addition to more thorough inspections of exterior tank and secondary containment components, the interior of tanks will be inspected when emptied or at not less than monthly frequencies to access condition and quantities of sludge or solids. The tank will be visually inspected through access ports to look for corrosion or damage and to determine if sludge is present within the vessels. If the bottom of the tank cannot be identified visually, the inspector will utilize a rod or probe with markings to measure the quantity of solids at the bottom of the tank. Any tank with over 12-inches of material will have material removed via vacuum truck for disposal.

4.6 Monitoring and Emergency Response Equipment

All stationary H_2S monitors, individual H_2S meters, the 4-gas meter, wind socks, fire extinguishers, first aid kits, and spill response kits will be inspected monthly or as directed by the manufacturer to ensure functionality. Fire extinguishers will be tested annually and inspected monthly.

FIGURES



Rev #	Date	Description	By	Chkd

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MOONSHINE ENERGY, LLC
C-137 APPLICATION

VICINITY MAP ON USGS QUADRANGLE THE BIG STILL WASTE FACILITY LEA COUNTY, NM

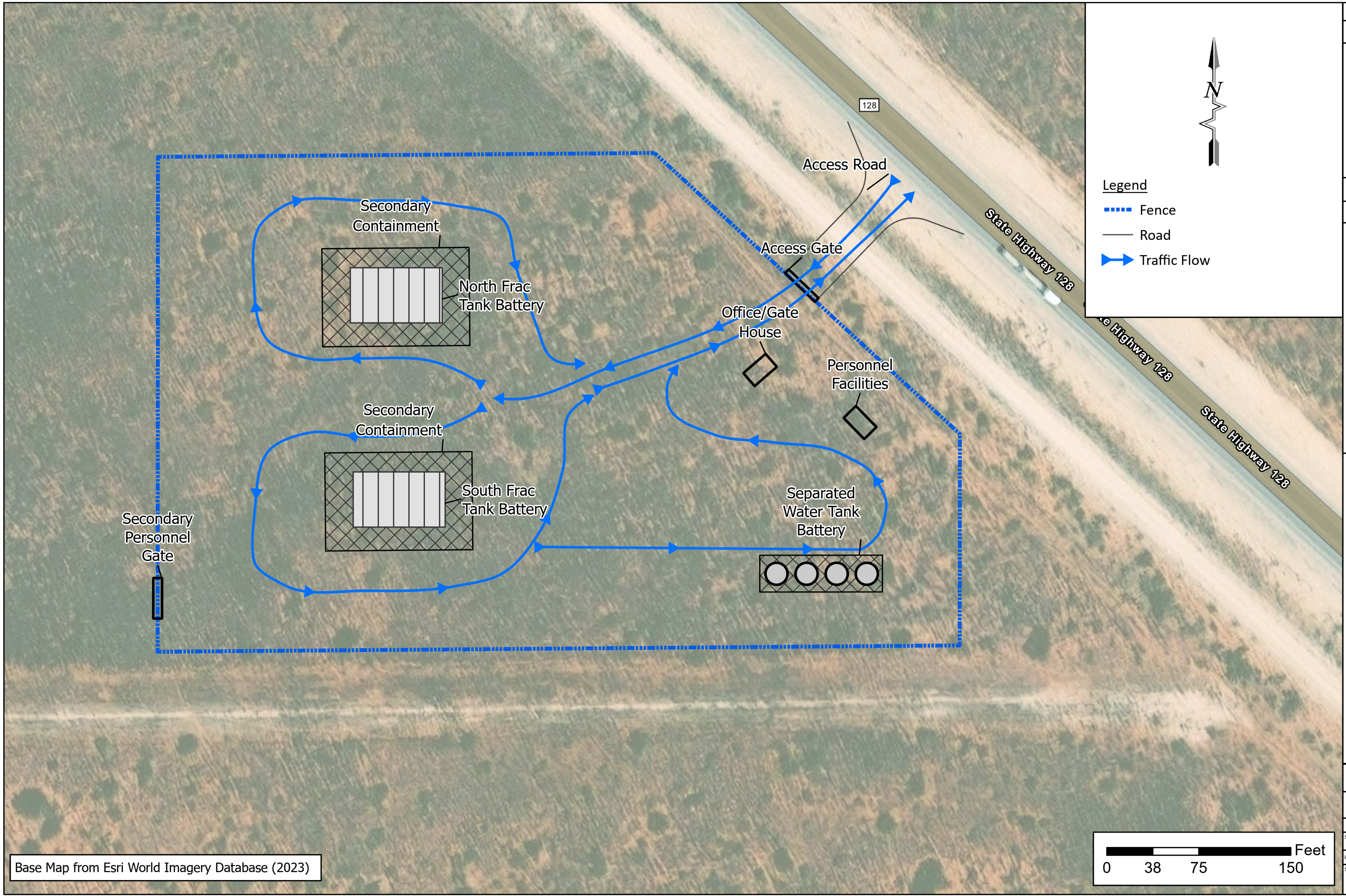
THIS DRAWING IS INCOMPLETE AND NOT TO BE USED FOR CONSTRUCTION UNLESS IT IS STAMPED, SIGNED AND DATED

Designed	Drawn	Checked
MAE	MAE	MJK

Date: 12/20/2024
Scale: Horiz: - 1" = 2,000' Vert: -
Project No: 1C33668
Sheet: FIGURE 1

Sources: ESRI, Souder, Miller & Associates

P:\5-Moonshine Energy C137 Oil Treatment Permitting (5E33797)\GIS\Moonshine Jal Facility C137 Permit



Base Map from Esri World Imagery Database (2023)

Rev #	Date	Description	By	Chkd

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MOONSHINE ENERGY, LLC

C-137 APPLICATION

FACILITY SITE PLAN
THE BIG STILL WASTE FACILITY
LEA COUNTY, NM

THIS DRAWING IS INCOMPLETE AND NOT TO BE USED FOR CONSTRUCTION UNLESS IT IS STAMPED, SIGNED AND DATED

Designed	Drawn	Checked
MAE	MAE	MJK

Date: 4/15/2025
Scale: Horiz: - 1" = 75'
Vert: -
Project No: 1C3668
Sheet: FIGURE 2

Sources: ESRI, Souder, Miller & Associates

P:\5-Moonshine Energy C137 Oil Treatment Permitting (5E33797)\GIS\Moonshine Jal Facility C137 Permit

ATTACHMENT 1

Operations Inspection Checklist Forms

DAILY INSPECTION CHECKLIST

Moonshine Energy, LLC. Big Still Oil Treatment Facility
NM-128, Lea County, New Mexico

INSPECTION DATE AND TIME:	
INSPECTION COMPLETED BY:	

Acceptable Condition/Present **Yes**	**No**	**N/A**	**Item**	**Comments**
☐	☐	☐	Gate and Road Condition	☐
☐	☐	☐	Standing Water	☐
☐	☐	☐	North Frac Tank Battery Secondary Containment	☐
☐	☐	☐	South Frac Tank Battery Secondary Containment	☐
☐	☐	☐	Water Tank Battery Secondary Containment	☐
☐	☐	☐	Hoses and PCC Connectors	☐
☐	☐	☐	Spill Kit, Fire Extinguishers Present	☐
☐	☐	☐	Litter and Odor Control	☐
☐	☐	☐	H_2S Monitors & Ambient Air H_2S Conc. (<1 ppm OK)	☐
☐	☐	☐		☐
☐	☐	☐		☐
☐	☐	☐		☐

Employee Signature: ____

MONTHLY INSPECTION CHECKLIST

Moonshine Energy, LLC. Big Still Oil Treatment Facility
NM-128, Lea County, New Mexico

INSPECTION DATE AND TIME:	
INSPECTION COMPLETED BY:	

Acceptable Condition/Present Yes	 No	 N/A	Item	Comments
General Facility Checklist				
☐	☐	☐	Fence & Gate Integrity	
☐	☐	☐	Berm Condition/Integrity	
☐	☐	☐	Ground Cover - Standing Water & Settling	
☐	☐	☐	Ground Cover – Erosion, Potholes, or Rills?	
☐	☐	☐	Road Condition	
☐	☐	☐	Sign Condition	
☐	☐	☐	Spill Kit, Fire Extinguishers Monitors – Condition	
☐	☐	☐		

Notes:

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Acceptable Condition/Present Yes	No	N/A	Item	Comments
Northern Frac Tank Battery				
☐	☐	☐	Secondary Containment Liner & Walls – Punctures?	
☐	☐	☐	Tank Flanges – Leaks or Wear?	
☐	☐	☐	Transfer Hoses – Leaks or Wear?	
☐	☐	☐	Staining?	
☐	☐	☐	PCC Containment – Signs of Leaks/Cracks/Wear	
☐	☐	☐	Tank Interiors – Visual Inspection	
☐	☐	☐	Tank Interiors – Solids/Sludge Thickness	
☐	☐	☐		
☐	☐	☐		
☐	☐	☐		

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Acceptable Condition/Present				
Yes	**No**	**N/A**	**Item**	**Comments**
Southern Frac Tank Battery				
☐	☐	☐	Secondary Containment Liner & Walls – Punctures?	☐
☐	☐	☐	Tank Flanges – Leaks or Wear?	☐
☐	☐	☐	Transfer Hoses – Leaks or Wear?	☐
☐	☐	☐	Staining?	☐
☐	☐	☐	PCC Containment – Signs of Leaks/Cracks/Wear	☐
☐	☐	☐	Tank Interiors – Visual Inspection	☐
☐	☐	☐	Tank Interiors – Solids/Sludge Thickness	☐
☐	☐	☐		☐
☐	☐	☐		☐
☐	☐	☐		☐

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Acceptable Condition/Present				
Yes	**No**	**N/A**	**Item**	**Comments**
Separated Water Tank Battery				
☐	☐	☐	Secondary Containment Liner & Walls – Punctures?	
☐	☐	☐	Tank Flanges – Leaks or Wear?	
☐	☐	☐	Transfer Hoses – Leaks or Wear?	
☐	☐	☐	Staining?	
☐	☐	☐	PCC Containment – Signs of Leaks/Cracks/Wear	
☐	☐	☐	Tank Interiors – Visual Inspection	
☐	☐	☐	Tank Interiors – Solids/Sludge Thickness	
☐	☐	☐		
☐	☐	☐		
☐	☐	☐		

Notes:

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Employee Signature: ____________________________________ Date: ___________________

APPENDIX F

HYDROGEN SULFIDE CONTINGENCY PLAN

Hydrogen Sulfide Prevention and Contingency Plan

The Big Still Oil Treatment Facility

Lea County, New Mexico

C-137 Surface Waste Management Facility Application

May 2025

Prepared for:

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HYDROGEN SULFIDE PREVENTION AND CONTINGENCY PLAN
THE BIG STILL OIL TREATMENT FACILITY

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NM OCD C-137 Facility Application

1.0 INTRODUCTION

The Moonshine Energy, LLC Big Still Oil Treatment Facility (Facility) is a proposed surface waste treatment facility which will be established and operated in accordance with New Mexico Oil Conservation Division (NM OCD) regulations as outlined and defined in 19.15.36 New Mexico Administrative Code (NMAC). The purpose of the facility will include processing tank bottoms, produced water, or other hydrocarbons from oil and gas operations to separate usable hydrocarbon material for sale and processing.

1.1 Purpose

This Hydrogen Sulfide (H_2S) Prevention and Contingency Plan (Plan) has been prepared to provide a thorough and available reference documenting emergency procedures resulting from a release of hydrogen sulfide gas at the Facility and to address the requirements of 19.15.36.8C(8) NMAC. This plan has been prepared in accordance with 19.15.11 NMAC.

This Plan is organized for easy reference by Facility personnel, each of whom will be required to read it. The Plan is designed to minimize hazards related to exposure of hydrogen sulfide gas and outline procedures utilized to alert and protect the public and facility personnel in the event of a H_2S release.

As detailed in Section 8.0 of this Plan, whenever significant changes to the Plan are made, revised copies of the Plan will replace existing copies; and NM OCD will be provided with the most recent Plan update.

1.2 General Information

The proposed Facility will be located near mile marker 37.3 on New Mexico Highway 128, approximately 15 miles west of the City of Jal, New Mexico. The property is located within Township 24 South, Range 34 East, Section 25, and consists of a 5.4± acre parcel leased to Moonshine Energy, LLC. The facility will utilize the entire parcel, and will consist of a fenced, cleared and leveled area with caliche surface cover allowing for access and maneuvering of large trucks and equipment. Three tank batteries will be located on the facility for processing tank bottoms, hydrocarbons, or produced water delivered to the facility. Two tank batteries, located in the west-central portions of the property, will be used for the receipt of waste and for storage of reclaimed hydrocarbons prior to sale. Each of the two batteries will consist of ten (10) 500 barrel (bbl) (21,000 gallon) capacity steel frac tanks, situated within a secondary containment area constructed of 3-foot steel walls lined with a with a 40-mil High Density Polyethylene (HDPE) liner to prevent release of any spilled material. An additional tank battery consisting of four (4) 750 bbl (31,500 gallon) fiberglass tanks situated within secondary containment (also steel walls with a 40-mil HDPE liner) will be located on the southeast portion of the Facility and be utilized to store saltwater until it is removed for disposal. The facility will have two skid-mounted modular buildings to function as an office/gate house and personnel facilities. The Facility will be staffed by at least one operator during all periods of operation.

1.3 Plan Availability & Agency Coordination

Copies of this Plan will be maintained as a component of the broader Contingency Plan in a readily accessible location within the Facility office. Copies of the H_2S plan will be provided during agency coordination with interested state and local emergency agencies as listed in Table 2. Local emergency response agencies are invited to the site for the purposes of inspecting the Facility, reviewing the Plan's contents, and for coordinating potential emergency response actions.

Emergency contact information will also be posted on signs located at the facility access gate and near the tank batteries.

1.4 Staff Training Program and Requirements

All employees working at the Facility will be required to attend training on hydrogen sulfide response and operations upon hire and attend annual refresher trainings thereafter. Refresher training will be completed and documented annually in employee files and maintained in facility records for no less than five (5) years. Topics for H_2S training will include:

- Hazards and Characteristics of H_2S
- Proper use and maintenance of personal protective equipment (PPE)
- Proper use and maintenance of H_2S detectors, alarms, warning systems
- Evacuation Procedures and Facility Operations

In addition to training, facility personnel will be required to participate in quarterly H_2S emergency response drills involving a simulated release of H_2S which would require a facility evacuation.

As no public residences are located within the Facility radius of exposure (Section 3.0 below) no public awareness training is expected to be required. Local emergency agencies and responders will be briefed on this Plan as outlined in Section 1.3.

2.0 H_2S and SO_2 CHARACTERISTICS

Hydrogen Sulfide (H_2S) is a colorless, toxic, and flammable gas that can be encountered during production and handling of crude oil, associated natural gas, and produced water. H_2S has a density slightly greater than air and will thus sink (vapor density of 1.19), resulting in accumulation and settlement of the gas in areas of low topography or underground utilities. H_2S can sometimes be identified by a rotten-egg smell at concentrations as low as 0.1 ppm, but at higher concentrations hazardous to health the gas can quickly overwhelm olfactory sensors which inhibits ability to rely on smell for detection. Exposure to H_2S can result in severe damage to the nervous and respiratory system, leading to death. The Immediately Dangerous to Life and Health (IDLH) concentration for H_2S is 100 ppm.

Sulfur Dioxide (SO_2) is a colorless and toxic gas with a choking or suffocating, acrid odor. SO_2 is formed during burning of fossil fuels including crude oil, and by burning H_2S. As such, SO_2 should not be a major gas of concern during normal operations at the proposed Facility, but in the event of a fire or if H_2S is required to be flared SO_2 may form and should be considered a potential contaminant. SO_2 is much denser than air and will sink (vapor density of 2.26), resulting in accumulation and settlement of the gas in areas of low topography or underground utilities. If mixed with water, SO_2 will form sulfuric acid, and is highly corrosive, acting as an eye and respiratory tract irritant. SO_2 can be identified by a strong, acrid odor (sometimes described as a “burning match”) at concentrations of 1 ppm or higher. Exposure to SO_2 can result in severe damage to the respiratory system, leading to death. The Immediately Dangerous to Life and Health (IDLH) concentration for SO_2 is 100 ppm.

Attachment 2 includes summary sheets from the CAMEO Chemical Database on H_2S and SO_2.

3.0 RADIUS OF EXPOSURE & IDENTIFIED PUBLIC AREAS

3.1 Assumed Radius of Exposure & Prevailing Wind Direction

The Facility accepts a variety of waste from multiple sources throughout the Permian Basin. As such, no anticipated concentration of H2S can be calculated or reasonably assumed (per 19.15.11.8.A NMAC) for the materials which are accepted at the facility. Given the inability to calculate a threshold value, the Facility will assume a conservative H_2S Radius of Exposure (ROE) of 3,000 feet at a concentration of 100 ppm H_2S in accordance with 19.15.11.7.K(3) NMAC. Figure 2 is a vicinity map of the Facility with the ROE indicated relative to other existing facilities.

The prevailing wind direction was evaluated by reviewing wind rose diagrams prepared by the NSDFSDF for the Carlsbad Municipal Airport, located 40 miles to the west of the facility, as well as the Winkler County Airport, located near Kermit, TX, approximately 40 miles southeast of the facility. Wind rose diagrams are included on Figure 3. The prevailing wind direction at both airports is from the South-Southeast; as such the prevailing winds at the proposed Facility will also assumed to be from the south-southeast.

3.2 Identified Roads, Public Areas, and Residences

As illustrated on Figure 2, three existing oil and gas facilities and one public road (New Mexico State Highway 128) are present within the assumed H_2S ROE. New Mexico State Highway 128 is located adjacent to the facility, and approximately 6,700 feet of the roadway is present within the assumed ROE.

The NGL Striker 4 Salt Water Disposal facility is located 1,100 feet to the northwest of the Facility; the Moomaw No. 1 Salt Water Disposal is located 1,400 feet to the southeast of the facility; and a Marathon Oil Dee Boot production well and storage facility is located 2,400 feet west of the proposed Facility.

4.0 H_2S MONITORING & SIGNAGE

4.1 H_2S Monitoring Equipment

The Facility will utilize two stationary H_2S detectors to monitor H_2S at the facility. The stationary detectors will be located at each of the two tank batteries near the unloading areas at an elevation of approximately 4 feet above ground, as indicated in Figure 4. The stationary monitors are expected to be Otis 6900-IP wireless meters and will alarm facility staff when H_2S is detected at a concentration above 1 part per million (ppm).

In addition to the stationary monitor, individual Honeywell BW Clip H_2S meters will be worn by facility personnel at all times. The sensors will be placed on the outside of clothing with the sensor facing out, and will be placed on the torso between the waistline and neck. Individual meters will be set to alarm personnel if H_2S is detected at a concentration of 10 ppm or greater.

Specification sheets detailing the stationary and individual monitors are included as Attachment 3.

4.2 Facility Signage

The Facility will post a sign compliant with ANSI standard Z535.1-2002 at the facility entrance and near unloading areas which states “Danger: H_2S may be present”

5.0 EMERGENCY COORDINATORS AND RESPONSE AGENCIES

The Facility has designated specific individuals with the responsibility and authority to implement response measures in the event of an emergency which threatens public health, welfare, or the environment. The Primary and Alternate Emergency Coordinators (ECs) will be thoroughly familiar with all aspects of this Plan; operations and activities at the Facility; location and characteristics of wastes to be managed; and the Facility layout. Table 1 lists the names, titles, and office and mobile phone numbers of the Primary EC and designated Alternate EC. The Primary EC and/or the designated Alternate EC are available to respond to an emergency 7 days a week, 24 hours a day. Upon arrival at the scene of an emergency, the Primary EC will assume responsibility for response measures initiated by the designated Alternate EC, if applicable. The contact information for the designated ECs will be posted at prominent locations at the facility.

TABLE 1
List of Emergency Coordinators
The Big Still Oil Treatment Facility

Primary Emergency Coordinator			
Name:	Calvin Brown		
Title:	Big Still Facility Manager	Mobile/Home Phone:	575-361-2730
Address:	491 Scarlet Ct., Canyon Lake, TX		
Alternate Emergency Coordinator			
Name:	Allen Mosig		
Title:	Facility Operator	Mobile/Home Phone:	432-241-7061
Address:	3206 Ma Mar Ave. Midland, TX 79705		
Alternate Emergency Coordinator			
Name:	Michael McCurdy		
Title:	Regional Manager	Mobile/Home Phone:	432-312-5251
Address:	2004 Humble Ave. Midland, TX 79705		

As detailed in Section 1.3, copies of this plan will be made available to emergency response agencies. The contact information for local, state, and federal emergency response agencies is included in Table 2 below.

TABLE 2
Emergency Response Agencies and Contacts
Big Still Oil Treatment Facility

Agency/Organization	Emergency Number
Fire	
• Jal Fire Department	911 or 575.395.2211
Police	
• Jal Police Department	911 or 575.395.2501
• Lea County Sheriffs Department	911 or 575.396.3611
• New Mexico State Police-Hobbs	911 or 575.392.5580
Medical/ Ambulance	
• Jal Fire Department	911 or 575.395.2211
• Jal Clinic	575.395.3400
• Winkler County Memorial Hospital (Kermit, TX)	432.586.8299
• Covenant Health Hospital (Hobbs, NM)	575.492.5000
State Emergency Response Contacts	
• New Mexico Oil Conservation Division Emergency Contacts	
○ OCD District 1 Office, Hobbs, NM	505.629.6116
○ OCD Main Office, Santa Fe, NM	505.476.3441
• New Mexico Environment Department	
○ Spill Emergencies 24 hr. Hotline (NMED)	505.827.9329
○ Hazardous Waste Bureau, Santa Fe	505.476.6000
○ Radiation Control Bureau, Santa Fe	505.476.8600
Federal Emergency Response Contacts	
• National Emergency Response Center (U.S. Coast Guard)	800.424.8802
• Region 6 Emergency Response Center (USEPA)	866.372.7745
Local Emergency Planning Committee Contact	
• Lea County Emergency Management	575.605.6561

5.1 Medical Facilities

The Jal Clinic, located at 805 W Kansas Ave in, Jal, New Mexico, is the closest medical center to the Facility. However, the clinic is only open limited hours and is not equipped to handle serious injuries. The closest hospital capable of providing care in an emergency facility is the Winkler County Memorial Hospital, located approximately 36 miles to the southeast in Kermit, Texas. A map with directions to the Winkler County Memorial Hospital is included as Figure 5.

6.0 EMERGENCY ACTION PLAN

This Emergency Action Plan will be implemented when a release of H_2S or emergency situation develops that represents a potential impact to public health or the safety of facility personnel. The Plan follows the guidance provided in the American Petroleum Institute (API) Recommended Practice 55 (RP 55) Standard, which is included as Attachment 4. The initial responses will be concerned primarily with the safety of facility personnel, and will then shift focus to protection of the public.

Although the plan will be used as a basis of response, the EC may deviate from this plan as necessary if actions or responses may create additional safety hazards. No facility personnel will attempt to contain or contract any H_2S releases beyond their corresponding scope of safety, training, and available equipment.

6.1 Plan Activation Thresholds

If H_2S is detected at or above 10 ppm by the facility's stationary monitoring equipment, an immediate evacuation of the entire facility, as detailed in Section 6.2, will be ordered by the EC or facility personnel who identify the release.

If H_2S is detected at or above 30 ppm by the facility's stationary monitoring equipment, which represents the National Oceanic and Atmospheric Administration (NOAA) Emergency Response Planning Guidelines Level 2 threshold (ERPG-2), the facility will be immediately evacuated as described above and in Section 6.3, and personnel will also secure the entirety of the ROE (3,000 foot radius) by establishing blockades along NM-128 and providing notification to any facilities located within the ROE.

In the event the H_2S Contingency plan is activated, the EC will notify the NM OCD within four hours of plan activation by phone and email as per 19.15.11.16 NMAC (Section 8.2 below).

6.2 H_2S Release Procedure

The response to a H_2S release will follow the procedures below and utilize the evaluation and assessment process detailed in Table 3.

1. The employee who first becomes aware of the release will immediately notify the EC. If the Primary EC is on-site they will be contacted first. In the event the Primary EC cannot be contacted, the Alternate EC will be contacted. The EC can be notified in person, via telephone, or by radio.
2. After being notified, the EC will assess the situation and make note of the general strength and direction of the wind to determine direction of travel for released gases.
3. An evacuation of the facility will be ordered if H_2S is detected at a concentration of 10 ppm or greater. Details on a facility evacuation are included in Section 6.3.
4. If H_2S is detected at a concentration of 30 ppm or greater, the facility will be evacuated (Section 6.3) and the ROE outside of the facility will be Secured (Section 6.4).
5. The employee who first becomes aware of the release will immediately initiate response actions within the scope of their training to eliminate the source of the release. If possible, the employee should attempt to minimize the spread of the release and contain any non-gas spills utilizing on-site equipment/spill kits (Table 5).
6. Once present at the scene, the EC will direct efforts at addressing the spill and engage with a third-party contractor to remediate the release, collect samples of released materials and impacted

media, and assess the extent of resources which may have been impacted by the release (soil, surface water, groundwater, etc.).

7. Once the release has been mitigated and concentrations of H_2S stabilize at levels below 10 ppm, personnel will be contacted via cell phone or two-way radio and provided the all-clear to return to the facility.
8. If the spill is a major or minor release (as defined by 19.15.29 NMAC and described in Section 7. 1), the EC will notify the NM OCD as detailed in Section 7.0. The Facility will also work with a third-party contractor and the NM OCD to develop a remediation and corrective action plan to address any remaining contamination.

TABLE 3
Emergency Response Procedures
Big Still Oil Treatment Facility

In the event of an H_2S release:
1. **Notification of Facility Personnel/EC:** The employee who first becomes aware of the release will immediately notify the Primary EC. If the Primary EC is on-site, he/she will be contacted first. In the event the Primary EC cannot be readily contacted, the Alternate EC will be contacted. The EC can be notified in person, via telephone, or by radio. The EC, alternate EC, or employee designated to coordinate the response, will then notify all active facility personnel by phone or radio and provide instructions regarding assessment, response, or if needed, evacuation. Table 4 includes details of procedures to be followed during evacuation.
2. **Assessment:** Upon arrival, the EC will assess the source, amount, and extent of any released material resulting from the situation and determine possible hazards to human health, welfare or the environment. The assessment may be conducted by direct observation, review of facility records and manifests, or by chemical analysis. The assessment will include: **a. Initial Hazard Identification** i. <u>Nature of the hazard:</u> is the emergency a fire, substance release or other ii. <u>Location:</u> identification of the area and extent of hazard iii. <u>Hazard Identification:</u> Evaluation of the type, quantity, and status of any burning or released material and potential characteristics including corrosivity, naturally occurring radioactive material (NORM), or H_2S. **b. Vulnerability Analysis (damage potential)** i. <u>Extent:</u> identify the extent of the vulnerable zone and potential impacts. This can include the size of fire/release, wind direction, proximity to receptors, etc. ii. <u>Human Safety:</u> identification of persons within the vulnerable zone, including facility personnel, other facility, general public, etc. iii. <u>Environmental Safety:</u> identification of potential environmental impacts, including critical habitat, endangered species, water resources, etc. iv. <u>Severity of hazard:</u> potential for hazard to damage people, environment, or property **c. Risk Analysis (probability of damage)**

        i. Environmental conditions: potential for the situation to spread or propagate due to precipitation, weather, etc.
        ii. Facility personnel training: ability for on-site personnel to control the situation or need for external resources
        iii. Equipment availability: Equipment present at the facility or nearby which can be used to mitigate/control the situation

3. **Containment:** Responses to the situation which will contain and control the threat and mitigate hazards.
    a. **Facility Response:** If deemed safe by the EC, containment actions will be performed by on-site personnel who are trained in response utilizing appropriate equipment and materials.
    b. **Emergency Response:** if the scope of the situation exceeds personnel training or equipment on-site, emergency responders, including the local fire department or police, will be notified utilizing information presented in Table 2.
    c. **Containment Responses:**
        i. Hydrogen Sulfide: Facility personnel will attempt to mitigate the source of a H_2S release, but if concentrations at detected at 10 ppm or greater the facility will be evacuated and emergency responders, capable of utilizing supplied-air sources, will be contacted to mitigate and contain the release.

4. **Notification of Emergency Authorities:** Appropriate state and local emergency authorities will be notified of the situation depending on the severity of the hazard and level of assistance needed. The NM OCD will also be notified of any situation within 15 business days (Section 7.0 below) utilizing Form C-141, and in the case of major spills or releases, will be notified within 24 hours. If an incident requires activation of this H_2S Contingency Plan, the NM OCD will be notified within four hours of activation of the plan. Table 2 lists phone numbers and contact information for both local and state agencies.

5. **Site Control:** As soon as the situation is assessed, the EC will divert any facility personnel or traffic from the area until the area is deemed safe and the situation is resolved. Site control measures may include implementation of the facility evacuation plan to remove non-essential personnel (Section 6.3, Figure 4), and closure of facility access by securing the main access gate. If necessary, the ROE will be secured via potential closure of NM-128 to prevent public/passing vehicles from entering an impacted area (Figure 2). Oil and gas facilities within the 3,000-foot ROE will be notified by phone, or if necessary, by in-person communication of the release.

6.3 Evacuation Plan for Facility Personnel

In the event of an emergency situation and/or the detection of H_2S at or above 10 ppm by on-site monitoring equipment, all non-essential facility personnel will be diverted from the facility, and if deemed necessary by the EC or responding staff, the facility will be evacuated. Imminent or actual dangers that constitute a situation that could require evacuation include:

- A generalized fire or threat of fire that cannot be avoided.
- An explosion or the threat of explosion that cannot be averted.

- A major spill or leak that cannot be readily contained and constitutes a potential threat to human health, welfare, or the environment.

1. When conditions warrant immediate action, Facility personnel will proceed to one of two Muster Points established for the Facility, as identified in Figure 4. The Primary Muster Point is located adjacent to the main access gate located at the northeast corner of the facility. In the event the Primary Muster Point cannot be reached, Facility personnel will gather at the Secondary Muster Point, located at the southwest corner of the Facility adjacent to the secondary personnel gate. Once at the assembly point, personnel will be provided verbal instructions regarding the type and location of hazard that is present. Verbal information will be supplemented by cellular phone or two-way radio contact. H_2S concentrations will be monitored at the Muster point utilizing a 4-gas meter if the EC is present at the facility; if the EC is not available, H_2S concentrations will be monitored utilizing personal H_2S meters on facility staff.
2. If time and conditions allow, personnel will attempt to shut down any applicable equipment which may pose a fire hazard or contribute to the release prior to departing for the Muster points. Facility personnel will not respond to situations outside of their training or attempt to work in conditions which would require supplied air respirators.
3. Following assembly, personnel will then exercise judgment and site conditions, including wind direction, to utilize either the primary or secondary evacuation route to exit the facility in an up-wind direction.
4. Once clear of the facility, personnel will secure the site by closing access gates, and coordinate via two-way radio or cell phone to divert any incoming deliveries or traffic.
5. If appropriate, the EC or personnel will initiate contact with local authorities as detailed in Table 2.

A Site Evacuation Map is provided as Figure 4, and a Medical Center Location Map and driving directions are included as Figure 5. Additional information regarding evacuation procedures is detailed below in Table 4.

TABLE 4
Evacuation Procedures
Big Still Oil Treatment Facility

In the event of evacuation (H_2S concentration at or above 10 ppm):
1. Facility personnel will be alerted verbally or contacted using two-way radio or cellular phones.
2. Any on-site delivery vehicles will be diverted away from the emergency location and routed towards the facility exit, if necessary. The facility access gate will be closed to prevent access from any public or delivery vehicles.
3. Operating equipment will be shut down, if appropriate.
4. Personnel will be directed to proceed to the Primary Muster Point at the main facility access gate, which will be the primary designated emergency response coordination location (Figure 4). Identification of any missing persons will be implemented at that time.
5. If the emergency limits access to the main facility entrance gate, personnel will gather at the Secondary Muster Point, located at the southwest corner of the property (Figure 4). Identification of any missing persons will be implemented at that time.
6. Once assembled, personnel will stand by to afford assistance, if and as needed, or evacuate through one of the two access points.
7. Once the facility is evacuated and secured, the EC will direct personnel, if necessary, to secure NM-128 at designed blockade locations and provide notification of other oil and gas facilities located within the H_2S ROE (Figure 2).
8. Upon mitigation of the release, facility personnel will be contacted by the EC or assigned personnel via two-way radio or cell phone to provide authorization to return to the facility.

6.4 Securing of H_2S ROE (implemented if H_2S is detected at or above 30 ppm)

If H_2S is detected above 30 ppm (the NOAA H_2S ERPG-2 concentration threshold) by any facility monitoring equipment, the EC will secure the entire assumed ROE, which is assumed to be a 3,000 foot radius around the facility.

1. Following evacuation of the facility, the EC will contact local emergency agencies to provide notification of the release, as in Section 6.3 above.
2. Once emergency authorities have been notified, the EC will coordinate the establishment of blockades along NM-128 outside of the 3,000-foot ROE (indicated in Figure 2) to prevent public access or exposure of passing vehicles. The blockades will be accomplished through the use of facility vehicles and any available traffic control equipment, including construction cones, barrels, or pylons.
3. The EC will notify personnel at any other facilities located within the assumed 100 ppm ROE; the responses of the facilities will be implemented in accordance with each facilities' standard operating procedures and emergency plans.

4. Once the source of the release is abated, the EC will work with emergency response agencies to monitor atmospheric H_2S concentrations at the Facility boundary and in public areas within the ROE. This will include measurements of area within the NM-128 roadway corridor and at any other permanent facilities. The area will be considered safe for reentry when H_2S levels are below no longer detectable outside of the facility boundary.
5. After responding to the incident, the EC will document the incident on an incident report form (Attachment 1) and meet with involved personnel to assess the cause of the release. Applicable processes or operational changes appropriate to prevent its recurrence will be developed and implemented. The NM OCD and any other applicable agencies will be notified as detailed in Section 7.0.

7.0 EMERGENCY EQUIPMENT

Emergency equipment will be made available to all personnel at the Facility. Figure 4 includes a site map with the locations of response equipment. Table 5 below includes a list of on-site emergency equipment present on the facility or within facility equipment – descriptions of each type of equipment are included in the sections below:

TABLE 5
Emergency Equipment
Big Still Oil Treatment Facility

Equipment Description	Location	Quantity	Purpose
On-Site Equipment			
Fire Extinguisher – ABC Rated, 10 lb	Facility Office	1	Fire Suppression
Fire Extinguisher – ABC Rated, 10 lb	Each Tank Battery Secondary Containment	3	Fire Suppression
Fire Extinguisher – ABC Rated, 10 lb	Facility Vehicles	1	Fire Suppression
Spill Response Kit (55 gallon drum with sorbent materials)	Each Tank Battery Secondary Containment	3	Spill Containment
Shovel	Each Tank Battery Secondary Containment	3	Fire Suppression & Spill Containment
pH Strips	Each Tank Battery Secondary Containment	2	Hazard Characterization
Otis Stationary H2S Monitor (OI-6900)	Central Tank Batteries Secondary Containment	2	Hazard Gas Detection
Windsock	Each Tank Battery	3	Wind Direction
4-Gas Meter	Facility Office	1	4-Gas Meter capable of detecting combustibility (%LEL), H_2S, CO, and O_2
First Aid Kit	Facility Office & Vehicle	2	First Aid
Personal Protective Equipment			
Gloves	Delivery/Facility Vehicle	1	Hand Protection
Hard Hat	Delivery/Facility Vehicle	1	Head Protection
Safety Goggles	Delivery/Facility Vehicle	1	Eye Protection
BW Clip-on H_2S Meter	On-Person	1	H2S gas detection

7.1 Internal and External Communications

Communications at Facility will be accomplished via cellular telephones and two-way radios. Key site personnel carry two-way radios or cell phones for individual communications and for contacting outside agencies (e.g., fire department, ambulance, etc.). The two-way radios and cellular phone network will be used daily, and any mechanical difficulties will be promptly addressed.

7.2 Fire Prevention

Portable ABC-type fire extinguishers are located at several locations at the facility and in delivery trucks and site vehicles. Fire extinguishers will be maintained in accordance with state and local fire codes and regulations. Shovels are also located near Facility spill kits which can be used to suppress/smother fires with soil or other materials.

7.3 Personnel Protection/First Aid/Safety Equipment

Personal protective equipment (PPE) necessary for daily operations and emergency response will be maintained by individual Facility staff and also included as part of the spill response kit installed at each tank battery. PPE includes, but is not limited to, gloves, vests, safety glasses, ear protection, spill response equipment, H_2S personal monitors, etc.

First aid kits are maintained within facility vehicles.

Prominent signs are posted at the Facility to identify the location of health and safety equipment and fire extinguishers.

7.4 Spill Response Equipment

The Facility maintains three spill kits on the facility, which are stored near the secondary containment wall at each of the Facility's three tank batteries. The kits include nitrile gloves, googles, an emergency handbook, disposal bags, and absorbent materials including sorbent socks, pads, pillows, and a bag of granular clay material. One shovel is also stored near each spill kit to aid in spill response. The kits are contained within a sealed, clearly labeled 55-gallon drum which can be used to contain and transport response materials after a response.

8.0 SPILL DEFINITIONS AND NOTIFICATION REQUIREMENTS

8.1 Spill/Release Definitions

Releases related to the production of oil and gas are addressed in 19.15.29 NMAC. The administrative code specifies two categories of releases – major and minor, which are defined as below.

19.15.29.7.A – "Major Release" means:
- (1) an unauthorized release of a volume, excluding gases, of 25 barrels or more;
- (2) an unauthorized release of a volume that:
  - (a) results in a fire or is the result of a fire;
  - (b) may with reasonable probability reach a watercourse;
  - (c) may with reasonable probability endanger public health; or
  - (d) substantially damages property or the environment;
- (3) an unauthorized release of gases exceeding 500 MCF; or
- (4) a release of a volume that may with reasonable probability be detrimental to fresh water.

19.15.29.7.B – “Minor Release” means an unauthorized release, which is not a major release and is a volume greater than five barrels but less than 25 barrels; or for gases, greater than 50 MCF but less than 500 MCF.

8.2 Notification Requirements

If the EC has determined that the incident could threaten human health, welfare, or the environment beyond the limits of the Facility, they will notify local emergency responders, the National Emergency Response Center, NM OCD, and NMED Spill Emergencies hotline at the following phone numbers:

- Local Emergency Agencies/Responders: 911
- NM OCD Main Office: 505.476.3441
- National Emergency Response Center - 24 Hr. Hotline: 800.424.8802
- NMED Spill Emergencies - 24 Hr. Hotline: 505.827.9329

In the event of an incident requiring activation of this H2S Contingency Plan, the EC will notify the NM OCD by phone and email within four hours of activation of the plan, as outlined in Section 19.15.11.16 NMAC.

In the event of a major or minor release as defined by 19.15.29.7 NMAC (Section 3.2.1), the EC will notify the NM OCD District 1 office by completing the online NM OCD Form C-141 within 15 days of discovery of the release.

If the release is considered a “major release”, the EC will also inform the NM OCD Division 1 office as well as the NM OCD Environmental Bureau Chief as required in 19.15.29.10.A NMAC by utilizing the “Notice of Release” application within the NM OCD online permitting module within 24 hours of discovery of the release. In addition to the NOR, the Facility will provide verbal or email notification. The notification will include information which will be required in the C-141 form, including:

- Facility information and location
- Date of release discovery
- Description and nature of the release, including type, volume, materials, and impact medial
- Initial response and mitigating actions

After responding to an incident (fire, spill, release, or other emergency), the EC will meet with involved personnel to assess the cause of the incident. The identified causative agent will be removed from the vicinity of the Facility if the possibility of re-ignition or further release exists. Mitigation measures or best management practices appropriate to prevent the incident’s recurrence will be developed and implemented.

As the facility is located within privately-owned land, 19.15.29.9.B NMAC is not applicable to the facility and there will be no need to notify state, federal, or tribal authorities.

9.0 STORAGE AND TREATMENT OF RELEASED MATERIALS

Spilled material or substances used to control/absorb materials will be containerized, stored and disposed of in accordance with applicable local, state and federal regulatory requirements. The EC will coordinate with Facility staff and management to ensure that no operations to treat, store, or dispose of additional oilfield waste, which may be incompatible with released material, are performed until all cleanup procedures are complete. During cleanup, the EC will coordinate with emergency response agencies or third-party contractors who may be assisting with cleanup to ensure segregation of any exempt or non-exempt wastes. If required, samples will be collected from containerized material for characterization prior to disposal. Waste removal and transport for disposal will typically be completed by third-party specialized contractors.

10.0 RECORD KEEPING REQUIREMENTS

The Primary EC will be responsible for ensuring that emergency response actions are fully documented; or the Primary EC may designate that the Alternate EC complete documentation requirements. The Incident Report Form (Attachment 1) illustrates the information that will be recorded as a result of an emergency incident and related response action. This form will be signed by both the Primary and Alternate ECs. Copies of the form will be maintained as part of the Facility Operating Record.

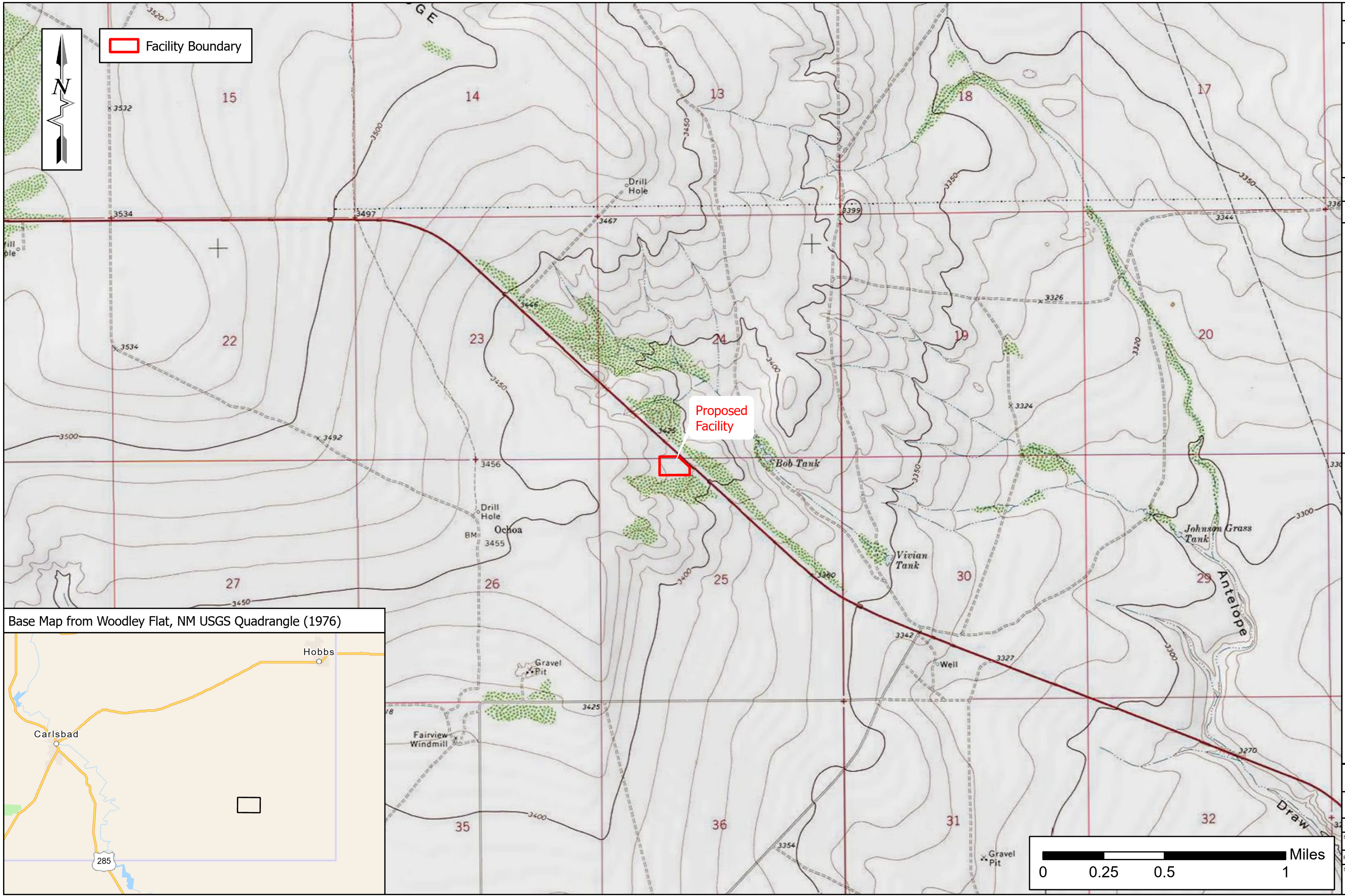
11.0 PLAN AMENDMENT

The Primary EC will be responsible for assuring the update or amendment of this Plan within five (5) business days in the event of any of the following:

1. The Facility Permit is revised or modified.
2. The Plan fails in an emergency.
3. Modification to the Facility design, construction, operation, maintenance or other circumstances that changes the potential for fires, explosion, or releases of hazardous waste constituents, or related changes in the appropriate emergency response.
4. The list of ECs changes (Table 1).
5. The list of emergency equipment changes.
6. The list of emergency response agencies and contacts changes (Table 2).
7. Changes in technology or emergency response equipment.
8. Changes to evacuation procedures (Table 4) and/or routes (Figure 4).
9. The designated medical center to be used in the event of an accident changes (Figure 5).

Following amendment, this Plan will be distributed to the New Mexico Oil Conservation Division and each of the interested organizations identified in Table 2 with a cover letter highlighting the substantive changes. The proposed changes will be made in compliance with 19.15.36 NMAC.

FIGURES



Base Map from Woodley Flat, NM USGS Quadrangle (1976)

Rev # | Date | Description | By | Chkd

Souder, Miller & Associates
Engineering ♦ Environmental
Geomatics
Serving the Southwest & Rocky Mountains

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MOONSHINE ENERGY, LLC

C-137 APPLICATION

VICINITY MAP ON USGS QUADRANGLE
THE BIG STILL WASTE FACILITY
LEA COUNTY, NM

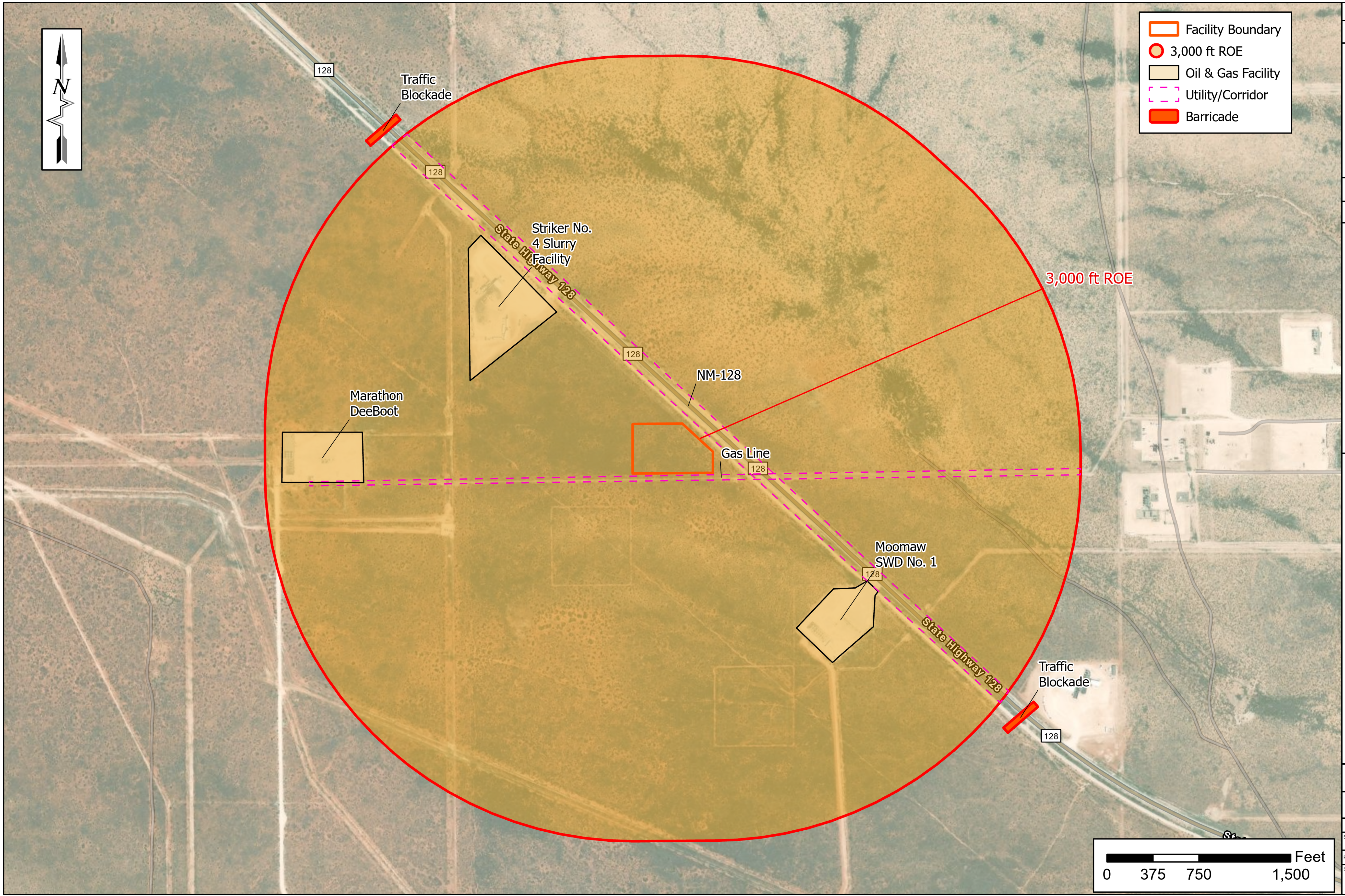
THIS DRAWING IS INCOMPLETE AND NOT TO BE USED FOR CONSTRUCTION UNLESS IT IS STAMPED, SIGNED AND DATED

Designed	Drawn	Checked
MAE	MAE	MJK

Date: 12/20/2024
Scale: Horiz: - 1" = 2,000'
Vert: -
Project No: 1C33668
Sheet: FIGURE 1

Sources: ESRI, Souder, Miller & Associates

P:\5-Moonshine Energy C137 Oil Treatment Permitting (5E33797)\GIS\Moonshine Jal Facility C137 Permit



Rev #	Date	Description	By	Chk'd

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MOONSHINE ENERGY, LLC
C-137 APPLICATION

RADIUS OF EXPOSURE WITH FACILITIES & PUBLIC AREAS THE BIG STILL WASTE FACILITY LEA COUNTY, NM

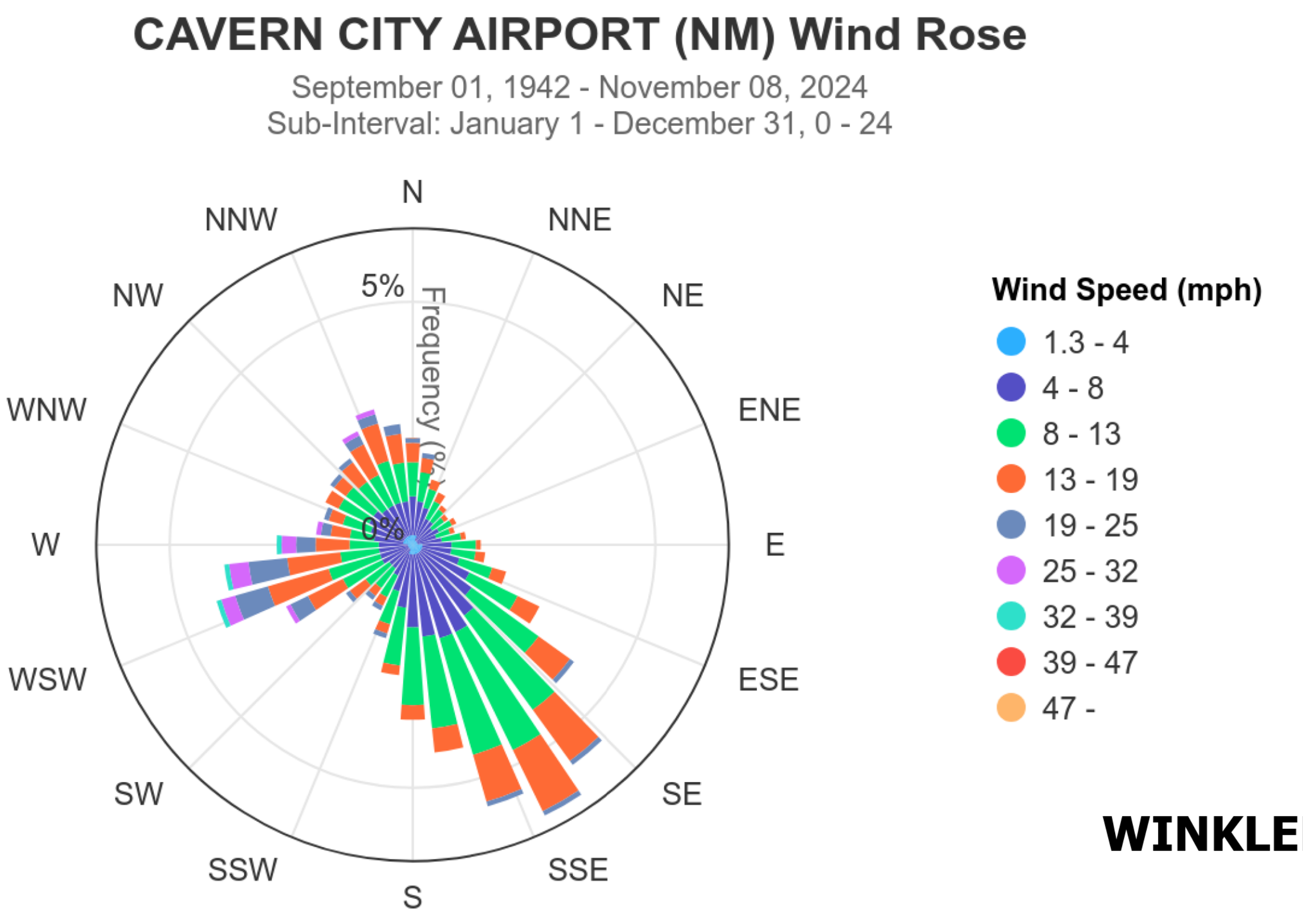
THIS DRAWING IS INCOMPLETE AND NOT TO BE USED FOR CONSTRUCTION UNLESS IT IS STAMPED, SIGNED AND DATED

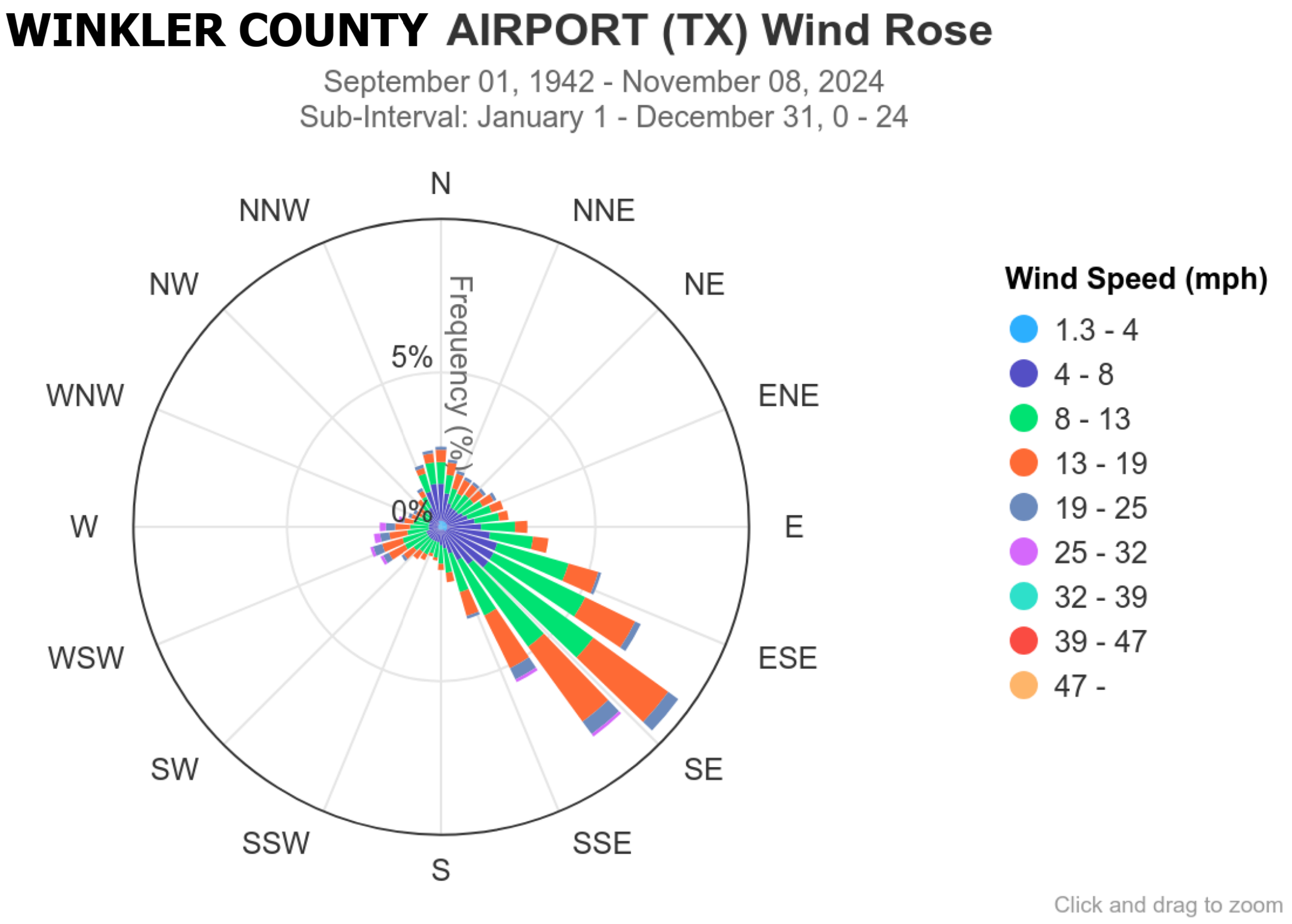
Designed	Drawn	Checked
MAE	MAE	MJK

Date: 12/20/2024
Scale: Horiz: - 1" = 750'
Vert: -
Project No: 1C33668
Sheet: FIGURE 2

Sources: ESRI, Souder, Miller & Associates

P:\5-Moonshine Energy C137 Oil Treatment Permitting (5E33797)\GIS\Moonshine Jal Facility C137 Permit





Wind Rose Diagrams from Midwestern Regional Climate Center (2024)

Rev #	Date	Description	By	Chkd

Souder, Miller & Associates
Engineering • Environmental
Geomatics
Serving the Southwest & Rocky Mountains

5454 Venice Avenue NE, Suite D
Albuquerque, NM 87113
Phone: (505) 299-0942

C-137 APPLICATION

MOONSHINE ENERGY, LLC

WIND ROSE DIAGRAMS
CARLSBAD & WINKLER CO. AIRFIELDS
THE BIG STILL WASTE FACILITY
LEA COUNTY, NM

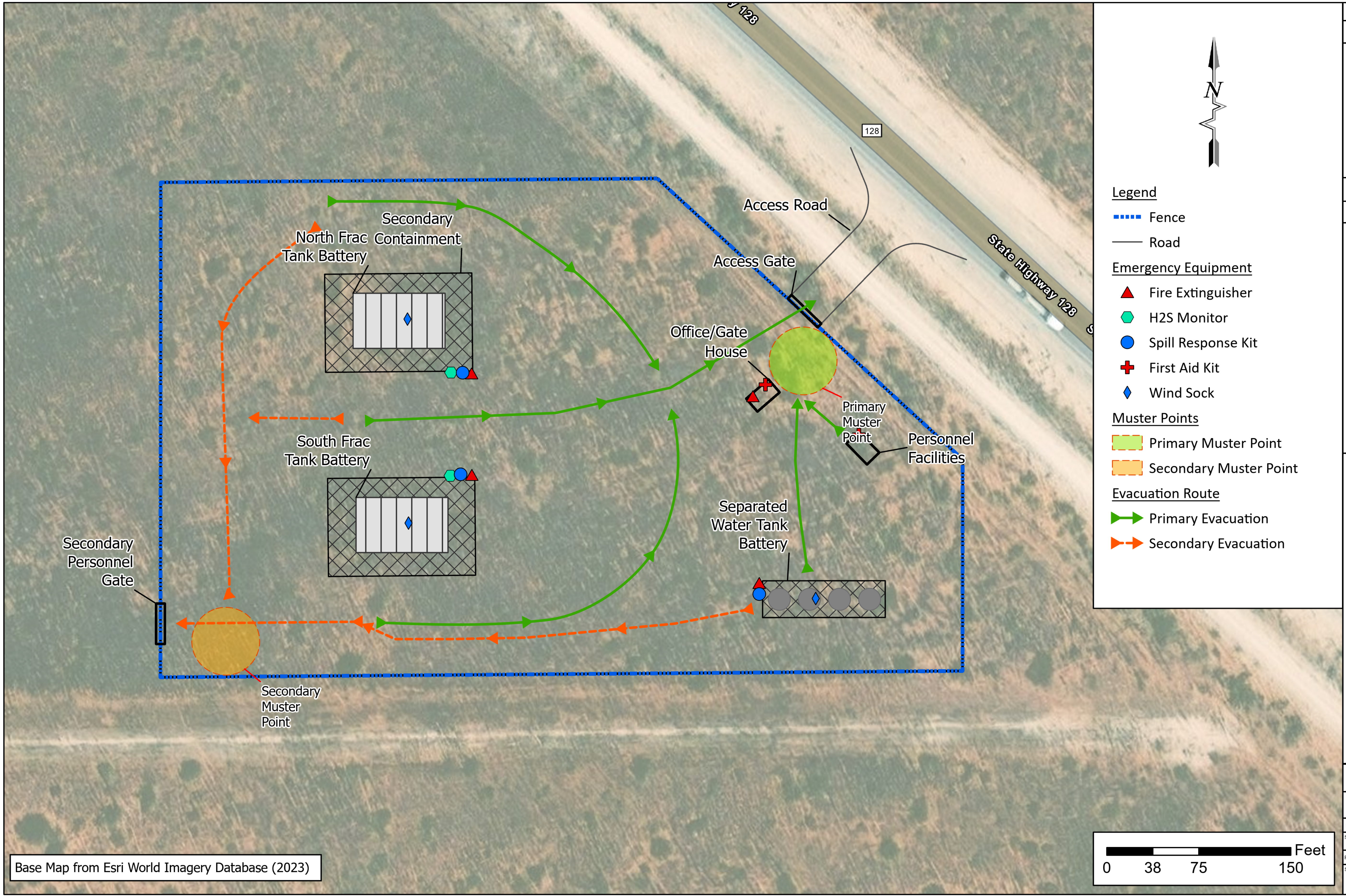
THIS DRAWING IS INCOMPLETE AND NOT TO BE USED FOR CONSTRUCTION UNLESS IT IS STAMPED, SIGNED AND DATED

Designed	Drawn	Checked
MAE	MAE	MJK

Date: 1/10/2025
Scale: Horiz: -
Vert: -
Project No: 1C33668
Sheet: FIGURE 3

Sources: ESRI, Souder, Miller & Associates

P:\5-Moonshine Energy C137 Oil Treatment Permitting (5E33797)\GIS\Moonshine Jal Facility C137 Permit



Base Map from Esri World Imagery Database (2023)

Rev #	Date	Description	By	Chkd

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C-137 APPLICATION

MOONSHINE ENERGY, LLC

EMERGENCY EQUIPMENT
AND EVACUATION ROUTES
THE BIG STILL WASTE FACILITY
LEA COUNTY, NM

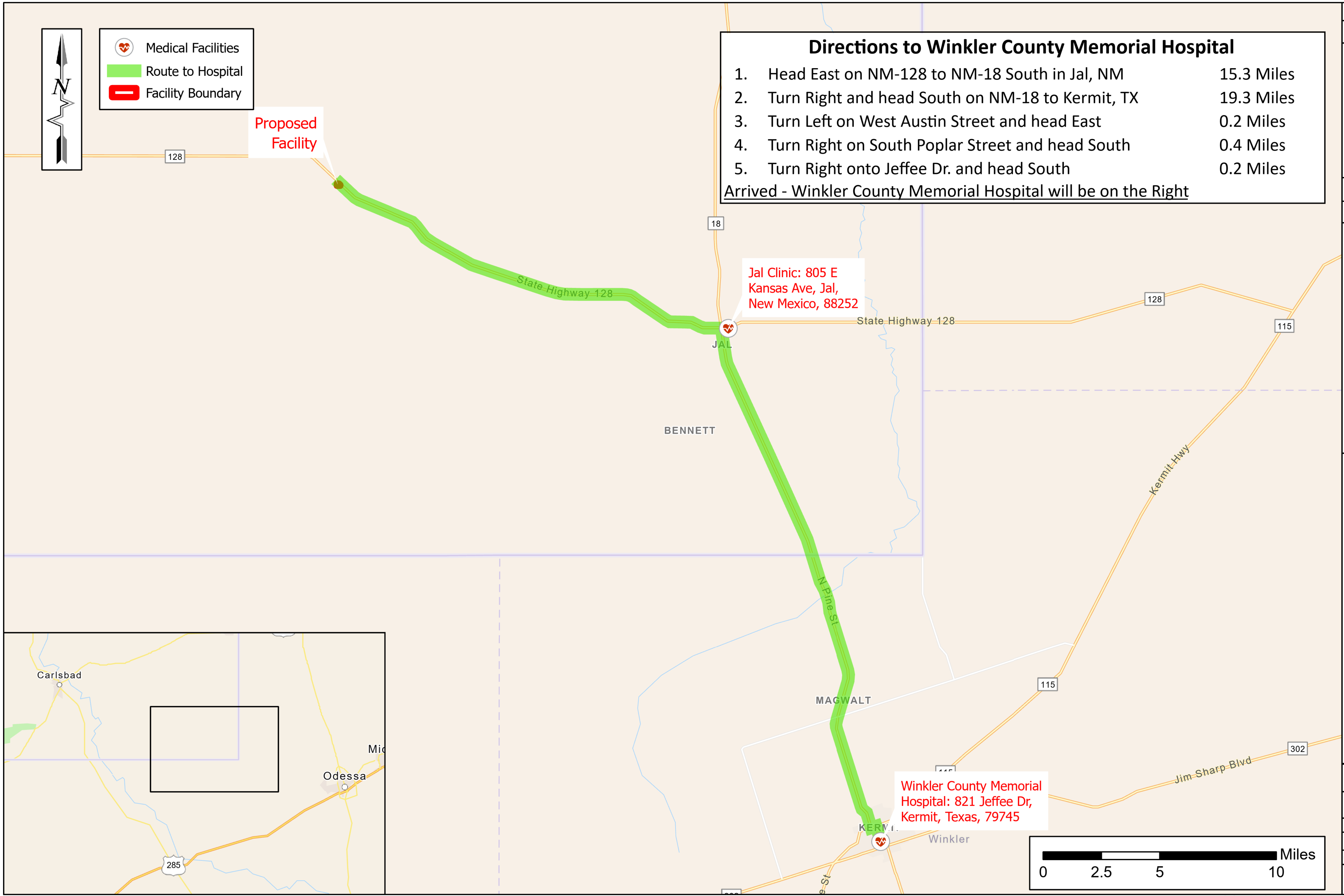
THIS DRAWING IS INCOMPLETE AND NOT TO BE USED FOR CONSTRUCTION UNLESS IT IS STAMPED, SIGNED AND DATED

Designed	Drawn	Checked
MAE	MAE	MJK

Date: 4/15/2025
Scale: Horiz: - 1" = 75'
Vert: -
Project No: 1C3668
Sheet: FIGURE 4

Sources: ESRI, Souder, Miller & Associates

P:\5-Moonshine Energy C137 Oil Treatment Permitting (5E33797)\GIS\Moonshine Jal Facility C137 Permit



Directions to Winkler County Memorial Hospital

1.	Head East on NM-128 to NM-18 South in Jal, NM	15.3 Miles
2.	Turn Right and head South on NM-18 to Kermit, TX	19.3 Miles
3.	Turn Left on West Austin Street and head East	0.2 Miles
4.	Turn Right on South Poplar Street and head South	0.4 Miles
5.	Turn Right onto Jeffee Dr. and head South	0.2 Miles

Arrived - Winkler County Memorial Hospital will be on the Right

Rev #	Date	Description	By	Chkd

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Phone: (505) 299-0942

MOONSHINE ENERGY, LLC
C-137 APPLICATION

DIRECTIONS TO NEAREST
MEDICAL FACILITIES
THE BIG STILL WASTE FACILITY
LEA COUNTY, NM

THIS DRAWING IS INCOMPLETE AND NOT TO BE USED FOR CONSTRUCTION UNLESS IT IS STAMPED, SIGNED AND DATED

Designed	Drawn	Checked
MAE	MAE	MJK

Date: 12/20/2024
Scale: Horiz: - 1" = 20,833' Vert: -
Project No: 1C33668
Sheet: FIGURE 5

Sources: ESRI, Souder, Miller & Associates

P:\5-Moonshine Energy C137 Oil Treatment Permitting (5E33797)\GIS\Moonshine Jal Facility C137 Permit

ATTACHMENT 1

Incident Report Form

INCIDENT REPORT FORM

Moonshine Energy, LLC. Big Still Oil Treatment Facility
NM-128, Lea County, New Mexico

Type of Incident and General Information

☐ Work Related Injury/Illness	☐ Vandalism/Criminal Activity
☐ Property Damage	☐ Fire
☐ Vehicular Accident	☐ Release/Spill
☐ Unsafe Act/Near Miss	☐ Other:____________(explosion, fall, etc.)

Employee Name:_____________________________ Job Title:______________________________

Phone No:________________ Date of Incident: _____________ Time of Incident:______________

Location of Incident:____

Start of Shift:_____________________________ Weather:______________________________

Date & Time Reported to Management: Date: _____________ Time:______________

Reported to:____________________ Title: _________________ Reported by:_________________

Injury Category of Incident when First Reported

- ☐ N/A: Employee does not claim an injury associated with the incident
- ☐ Notice Only of Incident, Declined Medical Treatment at this time
- ☐ First Aid done on site, Declined Medical Treatment at this time
- ☐ Medical Treatment. Transported by:___________________ to:______________________
- ☐ Fatality. Employee Name: ____

Employee's Description of Incident

Were you injured?	☐ Yes	☐ No
Type of Injury:		
Area of Body:		
Explanation of Incident (in your own words):		

TO BE COMPLETED BY EMERGENCY COORDINATOR
Describe the order and sequence of events leading to the incident and/or injury:
Identify possible hazards to human health or the environment:
Identify name and quantity of material(s) involved:

CORRECTIVE ACTIONS
Equipment, Practices, Environment, Retraining) Steps that have been, or will be, taken to prevent recurrence:
Date Corrective Action Completed:

Employee Signature: ____ Date: _____________________

Report Reviewed & Concluded by:

____ _____________________

Emergency Coordinator Signature Date

ATTACHMENT 2

Hydrogen Sulfide & Sulfur Dioxide Summary Sheets

Print

CAMEO Chemicals

Chemical Datasheet

HYDROGEN SULFIDE

Chemical Identifiers

CAS Number	UN/NA Number	DOT Hazard Label	USCG CHRIS Code
7783-06-4	1053	Poison Gas Flammable Gas	HDS

NIOSH Pocket Guide	International Chem Safety Card
Hydrogen sulfide	HYDROGEN SULFIDE

NFPA 704

Diamond	Hazard	Value	Description
4 4 0	◆ Health	4	Can be lethal.
	◆ Flammability	4	Burns readily. Rapidly or completely vaporizes at atmospheric pressure and normal ambient temperature.
	◆ Instability	0	Normally stable, even under fire conditions.
	◇ Special		

(NFPA, 2010)

General Description

A colorless gas having a strong odor of rotten eggs. Boiling point -60.2°C. Shipped as a liquid confined under its own vapor pressure. Density (liquid) 8.3 lb / gal. Contact with the unconfined liquid can cause frostbite by evaporative cooling. Gas is very toxic by inhalation. Fatigues the sense of smell which cannot be counted on to warn of the continued presence of the gas. Prolonged exposure of closed containers to heat may result in their violent rupturing and rocketing.

Rate of onset: Immediate & Delayed

Persistence: Minutes to hours

Odor threshold: 0.1 ppm

Source/use/other hazard: Disinfectant lubricant/oils; interm for HC manufacture; deadens sense of smell.

Hazards

Reactivity Alerts

Highly Flammable

Air & Water Reactions

Highly flammable; a flame can very easily flash back to the source of leak.

Fire Hazard

Compound is heavier than air and may travel a considerable distance to source of ignition and flash back. It forms explosive mixtures with air over a wide range. Also reacts explosively with bromine pentafluoride, chlorine trifluoride, nitrogen triiodide, nitrogen trichloride, oxygen difluoride, and phenyl diazonium chloride. When heated to decomposition, it emits highly toxic fumes of oxides of sulfur. Incompatible with many materials including strong oxidizers, metals, strong nitric acid, bromine pentafluoride, chlorine trifluoride, nitrogen triiodide, nitrogen trichloride, oxygen difluoride and phenyl diazonium chloride. Avoid physical damage to containers; sources of ignition; storage near nitric acid, strong oxidizing materials, and corrosive liquids or gases. (EPA, 1998)

Health Hazard

Exposure to very high concentrations causes immediate death. Also death or permanent injury may occur after very short exposure to small quantities. It acts directly upon the nervous system resulting in paralysis of respiratory centers. (EPA, 1998)

Reactivity Profile

HYDROGEN SULFIDE reacts as an acid and as a reducing agent. Explodes on contact with oxygen difluoride, bromine pentafluoride, chlorine trifluoride, dichlorine oxide, silver fulminate. May ignite and explode when exposed to powdered copper in oxygen [Mertz, V. et al., Ber., 1880, 13, p. 722]. May react similarly with other powdered metals. Ignites on contact with metal oxides and peroxides (barium peroxide, chromium trioxide, copper oxide, lead dioxide, manganese dioxide, nickel oxide, silver oxide, silver dioxide, thallium trioxide, sodium peroxide, mercury oxide, calcium oxide) [Mellor, 1947, vol. 10, p. 129, 141]. Ignites with silver bromate, lead(II) hypochlorite, copper chromate, nitric acid, lead(IV) oxide and rust. May ignite if passed through rusty iron pipes [Mee, A. J., School Sci. Rev., 1940, 22(85), p. 95]. Reacts exothermically with bases. The heat of the reaction with soda lime, sodium hydroxide, potassium hydroxide, barium hydroxide may lead to ignition or explosion of the unreacted portion in the presence of air / oxygen [Mellor, 1947, vol. 10, p. 140].

Belongs to the Following Reactive Group(s)

- Sulfides, Inorganic

Potentially Incompatible Absorbents

No information available.

Response Recommendations

Isolation and Evacuation

Excerpt from ERG Guide 117 [Gases - Toxic - Flammable (Extreme Hazard)]:

IMMEDIATE PRECAUTIONARY MEASURE: Isolate spill or leak area for at least 100 meters (330 feet) in all directions.

SPILL: See ERG Table 1 - Initial Isolation and Protective Action Distances on the UN/NA 1053 datasheet.

FIRE: If tank, rail tank car or highway tank is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions. (ERG, 2024)

Firefighting

Stop flow of gas. Use water to keep fire-exposed containers cool and to protect men effecting the shut-off. Keep unnecessary people away; isolate hazard area and deny entry. Stay upwind; keep out of low areas. Ventilate closed spaces before entering them. Wear positive pressure breathing apparatus and special protective clothing. Evacuate area endangered by gas. Move container from fire area. Stay away from ends of tanks. Withdraw immediately in case of rising sound from venting safety device or any discoloration on tank due to fire. Cool containers with water using unmanned device until well after the fire is out. Isolate for one-half mile in all directions if tank car or truck is involved in fire.

A very flammable gas. For small fires let burn unless leak can be stopped immediately. For large fires, use water spray, fog or foam. (EPA, 1998)

Non-Fire Response

Excerpt from ERG Guide 117 [Gases - Toxic - Flammable (Extreme Hazard)]:

ELIMINATE all ignition sources (no smoking, flares, sparks or flames) from immediate area. All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. Do not direct water at spill or source of leak. If possible, turn leaking containers so that gas escapes rather than liquid. Prevent entry into waterways, sewers, basements or confined areas. Isolate area until gas has dispersed. Consider igniting spill or leak to eliminate toxic gas concerns. (ERG, 2024)

Protective Clothing

Excerpt from NIOSH Pocket Guide for Hydrogen sulfide:

Skin: FROSTBITE - Compressed gases may create low temperatures when they expand rapidly. Leaks and uses that allow rapid expansion may cause a frostbite hazard. Wear appropriate personal protective clothing to prevent the skin from becoming frozen.

Eyes: FROSTBITE - Wear appropriate eye protection to prevent eye contact with the liquid that could result in burns or tissue damage from frostbite.

Wash skin: No recommendation is made specifying the need for washing the substance from the skin (either immediately or at the end of the work shift).

Remove: WHEN WET (FLAMMABLE) - Work clothing that becomes wet should be immediately removed due to its flammability hazard (i.e., for liquids with a flash point <100°F).

Change: No recommendation is made specifying the need for the worker to change clothing after the workshift.

Provide: FROSTBITE WASH - Quick drench facilities and/or eyewash fountains should be provided within the immediate work area for emergency use where there is any possibility of exposure to liquids that are extremely cold or rapidly evaporating. (NIOSH, 2024)

DuPont Tychem® Suit Fabrics

Normalized Breakthrough Times (in Minutes)

Chemical	CAS Number	State	QS	QC	SL	C3	TF	TP	RC	TK	RF
Hydrogen sulfide	7783-06-4	Vapor				imm		>480	>480	>480	>480

> indicates greater than.
"imm" indicates immediate; having a normalized breakthrough time of 10 minutes or less.

Special Warning from DuPont: Tychem® and Tyvek® fabrics should not be used around heat, flames, sparks or in potentially flammable or explosive environments. Only...

(DuPont, 2024)

First Aid

Warning: Caution is advised. Vital signs should be monitored closely.

Signs and Symptoms of Acute Hydrogen Sulfide Exposure: Signs and symptoms of acute exposure to hydrogen sulfide may include tachycardia (rapid heart rate) or bradycardia (slow heart rate), hypotension (low blood pressure), cyanosis (blue tint to skin and mucous membrane), cardiac palpitations, and cardiac arrhythmias. Dyspnea (shortness of breath), tachypnea (rapid respiratory rate), bronchitis, pulmonary edema, respiratory depression, and respiratory paralysis may occur. Neurological effects include giddiness, irritability, drowsiness, weakness, confusion, delirium, amnesia, headache, sweating, and dizziness. Muscle cramping, tremor, excessive salivation, cough, convulsions, and coma may be noted. Nausea, vomiting, and diarrhea are commonly seen. Exposure to hydrogen sulfide gas may result in skin irritation, lacrimation (tearing), inability to detect odors, photophobia (heightened sensitivity to light), and blurred vision.

Emergency Life-Support Procedures: Acute exposure to hydrogen sulfide may require decontamination and life support for the victims. Emergency personnel should wear protective clothing appropriate to the type and degree of contamination. Air-purifying or supplied-air respiratory equipment should also be worn, as necessary. Rescue vehicles should carry supplies such as plastic sheeting and disposable plastic bags to assist in preventing spread of contamination.

Inhalation Exposure:
1. Move victims to fresh air. Emergency personnel should avoid self-exposure to hydrogen sulfide.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
3. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
4. RUSH to a health care facility!

Dermal/Eye Exposure:
1. Remove victims from exposure. Emergency personnel should avoid self- exposure to hydrogen sulfide.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
3. Remove contaminated clothing as soon as possible.
4. If eye exposure has occurred, eyes must be flushed with lukewarm water for at least 15 minutes.
5. Wash exposed skin areas for at least 15 minutes with soap and water.
6. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
7. RUSH to a health care facility!

Ingestion Exposure: No information is available. (EPA, 1998)

Physical Properties

Chemical Formula: H_2S

Flash Point: data unavailable

Lower Explosive Limit (LEL): 4.3 % (EPA, 1998)

Upper Explosive Limit (UEL): 45 % (EPA, 1998)

Autoignition Temperature: 500°F (USCG, 1999)

Melting Point: -121.9°F (EPA, 1998)

Vapor Pressure: 15200 mmHg at 77.9°F (EPA, 1998)

Vapor Density (Relative to Air): 1.19 (EPA, 1998) - Heavier than air; will sink

Specific Gravity: 0.916 at -76°F (EPA, 1998) - Less dense than water; will float

Boiling Point: -76.59°F at 760 mmHg (EPA, 1998)

Molecular Weight: 34.08 (EPA, 1998)

Water Solubility: 0.4 % (NIOSH, 2024)

Ionization Energy/Potential: 10.46 eV (NIOSH, 2024)

IDLH: 100 ppm (NIOSH, 2024)

AEGLs (Acute Exposure Guideline Levels)

Final AEGLs for Hydrogen sulfide (7783-06-4)

Exposure Period	AEGL-1	AEGL-2	AEGL-3
10 minutes	0.75 ppm	41 ppm	76 ppm
30 minutes	0.6 ppm	32 ppm	59 ppm
60 minutes	0.51 ppm	27 ppm	50 ppm
4 hours	0.36 ppm	20 ppm	37 ppm
8 hours	0.33 ppm	17 ppm	31 ppm

Level of Odor Awareness = 0.01 ppm
(NAC/NRC, 2024)

ERPGs (Emergency Response Planning Guidelines)

Chemical	ERPG-1	ERPG-2	ERPG-3
Hydrogen Sulfide (7783-06-4)	0.1 ppm ✪	30 ppm	100 ppm

✪ indicates that odor should be detectable near ERPG-1.
(AIHA, 2022)

PACs (Protective Action Criteria)

Chemical	PAC-1	PAC-2	PAC-3	
Hydrogen sulfide (7783-06-4)	0.51 ppm	27 ppm	50 ppm	LEL = 40000 ppm

(DOE, 2024)

Regulatory Information

EPA Consolidated List of Lists

Regulatory Name	CAS Number/ 313 Category Code	EPCRA 302 EHS TPQ	EPCRA 304 EHS RQ	CERCLA RQ	EPCRA 313 TRI	RCRA Code	CAA 112(r) RMP TQ
Hydrogen sulfide	7783-06-4	500 pounds	100 pounds	100 pounds	313	U135	10000 pounds

(EPA List of Lists, 2024)

CISA Chemical Facility Anti-Terrorism Standards (CFATS)

		RELEASE			THEFT			SABOTAGE		
Chemical of Interest	**CAS Number**	**Min Conc**	**STQ**	**Security Issue**	**Min Conc**	**STQ**	**Security Issue**	**Min Conc**	**STQ**	**Security Issue**
Hydrogen sulfide	7783-06-4	1.00 %	10000 pounds	toxic	23.73 %	45 pounds	WME			

WME = weapons of mass effect.

(CISA, 2007)

OSHA Process Safety Management (PSM) Standard List

Chemical Name	CAS Number	Threshold Quantity (TQ)
Hydrogen Sulfide	7783-06-4	1500 pounds

(OSHA, 2019)

Alternate Chemical Names

- DIHYDROGEN MONOSULFIDE
- DIHYDROGEN SULFIDE
- HYDROGEN SULFIDE
- HYDROGEN SULFIDE, LIQUEFIED
- HYDROGEN SULPHIDE
- HYDROGEN SULPHIDE, LIQUEFIED
- HYDROSULFURIC ACID
- SEWER GAS
- STINK DAMP
- SULFUR DIHYDRIDE
- SULFUR HYDRIDE
- SULFUR HYDRIDE (SH2)
- SULFURETED HYDROGEN
- SULFURETTED HYDROGEN
- SULPHURETTED HYDROGEN

Print

CAMEO Chemicals

Chemical Datasheet

SULFUR DIOXIDE

Chemical Identifiers

CAS Number	**UN/NA Number**	**DOT Hazard Label**	**USCG CHRIS Code**
7446-09-5	1079	Poison Gas Corrosive	SFD

NIOSH Pocket Guide	**International Chem Safety Card**
Sulfur dioxide	SULPHUR DIOXIDE

NFPA 704

Diamond	Hazard	Value	Description
0 3 0	◆ Health	3	Can cause serious or permanent injury.
	◆ Flammability	0	Will not burn under typical fire conditions.
	◆ Instability	0	Normally stable, even under fire conditions.
	◇ Special		

(NFPA, 2010)

General Description

A colorless gas with a choking or suffocating odor. Boiling point -10°C. Heavier than air. Very toxic by inhalation and may irritate the eyes and mucous membranes. Under prolonged exposure to fire or heat the containers may rupture violently and rocket. Used to manufacture chemicals, in paper pulping, in metal and food processing.

Rate of onset: Immediate & Delayed

Persistence: Minutes to hours

Odor threshold: 1 ppm

Source/use/other hazard: Disinfectant and preserving in breweries and food/canning; textile industry; batteries.

Hazards

Reactivity Alerts

Water-Reactive

Air & Water Reactions

Dissolves in water to form sulfurous acid, a corrosive liquid. Moist sulfur dioxide is very corrosive due to the slow formation of sulfuric acid [Handling Chemicals Safely 1980 p. 876].

Fire Hazard

Containers may explode in heat of fire or they may rupture and release irritating toxic sulfur dioxide. Sulfur dioxide has explosive properties when it comes in contact with sodium hydride; potassium chlorate at elevated temperatures; ethanol; ether; zinc ethylsulfurinate at very cool temperatures (-15C); fluorine; chlorine trifluoride and chlorates. It will react with water or steam to produce toxic and corrosive fumes. When the liquid is heated it may release irritating, toxic sulfur dioxide gas. Avoid ammonia, monocesium or monopotassium acetylide; dicesium monoxide; iron (II) oxide; tin oxide; lead (IV) oxide; chromium; manganese; molten sodium, powder aluminum and rubidium. Sulfur dioxide has explosive properties when it comes in contact with sodium hydride; potassium chlorate at elevated temperatures; ethanol; ether; zinc ethylsulfurinate at very cool temperatures (-15C); fluorine; chlorine trifluoride and chlorates. It will react with water or steam to produce toxic and corrosive fumes. Hazardous polymerization may not occur. (EPA, 1998)

Health Hazard

It may cause death or permanent injury after very short exposure to small quantities. 1,000 ppm causes death in from 10 minutes to several hours by respiratory depression. It is an eye and respiratory tract irritant. Persons with asthma, subnormal pulmonary functions or cardiovascular disease are at a greater risk. (EPA, 1998)

Reactivity Profile

SULFUR DIOXIDE is acidic. Reacts exothermically with bases such as amines, amides, metal oxides, and hydroxides. Frequently used as a reducing agent although it is not a powerful one. Acts as a reducing bleach to decolorize many materials. Can act as an oxidizing agent. Supports combustion of powdered aluminum [Mellor 5:209-212 1946-47]. Reacts explosively with fluorine [Mellor 2:1 1946-47]. Supports burning of manganese [Mellor 12:187 1946-47]. Readily liquefied by compression. Contact between the liquid and water may result in vigorous or violent boiling and extremely rapid vaporization. If the water is hot an explosion may occur. Pressures may build to dangerous levels if the liquid contacts water in a closed container [Handling Chemicals Safely 1980]. Supports incandescent combustion of monocesium acetylide, monopotassium acetylide, cesium oxide, iron(II) oxide, tin oxide, and lead oxide [Mellor]. Ethylene oxide and SO_2 can react violently in pyridine solution with pressurization if ethylene oxide is in excess (Nolan, 1983, Case History 51).

Belongs to the Following Reactive Group(s)

- Acids, Strong Non-oxidizing
- Reducing Agents, Weak

Potentially Incompatible Absorbents

No information available.

Response Recommendations

Isolation and Evacuation

Excerpt from ERG Guide 125 [Gases - Toxic and/or Corrosive]:

IMMEDIATE PRECAUTIONARY MEASURE: Isolate spill or leak area for at least 100 meters (330 feet) in all directions.

SPILL: See ERG Tables 1 and 3 - Initial Isolation and Protective Action Distances on the UN/NA 1079 datasheet.

FIRE: If tank, rail tank car or highway tank is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions. (ERG, 2024)

Firefighting

Wear self-contained breathing apparatus and full protective clothing. Move container from fire area. Stay away from ends of tanks. Cool containers that are exposed to flames with water from the side until well after the fire is out. Isolate area until gas has dispersed. Keep unnecessary people away.

Not flammable. Extinguish fires with dry chemical, carbon dioxide, water spray, fog or foam. (EPA, 1998)

Non-Fire Response

Excerpt from ERG Guide 125 [Gases - Toxic and/or Corrosive]:

Do not touch or walk through spilled material. Stop leak if you can do it without risk. If possible, turn leaking containers so that gas escapes rather than liquid. Prevent entry into waterways, sewers, basements or confined areas. Do not direct water at spill or source of leak. Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. Isolate area until gas has dispersed. (ERG, 2024)

Protective Clothing

Excerpt from NIOSH Pocket Guide for Sulfur dioxide:

Skin: FROSTBITE - Compressed gases may create low temperatures when they expand rapidly. Leaks and uses that allow rapid expansion may cause a frostbite hazard. Wear appropriate personal protective clothing to prevent the skin from becoming frozen.

Eyes: FROSTBITE - Wear appropriate eye protection to prevent eye contact with the liquid that could result in burns or tissue damage from frostbite.

Wash skin: No recommendation is made specifying the need for washing the substance from the skin (either immediately or at the end of the work shift).

Remove: WHEN WET OR CONTAMINATED (LIQUID) - If this chemical is in liquid form, work clothing that becomes wet or significantly contaminated should be removed and replaced.

Change: No recommendation is made specifying the need for the worker to change clothing after the workshift.

Provide: FROSTBITE WASH - Quick drench facilities and/or eyewash fountains should be provided within the immediate work area for emergency use where there is any possibility of exposure to liquids that are extremely cold or rapidly evaporating. (NIOSH, 2024)

DuPont Tychem® Suit Fabrics

Normalized Breakthrough Times (in Minutes)

Chemical	CAS Number	State	QS	QC	SL	C3	TF	TP	RC	TK	RF
Sulfur dioxide	7446-09-5	Vapor		imm	>480		28*/46	26*/37	>480	>480	>480

> indicates greater than.
"imm" indicates immediate; having a normalized breakthrough time of 10 minutes or less.
* indicates based on lowest single value.

Special Warning from DuPont: Tychem® and Tyvek® fabrics should not be used around heat, flames, sparks or in potentially flammable or explosive environments. Only...

(DuPont, 2024)

First Aid

Note: Persons with asthma, subnormal pulmonary function, or cardiovascular disease are at greater risk.

Signs and Symptoms of Acute Sulfur Dioxide Exposure: Sulfur dioxide may irritate the eyes and respiratory tract. Signs and symptoms of acute exposure to sulfur dioxide may be severe and include coughing, choking, dyspnea (shortness of breath), sneezing, wheezing, and chest discomfort. Upper airway edema (swelling) or obstruction, bronchoconstriction, pneumonia, pulmonary edema, and respiratory paralysis may occur. Fatigue may be noted. Gastrointestinal effects may include nausea, vomiting, and abdominal pain. Cyanosis (blue tint to skin and mucous membranes) may be noted following exposure to sulfur dioxide.

Emergency Life-Support Procedures: Acute exposure to sulfur dioxide may require decontamination and life support for the victims. Emergency personnel should wear protective clothing appropriate to the type and degree of contamination. Air-purifying or supplied-air respiratory equipment should also be worn, as necessary. Rescue vehicles should carry supplies such as plastic sheeting and disposable plastic bags to assist in preventing spread of contamination.

Inhalation Exposure:
1. Move victims to fresh air. Emergency personnel should avoid self-exposure to sulfur dioxide.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
3. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
4. Transport to a health care facility.

Dermal/Eye Exposure:
1. Remove victims from exposure. Emergency personnel should avoid self- exposure to sulfur dioxide.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
3. Remove contaminated clothing as soon as possible.
4. If eye exposure has occurred, eyes must be flushed with lukewarm water for at least 15 minutes.
5. Wash exposed skin areas with soap and water.
6. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
7. Transport to a health care facility.

Ingestion Exposure: No information is available. (EPA, 1998)

Physical Properties

Chemical Formula: SO_2

Flash Point: data unavailable

Lower Explosive Limit (LEL): data unavailable

Upper Explosive Limit (UEL): data unavailable

Autoignition Temperature: Not flammable (USCG, 1999)

Melting Point: -98.9°F (EPA, 1998)

Vapor Pressure: 2432 mmHg at 68°F (EPA, 1998)

Vapor Density (Relative to Air): 2.26 (EPA, 1998) - Heavier than air; will sink

Specific Gravity: 1.434 (EPA, 1998) - Denser than water; will sink

Boiling Point: 14°F at 760 mmHg (EPA, 1998)

Molecular Weight: 64.07 (EPA, 1998)

Water Solubility: 10 % (NIOSH, 2024)

Ionization Energy/Potential: 12.30 eV (NIOSH, 2024)

IDLH: 100 ppm (NIOSH, 2024)

AEGLs (Acute Exposure Guideline Levels)

Final AEGLs for Sulfur Dioxide (7446-09-5)

Exposure Period	AEGL-1	AEGL-2	AEGL-3
10 minutes	0.2 ppm	0.75 ppm	30 ppm
30 minutes	0.2 ppm	0.75 ppm	30 ppm
60 minutes	0.2 ppm	0.75 ppm	30 ppm
4 hours	0.2 ppm	0.75 ppm	19 ppm
8 hours	0.2 ppm	0.75 ppm	9.6 ppm

(NAC/NRC, 2024)

ERPGs (Emergency Response Planning Guidelines)

Chemical	ERPG-1	ERPG-2	ERPG-3
Sulfur Dioxide (7446-09-5)	0.3 ppm ✪	3 ppm	25 ppm

✪ indicates that odor should be detectable near ERPG-1.

(AIHA, 2022)

PACs (Protective Action Criteria)

Chemical	PAC-1	PAC-2	PAC-3
Sulfur dioxide (7446-09-5)	0.2 ppm	0.75 ppm	30 ppm

(DOE, 2024)

Regulatory Information

EPA Consolidated List of Lists

Regulatory Name	CAS Number/ 313 Category Code	EPCRA 302 EHS TPQ	EPCRA 304 EHS RQ	CERCLA RQ	EPCRA 313 TRI	RCRA Code	CAA 112(r) RMP TQ
Sulfur dioxide	7446-09-5	500 pounds	500 pounds				
Sulfur dioxide (anhydrous)	7446-09-5	500 pounds	500 pounds				5000 pounds

(EPA List of Lists, 2024)

CISA Chemical Facility Anti-Terrorism Standards (CFATS)

		RELEASE			THEFT			SABOTAGE		
Chemical of Interest	**CAS Number**	**Min Conc**	**STQ**	**Security Issue**	**Min Conc**	**STQ**	**Security Issue**	**Min Conc**	**STQ**	**Security Issue**
Sulfur dioxide (anhydrous)	7446-09-5	1.00 %	5000 pounds	toxic	84.00 %	500 pounds	WME			

WME = weapons of mass effect.

(CISA, 2007)

OSHA Process Safety Management (PSM) Standard List

Chemical Name	CAS Number	Threshold Quantity (TQ)
Sulfur Dioxide (liquid)	7446-09-5	1000 pounds

(OSHA, 2019)

Alternate Chemical Names

- FERMENTICIDE LIQUID
- SULFUR DIOXIDE
- SULFUR DIOXIDE (ANHYDROUS)
- SULFUR DIOXIDE (SO2)
- SULFUR DIOXIDE, LIQUEFIED
- SULFUR OXIDE
- SULFUR OXIDE (SO2)
- SULFUR SUPEROXIDE
- SULFUROUS ACID ANHYDRIDE
- SULFUROUS ANHYDRIDE
- SULFUROUS OXIDE
- SULPHUR DIOXIDE
- SULPHUR DIOXIDE, LIQUEFIED

ATTACHMENT 3

H_2S Equipment Specification/Cut Sheets

Honeywell | Gas Detection
THE POWER OF **CONNECTED**

BW Clip Series

Maintenance-Free Single-Gas Detectors

The most user-friendly, reliable and cost-effective way to ensure safety, compliance and productivity.

The BW Clip Series of single-gas detectors provides up to three years maintenance-free operation: Just turn on the device and it runs continuously — no need for calibration, sensor replacement, battery replacement or battery charging. That means great reliability and no downtime.

Plus, with the two-year version for H_2S or CO, you can put the device in a hibernation case when you're not using it for a week or more — and extend its life by that period of time.

Choose from two detectors; both of which are compact, lightweight and easy to handle, while tough enough for harsh environments and extreme temperatures:

- BW Clip – provides standard operation and no calibration
- BW Clip Real Time – includes a real-time gas level display and the ability to calibrate the device.

Both detectors are compatible with the IntelliDoX instrument management system.

Use our unique advanced technology for safety, compliance and productivity.

- **Surecell™**: unique dual reservoir sensor design dramatically improves instrument performance, response time, and longevity compared to traditional electrochemical sensors and consistently delivers reliable instrument performance under the harshest environmental conditions
- **Reflex Technology™**: advanced automated self-test function routinely checks the operating condition of the sensor to increase safety, up-time, and overall worker confidence
- **IntelliDoX:** instrument management system
  - The quickest bump test in the industry
  - Configuration of alarm set points and more
  - Performing different tests for up to five BW Clip detectors at once — for maximum productivity
  - Easy and accurate record-keeping

Configurable Options:

- Configuration of high and low alarm set points before the device is activated
- Adjustment of alarm set points and other parameters as needed throughout the lifespan
- Option to enable the noncompliance indicator, which flashes red when a bump test is due or a gas event occurs
- Option to display gas reading during alarm (BW Clip only)
- User settable bump test reminder
- User settable calibration reminder (BW Clip Real Time only)
- Option to display the Real Time Clock

FEATURES & BENEFITS

- Maintenance-free: no sensor or battery changes necessary
- Compact, lightweight design with one-button operation
- Designed for a range of harsh environments and extreme temperatures
- Hibernation mode with case accessory or IntelliDoX
- Automated self-test of battery, sensor and electronics
- Wide-angle flash, which alerts simultaneously with audible and vibrating alarm
- Automatic logging of the 35 most recent gas events and bump test results
- Affordable, with low cost of ownership
- Device Management with Honeywell SafetySuite

BW Clip Series Specifications

BW CLIP SERIES SPECIFICATIONS	
SIZE	1.6 x 2.0 x 3.4 in. / 4.1 x 5.0 x 8.7 cm
WEIGHT	3.2 oz. / 92 g
TEMPERATURE	H_2S: -40 to +122°F / -40 to +50°C CO: -22 to +122°F / -30 to +50°C O_2: -4 to +122°F / -20 to +50°C SO_2: -22 to +122°F / -30 to +50°C
HUMIDITY	5% - 95% RH (non-condensing)
ALARMS	Visual, vibrating, audible (95 dB) • Low, High
TESTS	Activated detectors automatically perform one internal diagnostic test every 24 hours
TYPICAL BATTERY LIFE	Two years (H_2S, CO, O_2 or SO_2) or three years (H_2S or CO) depending on the version
EVENT LOGGING	35 most recent events
INGRESS PROTECTION	IP 66/67
CERTIFICATIONS AND APPROVALS	CLASSIFIED c UL us Class I, Div. 1, Gr. A, B, C, D. Class I, Zone 0 , Gr. IIC **ATEX:** II 1G Ex ia IIC T4 Ga **IECEx:** Ex ia IIC T4 Ga CE European Conformity American Bureau of Shipping EAC Ex CU TR Ex (Customs Union)
WARRANTY	Two or three years from activation (given normal operation), plus one year shelf life (6 months for O_2). Up to three years for two-year H_2S and CO detectors when used with the hibernation feature, limited to 24 months of detector operation.

SENSOR SPECIFICATIONS

GAS	MEASURING RANGE	LOW ALARM LEVEL	HIGH ALARM LEVEL
2 OR 3 YEAR DETECTOR			
H_2S	0 -100 ppm	10 ppm	15 ppm
CO	0 - 300 ppm	35 ppm	200 ppm
2 YEAR DETECTOR			
O_2	0 - 25.0 % by vol.	19.5 %	23.5 %
SO_2	0 - 100 ppm	5 ppm	10 ppm

ALARM SETPOINTS ARE USER ADJUSTABLE BEFORE AND AFTER ACTIVATING THE DETECTOR.
SET POINTS SHOWN ARE MOST COMMON DEFAULT VALUES. ADDITIONAL DEFAULT VALUES ARE AVAILABLE.

Easy gas identification with color coded labels and LCD indication:

H_2S

CO

O_2

SO_2

Optional Accessories

- Hibernation Case
- Hard Hat Clip
- IntelliDoX instrument management system

For a complete list of kits and accessories, please contact Honeywell.

For more information
www.honeywellanalytics.com

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Americas
detectgas@honeywell.com

Asia Pacific
analytics.ap@honeywell.com

Technical Services
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US: ha.us.service@honeywell.com
AP: ha.ap.service@honeywell.com

Device Management with
Honeywell SafetySuite

honeywellanalytics.com/
SafetySuite

Datasheet_BW Clip Series_DS20150108-04_US-EN | 04/18

Honeywell

OTIS
INSTRUMENTS INC.

OI-6900-O-2B Sensor Assembly

WireFree Dual Battery Ambient Air Hazardous Gas Detector

The Otis Instruments WireFree OI-6900 Series Ambient Air Hazardous Gas Detector is a wireless, dual battery-powered assembly that uses an Electrochemical, PID, or Low-Power Infrared sensor element to detect a variety of toxic or combustible gases. The OI-6900 offers non-intrusive calibration, allowing the device to remain Class I, Division 1, Groups B, C, and D certified, while adjustments are made in the field. The OI-6900 continuously monitors the gas level of the surrounding environment and reports once a minute, the reporting rate will increase to once every five seconds when the detected gas is above the Background Gas Set point. This set-point is adjustable to account for sites that may have a constant low level of gas always present. The display screen always shows the present gas concentration.

Gas Type	Range	T_{90}	Warranty
CO	0-1000 ppm	< 210 sec.	24 months
EC-CL2	0-10 ppm	< 60 sec.	12 months
EC-CLO2	0-1 ppm	< 120 sec.	12 months
EC-CO	0-1000 ppm	< 30 sec.	24 months
IR-CO2	0-5% vol.	< 30 sec.	60 months
EC-H2	0-4% vol.	< 60 sec.	18 months
EC-H2S	0-100 ppm	< 30 sec.	24 months
EC-H2S2K	0-2000 ppm	< 25 sec.	24 months
EC-HCL	0-30 ppm	< 300 sec.	12 months
EC-HCN	0-50 ppm	< 70 sec.	12 months
IR-LEL	0-100% LEL	< 30 sec.	60 months
EC-NH3	0-100 ppm	< 90 sec.	12 months
EC-NH3300	0-300 ppm	<120 sec.	12 months
EC-NH3A	0-1000 ppm	< 120 sec.	12 months
EC-NO2	0-20 ppm	< 25 sec.	12 months
EC-O2	0-25% vol.	< 15 sec.	24 months
EC-PH3	0-5 ppm	< 30 sec.	12 months
EC-SO2	0-20 ppm	< 35 sec.	24 months
PID-VOC10	0-10 ppm	< 3 sec.	6 months
PID-VOC20	0-20 ppm	< 3 sec.	6 months
PID-VOC50	0-50 ppm	< 3 sec.	6 months
PID-VOC1K	0-1000 ppm	< 3 sec.	6 months
PID-VOC2K	0-2000 ppm	< 3 sec.	6 months

c PSQ US
CERTIFIED

Reliable monitoring of hazardous gases in harsh conditions by use of the Otis wireless dual battery-powered detector.

Corporate Office

301 S. Texas Avenue
Bryan, Texas 77803
P: 979-776-7700

sales@otisinstruments.com

www.otisinstruments.com

Midland Office

3308 Norden Drive
Midland, Texas 79706
P: 432-563-5858

OI-6900-O-2B Sensor Assembly

WireFree Ambient Air Hazardous Gas Detector

OI-6900-O-2B Product Specifications	
Sensor Type	Electrochemical, Photo Ionization Detector, or Low-Power Infrared Sensor
Power Type	Dual Battery-Powered
Operating Voltage	3.6 V (19 Ah each, 38 Ah total) Lithium-Thionyl ($Li\text{-}SOCl_2$) Battery, with Connector (Non-Rechargeable)
Estimated Battery Life	• Low Power Infrared—1-Year Max Battery Life • Photo Ionization Detector– 14+ Days Battery Life • Electrochemical—2-Year Max Battery Life
RF Connection	External N-Female Radio Frequency (RF) Connector
Display Screen	102x64 Resolution Graphical LCD Screen Transflective (Sunlight Readable) with LED Backlight
Interface	3 Push-Buttons (MENU, ADD, and SUB) 3 Magnetic Non-Intrusive Switches for Calibration (MENU, ADD, and SUB)
Customizable Settings	Adjustable Background Gas Setting (1% to 10% of Full Scale)
T_{amb} Temperature Range	-40 to +54°C
WireFree Radio Options	GEN II 900 MHz (200 mW) Radio or GEN II 2.4 GHz (125 mW) Radio
Networks	52 Networks (GEN II 900 MHz Radio) or 78 Networks (GEN II 2.4 GHz Radio) 255 Addresses per Network
Product Dimensions	5.42 in. L x 6.03 in. W x 17.03 in. H (Max. Dimensions w/ Attachments)
Total Weight	6 lbs.
Remote Sensor Kit Additional feature	OI-501 Remote Sensor Kit with Enclosure (7 pin) • Electrochemical Sensor Max Length: 250 Feet • Low Power Infrared Sensor Max Length: 40 Feet • Photo Ionization Detector Max Length: 35 Feet
Hazardous Location Certifications and Approvals QPS Component Certified	Class I, Division 1, Groups B, C, and D T_{amb} –40°C to +60°C
Ex Location Certifications ATEX QPS 23ATEX5008X IECEx QPS 19.0025X	Ex db mb ia [ia Ga] IIB T6 Gb CE 2460 Ex II 2 (1) G -40°C ≤ Ta ≤ +54°C
Hardware Warranty	Limited one year
Sensor Element Warranty	Varies with Sensor Element and Type
Part Number Formula	OI-6900-[Gas]-[Radio]-[Enclosure]-[2 Battery] OI-6900-X-X-O-2B

ATTACHMENT 4

API RP-55 Recommended Practice for Oil and Gas Producing and Gas Processing Plan Operations involving Hydrogen Sulfide

Recommended Practice for Oil and Gas Producing and Gas Processing Plant Operations Involving Hydrogen Sulfide

Upstream Segment

API RECOMMENDED PRACTICE 55
SECOND EDITION, FEBRUARY 1995

REAFFIRMED, JANUARY 2013

AMERICAN PETROLEUM INSTITUTE

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FOREWORD

These recommended practices were prepared by the API Subcommittee on Production Operations Involving Hydrogen Sulfide. This standard is under the administration of the American Petroleum Institute Exploration & Production Department's Executive Committee on Drilling & Production Practices.

It is intended that these voluntary recommended practices serve as a guide to promote and maintain integrity of oil and/or gas producing and gas processing facilities in the interests of public safety, personnel safety, and protection of the environment. Users of this publication are reminded that constantly developing technology, specific company requirements and policy, and specialized or limited operations do not permit coverage of all possible operations, practices, or alternatives. This standard is not so comprehensive as to present *all* of the recommended practices for oil and gas well producing operations and gas processing plant operations involving hydrogen sulfide. Alternative operating procedures and/or equipment are available and routinely used to meet or exceed recommended practices or performance levels set forth herein. Recommendations presented in this publication are based on industry experience and expertise involving a wide range of operating locations and conditions. Recommendations presented in this publication are not intended to inhibit developing technology and equipment improvements or improved operating procedures. This publication, or portions thereof, cannot be substituted for qualified technical/operations analysis and judgment to fit a specific situation.

There may be federal, state, or local statutes, rules, or regulations requiring oil and gas producing and gas processing operations to be conducted in a safe or environmentally sound manner. Organizations and individuals using this standard are cautioned that requirements of federal, state, or local laws and regulations are constantly evolving. These requirements should be reviewed to determine whether the practices recommended herein and the operations being planned or conducted are consistent with current laws and regulations.

Information concerning safety and health risks and proper precautions with respect to particular materials and conditions should be obtained from the employer, the manufacturer or supplier of that material, or the material safety data sheet (MSDS).

Provisions of these voluntary recommended practices include use of the verbs "shall" and "should", whichever is deemed most applicable for the specific situation. For purposes of this publication, the following definitions are applicable.

Shall: Indicates the "recommended practice(s)" has universal applicability to that specific activity.

Should: Denotes a "recommended practice(s)" 1) where a safe comparable alternative practice(s) is available; 2) that may be impractical under certain circumstances; or 3) that may be unnecessary under certain circumstances.

Suggested revisions to these recommended practices are invited and should be submitted in writing to: Director, Exploration & Production Department, American Petroleum Institute, 700 North Pearl Street, Suite 1840, Dallas, Texas 75201-2845.

Recommended Practices for Oil and Gas Producing and Gas Processing Plant Operations Involving Hydrogen Sulfide

0 Introduction

The petroleum industry, through many years of research and operating experience, has developed guidelines for safe operations under conditions involving hydrogen sulfide. Continuing industry efforts, which include planning, prudent selection and layout of equipment, prudent selection of materials, operating and emergency procedures, specialized safety equipment, and appropriate personnel training are all necessary to ensure successful and safe operations. Effective response to emergencies requires prior planning. *Good engineering practice (engineering and administrative controls) dictates that producing and gas processing systems be designed to minimize exposure of personnel and the public to hydrogen sulfide and sulfur dioxide.*

1 Scope

Recommendations set forth in this publication apply to oil and gas producing and gas processing plant operations conducted with hydrogen sulfide present in the fluids being handled. The presence of hydrogen sulfide in these operations also presents the possibility of exposure to sulfur dioxide from the combustion of hydrogen sulfide. *Refer to Section 4 for applicability of this standard.*

2 References

2.1 STANDARDS

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. All standards are subject to revision, and users are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ACGIH[1]

1.		*Threshold Limit Values and Biological Exposure Indices (1993-94).*

ANSI[2]

2.	B31.3	*Chemical Plant and Petroleum Refining Piping.*
3.	B31.4	*Liquid Petroleum Transportation Piping Systems.*
4.	B31.8	*Gas Transmission and Distribution Piping Systems.*
5.	CGA G-7.1	*Breathing Air, Grade D.*
6.	ISEA 102	*Standard for Gas Detector Tube Units—Short Term Type for Toxic Gases and Vapors in Working Environments.*
7.	Z88.2	*Practices for Respiratory Protection.*

API[3]

8.	BUL E1	*Bulletin on the Generic Hazardous Chemical Category List and Inventory for the Oil and Gas Exploration & Production Industry.*
9.	BUL E2	*Bulletin on Management of Naturally Occurring Radioactive Materials (NORM) in Oil and Gas Production.*
10.	BUL E3	*Well Abandonment and Inactive Well Practices for U.S. Exploration and Production Operations.*
11.	BUL E4	*Release Reporting for the Oil and Gas Exploration and Production Industry as Required by the CWA, CERCLA, and SARA Title III.*
12.	RP12R1	*Recommended Practice for Setting, Maintenance, Inspection, Operation, and Repair of Tanks in Production Service.*
13.	RP14C	*Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms.*
14.	RP49	*Recommended Practice for Drilling and Drill Stem Testing Operations Involving Hydrogen Sulfide.*
15.	RP500	*Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities.*
16.	API 510	*Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration.*
17.	RP576	*Inspection of Pressure Relieving Devices.*
18.	RP750	*Management of Process Hazards.*
19.	STD 1104	*Welding of Pipelines and Related Facilities.*
20.	PUBL 2217A	*Guidelines for Work in Inert Confined Spaces in the Petroleum Industry.*

ASME[4]

21.		*Boiler & Pressure Vessel Code.*

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[1] American Conference of Governmental Industrial Hygienists, 1330 Kemper Drive, Cincinnati, OH 45240.

[2] American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

[3] American Petroleum Institute, Publications & Distribution Section, 1220 L Street NW, Washington, D.C. 20005.

[4] American Society of Mechanical Engineers, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.

EPA[5]

22.	EPA/600/8-86/026A	*Health Assessment Document for Hydrogen Sulfide.*

ISA[6]

23.	S12.15, Part I	*Performance Requirements for Hydrogen Sulfide Detection Instruments.*
24.	RP12.15, Part II	*Installation, Operation, and Maintenance of Hydrogen Sulfide Detection Instruments.*

NACE[7]

25.	MR0175-94	*Standard Material Requirements Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment.*

National Response Team[8]

26.	NRT-1	*Hazardous Materials Emergency Planning Guide.*
27.	*Technical Guidance*	*for Hazards Analysis, Emergency Planning for Extremely HazardousSubstances.*

NFPA[9]

28.	NFPA 70	*National Electrical Code.*
29.	NFPA 496	*Purged and Pressurized Enclosures for Electrical Equipment in Hazardous (Classified) Locations.*

NIOSH[10]

30.	NIOSH 74-111	*Criteria for a Recommended Standard for Occupational Exposure to Sulfur Dioxide (GPO No. 017-033-00029).*
31.	NIOSH 77-158	*Criteria for a Recommended Standard for Occupational Exposure to Hydrogen Sulfide (GPO No. 017-033-00217-7).*
32.	DHHS 85-114	*NIOSH Pocket Guide to Chemical Hazards.*

PACE[11]

33.	Report 85-5	*Review of Ambient Hydrogen Sulfide Standards in Canada.*

2.2 REGULATIONS

The following regulations are referenced in this standard. All regulations are subject to revision, and users should determine the latest version to ensure compliance. .

Bureau of Mines (DOI)[12]

34.	30 *CFR* Chapter 1, Subchapter B, Part II, Subpart H	*Respiratory Protection Devices.*

Coast Guard (DOT)[13]

35.	33 *CFR* Parts 140, 143, and 146	*Emergency Evacuation Plans for Manned OCS Facilities.*
36.	54 *FR* 21566, May 18, 1989	*Emergency Evacuation Plans for Manned OCS Facilities.*

DOT[14]

37.	49 *CFR* Part 178, Subpart C	*Shipping Container Specifications.*

EPA[5]

38.	40 *CFR* Part 264, Subpart D	*Contingency Plans and Emergency Procedures.*
39.	40 *CFR* Part 302	*Designation, Reportable Quantities, and Notification.*
40.	40 *CFR* Part 355	*Emergency Planning and Notification.*
41.	40 *CFR* Part 370	*Hazardous Chemical Reporting: Community Right-to-Know.*

MMS (DOI)[15]

42.	30 *CFR* Parts 250 & 256	*Oil, Gas, and Sulphur Operations in the Outer Continental Shelf.*
43.	53 *FR* 10596-10777, April 1, 1988	*Oil, Gas, and Sulphur Operations in the Outer Continental Shelf.*
44.	MMS-OCS-1	*Safety Requirements for Drilling Operations in a Hydrogen Sulfide Environment, Outer Continental Shelf. (February 1976).*

---

[5] Environmental Protection Agency, available from U.S. Government Printing Office, Washington, D.C. 20402.

[6] Instrument Society of America, Box 12277, Research Triangle Park, NC 27709.

[7] National Association of Corrosion Engineers, NACE International, Box 218340, Houston, Texas 77218-8340.

[8] National Response Team, National Oil and Hazardous Substances Contingency Plan GWDR/12, 2100 Second Street SW, Washington, D.C. 20593.

[9] National Fire Protection Association, 60 Batterymarch Park, Quincy, MA 02269.

[10] National Institute for Occupational Safety and Health (U.S. Department of Health, Education, and Welfare), available from U.S. Government Printing Office, Washington, D.C. 20402.

[11] Petroleum Association for Conservation of the Canadian Environment, 12002-275 Slater Street, Ottawa, Ontario, Canada LIP-5H9.

[12] Bureau of Mines, U.S. Department of Interior, available from U.S. Government Printing Office, Washington, D.C. 20402.

[13] Coast Guard, U.S. Department of Transportation, available from U.S. Government Printing Office, Washington, D.C. 20402.

[14] U.S. Department of Transportation, available from U.S. Government Printing Office, Washington, D.C. 20402.

[15] Minerals Management Service, U.S. Department of Interior, 381 Elden Street, Herndon, VA 22070-4817. Available from U.S. Government Printing Office, Washington, D.C. 20402.

45.	47 *FR* 28888, July 1, 1982	*Safety Requirements for Drilling Operations in a Hydrogen Sulfide Environment, Outer Continental Shelf. (July 1, 1982).*
OSHA[16]		
46.	29 *CFR* Part 1910.38	*Employee Emergency Plan and Fire Prevention Plans.*
47.	29 *CFR* Part 1910.119	*Process Safety Management of Highly Hazardous Chemicals.*
48.	29 *CFR* Part 1910.120	*Hazardous Waste Operations and Emergency Response.*
49.	54 *FR* Part 9294, March 6, 1989	*Hazardous Waste Operations and Emergency Response.*
50.	29 *CFR* Part 1910.134	*Respiratory Protection Standard.*
51.	29 *CFR* Part 1910.146	*Permit-required Confined Spaces.*
52.	29 *CFR* Part 1910.1000	*Toxic and Hazardous Substances (Air Contaminants).*
53.	54 *FR* 2332, January 19, 1989	*Air Contaminants.*
54.	58 *FR* 35338, June 30, 1993	*Air Contaminants.*
55.	29 *CFR* Part 1910.1200	*Hazard Communication Standard.*

2.3 OTHER REFERENCES

56. Poda, George A., “Hydrogen Sulfide Can Be Handled Safely”, *Archives of Environmental Health,* Vol. 12, 795-800, June 1966.

57. Ronk, Richard and White, M. K., “Hydrogen Sulfide and the Probabilities of Inhalation Through a Tympanic Membrane Defect”, *Journal of Occupational Medicine,* Vol. 25, No. 5, 337-340, May 1985.

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2.5 ACRONYMS AND ABBREVIATIONS

The following acronyms and abbreviations are used in this publication:

ACC	Acceptable Ceiling Concentration
ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	*Code of Federal Regulations*
CWA	*Clean Water Act*
DC	Direct Current
DOI	U. S. Department of Interior
DOL	U. S. Department of Labor
DOT	U. S. Department of Transportation
EMI	Electromagnetic Interference
EPA	Environmental Protection Agency
ERPG	*Emergency Response Planning Guide*
FR	*Federal Register*
HAZWOPER	Hazardous Waste Operations and Emergency Response
IDLH	Immediately Dangerous to Life or Health
ISA	Instrument Society of America
LEL	Lower Explosive Limit
LEPC	Local Emergency Planning Committee
MMS	Minerals Management Service
MSDS	Material Safety Data Sheet
NACE	National Association of Corrosion Engineers
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NORM	Naturally Occurring Radioactive Material
NRTL	National Recognized Testing Laboratory
NTIS	National Technical Information Service
OCS	Outer Continental Shelf
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PG	Pasquill-Gifford
RCRA	*Resource Conservation & Recovery Act*
REL	Recommended Exposure Level
RFI	Radio Frequency Interference
ROE	Radius of Exposure
RP	*Recommended Practice*
RQ	Reportable Quantity
SARA	*Superfund Amendments and Reauthorization Act*
SCF	Standard Cubic Foot
SSC	Sulfide Stress Cracking
STEL	Short Term Exposure Level
TLV	Threshold Limit Value
TPQ	Threshold Planning Quantity
WPS	Welding Procedure Specification

3 Definitions

For the purposes of this standard, the following definitions are applicable.

3.1 acceptable ceiling concentration: (ACC). The designated level of an air contaminant to which an employee may be exposed at any time during an 8-hour shift, except for a specified time period and up to a specified concentration not exceeding the "acceptable maximum peak concentration" above the acceptable ceiling concentration for an 8-hour shift. Refer to 29 *CFR* 1910.1000 and Appendix A, Par. A.2.

3.2 breathing zone: A hemisphere forward of the shoulders with a radius of 6 to 9 inches. Refer to OSHA Instruction CPL 2-2.20A, March 30, 1984; amended by CPL 2-20A CH-1, October 29, 1984.

3.3 continuous hydrogen sulfide monitoring equipment: Equipment capable of continuously measuring and displaying the concentration of hydrogen sulfide in ambient air.

3.4 emergency response planning guide—level 2: (ERPG-2). The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective actions. Refer to *Technical Guidance for Hazards Analysis; Emergency Planning for Extremely Hazardous Substances.*

3.5 enclosed facility: A three-dimensional space enclosed by more than two-thirds (2/3) of the possible projected plane surface and of sufficient size to allow the entry of personnel. For a typical building, this would require that more than two-thirds of the walls, ceiling, and floor be present. Refer to *API Recommended Practice 500.*

3.6 essential personnel: Those individuals required to provide proper and prudent safe operations activities and those required to effect control of the hazardous hydrogen sulfide or sulfur dioxide conditions.

3.7 gas detection instrument: An assembly of electrical, mechanical, and chemical components designed to sense and respond continuously to the presence of chemical gases in atmospheric mixtures.

3.8 hydrogen sulfide: Chemical formula is H_2S. A flammable, toxic gas that is heavier than air and sometimes found in fluids encountered in oil and gas producing and gas processing operations. *Inhalation at certain concentrations can lead to injury or death.* Refer to Appendix A.

3.9 immediately dangerous to life and health: (IDLH). An atmospheric concentration of any toxic, corrosive, or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere. The National Institute for Occupational Safety & Health (NIOSH) considers 300 ppm and 100 ppm to be the IDLH concentrations for hydrogen sulfide and sulfur dioxide, respectively. *API Publication 2217A* specifies an oxygen content of less than 19.5% as oxygen deficient and an oxygen content of less than 16% is considered IDLH.

3.10 inadequately ventilated: Ventilation (natural or artificial) that is *not* sufficient to prevent the accumulation of significant quantities of hydrogen sulfide-air mixtures in excess of 10 ppm.

3.11 length-of-stain detector: A specially designed pump and colorimetric indicator tube detector (length-of-stain), with a supply of detector tubes, that operates by using the pump to pull a known volume of air or gas through a detector tube. The tubes contain chemical reagents that are designed to detect the presence and display the concentration of hydrogen sulfide or sulfur dioxide in the sample. The length of the resultant color band in the tube indicates an instantaneous quantitative concentration of the specific chemical in the sample.

3.12 permissible exposure limit: (PEL). The designated level of any airborne contaminant to which an employee may be exposed. The PEL may be expressed as an eight-hour time weighted average (TWA), a ceiling value, a short term exposure level (STEL), or a skin designation. PELs are subject to change and users should check the latest version of *29 Code of Federal Regulations* Part 1910.1000 for compliance.

3.13 shall: Indicates the "recommended practice(s)" has universal applicability to that specific activity.

3.14 shelter-in-place: The concept of providing the public additional protection by having residents stay indoors until emergency evacuators arrive or the emergency is over. Refer to references *62*, *63*, *64*, *65*, *66*, and *67*.

3.15 should: Denotes a "recommended practice(s)" 1) where a safe comparable alternative practice(s) is available; 2) that may be impractical under certain circumstances; or 3) that may be unnecessary under certain circumstances.

3.16 sulfur dioxide: Chemical formula is SO_2. A toxic product of combustion of hydrogen sulfide. This gas is heavier than air. *Inhalation at certain concentrations can lead to injury or death.* Refer to Appendix B.

3.17 threshold limit value: (TLV). The maximum airborne concentration of a substance to which, it is believed that, nearly all workers may be repeatedly exposed day after day without adverse effects, as determined by the responsible committees of the American Conference of Governmental Industrial Hygienists (ACGIH). Refer to *"Threshold Limit Values and Biological Indices.* "TLV" is a trademarked term of ACGIH. TLVs are subject to change and users should check the latest edition of the forestated reference.

4 Applicability

4.1 PERSONNEL AND EQUIPMENT PROTECTION

In oil and gas producing operations and gas processing plant operations, severity of the environment shall be assessed. As a minimum, the following measures shall be implemented:

a. Personnel protection should be provided if the work area concentration of hydrogen sulfide (refer to Par. 3.8) exceeds 10 ppm eight-hour time weighted average (TWA) or 15 ppm as a short term exposure level (STEL) averaged over 15 minutes (refer to Appendix A); or the work area concentration of sulfur dioxide (refer to Par. 3.16) exceeds 2 ppm as an eight-hour TWA or 5 ppm as a STEL averaged over 15 minutes (refer to Appendix B). Personnel safety provisions of this publication do not apply when:
1. the atmospheric concentration of hydrogen sulfide could not exceed 10 ppm (by volume), or
2. the atmospheric concentration of sulfur dioxide could not exceed 2 ppm (by volume).

b. Equipment and materials shall be selected on the basis of resistance to sulfide stress cracking and corrosion. Refer to Section 8, "Design and Construction Practices", Appendix D, and *NACE Standard MR0175* for recommendations for selection of equipment and materials. The equipment and materials provisions of this publication do not apply when the partial pressure of hydrogen sulfide in the gas could not exceed 0.05 psia or 10 psia in the gas phase of sour crude systems (refer to Appendix D, Par. D.1.1.2).

Some conditions may require extensive personnel safety measures but only the use of conventional equipment and materials; other conditions may require the use of special equipment and materials but only minimal personnel safety measures; still other conditions may require both.

Throughout this publication, "trigger levels" for various actions are used to ensure safety of employees and the public. These trigger levels have been established considering threshold limit values (TLVs—refer to Par. 3.17). These TLVs are subject to change and users should check the latest edition of *Threshold Limit Values and Biological Exposure Indices* and the latest revision of *29 Code of Federal Regulations* Part 1910.1000, "Toxic and Hazardous Substances", for compliance.

In 1989, the U. S. Department of Labor, Occupational Safety and Health Administration (OSHA) issued updated permissible exposure limits (PELs) for several hundred chemicals, including revised PELs for hydrogen sulfide (10 ppm as an eight-hour TWA or 15 ppm STEL averaged over 15 minutes) and sulfur dioxide [2 ppm as an eight-hour TWA or 5 ppm STEL averaged over 15 minutes (refer to 54 *Federal Register (FR)* 2333, January 19, 1989]. A federal court set aside the OSHA 1989 rule (refer to 58 *Federal Register* 35338, June 30, 1993).

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a hydrogen sulfide TLV of 10 ppm (eight-hour TWA) and a STEL of 15 ppm averaged over 15 minutes and recommends 2 ppm as an eight-hour TWA TLV and 5 ppm as a STEL averaged over 15 minutes for sulfur dioxide (refer to *Threshold Limit Values for Chemical Substances and Biological Exposure Indices*).

In the interest of safety and health, this standard recommends use of the ACGIH TLVs (refer to *Threshold Limit Values for Chemical Substances and Biological Exposure Indices 1993-94*) as trigger levels for employee safety (refer to Appendices A and B). Some states have adopted these levels as requirements for personal safety.

Individual employers may set their own trigger levels after review and due consideration of site specific conditions, various regulatory requirements, and material safety data sheet (MSDS) information. Users should check the current status of OSHA PELs, OSHA acceptable ceiling concentrations (ACCs), ACGIH TLVs, and applicable regulatory requirements concerning substances of interest.

4.2 LEGAL REQUIREMENTS

This publication presents recommended practices and precautions deemed pertinent to protect personnel and the public from exposure to potentially hazardous concentrations of hydrogen sulfide and sulfur dioxide. These recommended practices recognize that owners, operators, contractors, and their employees have separate responsibilities that may be contractual in nature. It is not the intent of these recommended practices to alter the contractual relationship(s) between the parties. Some of the practices recommended herein are mandatory by local, state, or federal laws, rules, and regulations. Because of the functional and geographical diversity of these requirements, no attempt has been made in these recommended practices to designate which are optional and which are required. Furthermore, even if all the practices recommended herein are followed, there still may be existing or future legally imposed laws or regulations which would not be met. *In the event of any omission or conflict between these recommended practices and legally required action(s) the requirements of laws and regulations must control.* Some of the federal regulations pertinent to safe production operations involving hydrogen sulfide are listed in Section 2, "References". Users of this publication shall review these regulations and other federal, state, and local laws to assure appropriate compliance in their specific operations.

4.3 HAZARD COMMUNICATION (WORKER RIGHT-TO-KNOW)

This publication contains important information that is intended as a guide but may not comply in all respects with OSHA's Hazard Communication Standard. Appropriate counsel should be sought to assure compliance with hazard communication requirements for the specific operations. Refer to OSHA rules on hazard communication in 29 *Code of Federal Regulations* Part 1910.1200, "Hazard Communication Standard" (52 *Federal Register (FR)* 31877-31886, August 24, 1987).

4.4 *COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT* (CERCLA) AND *SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT* (SARA) TITLE III (EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW)

Environmental Protection Agency (EPA) regulations implementing Title III of the *Superfund Amendments and Reauthorization Act of 1986* (SARA Title III) set threshold levels (threshold planning quantities, i.e., TPQs) for emergency planning at a local level. Both SARA Title III and CERCLA set reportable quantities (RQs) for reporting releases to the environment. The TPQ for both hydrogen sulfide and sulfur dioxide is 500 pounds; RQs for release reporting are 100 pounds for hydrogen sulfide and 1 pound for sulfur dioxide. TPQs and RQs (trigger levels) and the regulations requiring response plans and release reports under both SARA Title III and CERCLA are set forth in 40 *Code of Federal Regulations* Part 302, and 40 *Code of Federal Regulations* Part 355. Refer to *API Bulletin E-4* for guidance on release reporting requirements. "Trigger levels" for response plan and release reporting requirements are subject to change and users shall check the latest revisions for compliance. SARA Title III also requires submission of periodic and annual reports of information to state and local officials on the presence of hazardous chemicals at production and gas processing facilities. Those regulations are set forth in 40 *Code of Federal Regulations* Part 370, and API has published suggested generic reporting forms (refer to *API Bulletin E-1*) that are acceptable to EPA. Appropriate guidance should be sought to assure compliance with these programs for the specific operations.

4.5 HAZARDOUS WASTE OPERATIONS AND AND EMERGENCY RESPONSE (HAZWOPER)

OSHA's standard, 29 *Code of Federal Regulations* Part 1910.120, sets requirements for safety and health protection of employees involved in cleanup operations at uncontrolled hazardous waste sites being performed under government mandate; certain hazardous waste treatment, storage, and disposal operations conducted under the *Resource Conservation and Recovery Act* (RCRA); and emergency response to incidents involving hazardous substances. Appropriate guidance should be sought to assure compliance with 29 *Code of Federal Regulations* Part 1910.120 requirements for the specific operations (refer to 54 *Federal Register* 9294-9336, March 6, 1989).

5 Personnel Training

5.1 INTRODUCTION

Operators of oil and gas producing and gas processing operations involving hydrogen sulfide shall alert personnel (including employees, service companies, and contractors) of the possibility of hydrogen sulfide atmospheric concentrations greater than 10 ppm and sulfur dioxide atmospheric concentrations greater than 2 ppm that may be encountered in the performance of their work. All personnel working in an area where concentrations of hydrogen sulfide or sulfur dioxide may exceed the levels stipulated in Par. 4.1.a should be provided with training prior to beginning the work assignment. All employers, whether operator, contractor, or subcontractor, shall be responsible for training and instruction of their own employees. Personnel assigned to work in areas where they may be exposed to hydrogen sulfide or sulfur dioxide shall be trained by a hydrogen sulfide safety instructor, as defined in Par. 5.6.

5.2 MINIMUM TRAINING

The value of training and periodic drills in all oil and gas producing and gas processing plant operations cannot be over emphasized. The uniqueness or complexity of a specific facility or operation will determine the extent of the training (e.g., SARA Title III and HAZWOPER; refer to Pars. 4.4 and 4.5) deemed necessary for the assigned personnel. However, the following elements are considered a minimum level of training for regularly assigned personnel:

a. The hazards, characteristics, and properties of hydrogen sulfide and sulfur dioxide (refer to Appendices A and B).
b. Sources of hydrogen sulfide and sulfur dioxide.
c. Proper use of hydrogen sulfide and sulfur dioxide detection methods used at the workplace.
d. Recognition of and proper response to the warning signals for hydrogen sulfide and sulfur dioxide detection systems used at the workplace.
e. Symptoms of hydrogen sulfide exposure (refer to Appendix A); symptoms of sulfur dioxide exposure (refer to Appendix B).
f. Rescue techniques and first aid to victims of hydrogen sulfide and sulfur dioxide exposure.
g. Proper use and maintenance of breathing equipment for working in a hydrogen sulfide and sulfur dioxide atmosphere (theory and hands-on practice, with demonstrated proficiency). Refer to 29 *Code of Federal Regulations* Part 1910.134.
h. Workplace practices and relevant maintenance procedures that have been established to protect personnel from the hazards of hydrogen sulfide and sulfur dioxide.
i. Wind direction awareness and routes of egress (refer to Par. 6.7).
j. Confined space and enclosed facility entry procedures (if applicable).
k. Emergency response procedures that have been established for the facility. Refer to Section 7, "Contingency Planning Including Emergency Procedures".
l. Locations and use of safety equipment.
m. Locations of emergency assembly areas, if so designated.

5.3 ADDITIONAL TRAINING FOR ONSITE SUPERVISORY PERSONNEL

Those personnel assigned supervising responsibilities at the site shall have additional training in the following elements:

a. Supervisor responsibilities of the contingency plan (refer to Section 7).
b. Effects of hydrogen sulfide on components of the hydrogen sulfide handling system (i.e., corrosion, embrittlement, etc.).

5.4 REFRESHER TRAINING

A formal recurring training program shall be implemented to maintain proficiency in the elements listed in Pars. 5.2 and 5.3, as appropriate.

5.5 TRAINING VISITORS AND OTHER NON-REGULARLY ASSIGNED PERSONNEL

Prior to entering a potentially hazardous area, visitors and other non-regularly assigned personnel shall be briefed on route(s) of egress, emergency assembly area(s), applicable warning signals, and how to respond in the event of an emergency, including use of personal protective equipment, if required. These personnel may be allowed in potentially hazardous areas only in the presence of trained personnel, after being briefed on emergency action and evacuation procedures. In the event of an emergency, these personnel shall be immediately evacuated or immediately supplied with proper personal protective equipment.

5.6 HYDROGEN SULFIDE SAFETY INSTRUCTORS

Hydrogen sulfide safety instructors are persons who have successfully completed a course in hydrogen sulfide instructor training from an institution or organization offering such courses, or have received equivalent instruction from a company-designated hydrogen sulfide safety instructor/trainer, or have had equivalent instructor/trainer experience. A recurring training program shall be implemented to maintain proficiency of the hydrogen sulfide safety instructor.

5.7 SAFETY REVIEW

Before any persons unfamiliar with the job site enter the location, they shall, as a minimum, be briefed on emergency evacuation procedures.

5.8 SUPPLEMENTAL TRAINING

Training should be a continuing educational program for personnel (including personnel engaged in maintenance and repair work) whose work may involve exposure to hydrogen sulfide or sulfur dioxide. Effective ongoing training will ensure that personnel have current knowledge of potential job hazards, procedures for dealing with confined space entry, procedures for enclosed facilities work, relevant maintenance procedures, and cleanup methods. Depending on the nature of the programs, certain appropriate training aids may be very useful. These aids may include, but are not limited to, films, manuals, and industry publications or documents (refer to Section 2 "References"). Guest speakers, demonstrations, and consultants are also recommended.

5.9 RECORDS

Dates, instructors, attendees, and subjects for all personnel training sessions shall be documented and appropriate records should be retained for a minimum of one year.

5.10 OTHER PERSONNEL CONSIDERATIONS

5.10.1 Enclosed Facilities and Confined Space Entry

Refer to 29 *Code of Federal Regulations* Part 1910.146 for OSHA's confined space entry regulations. Refer to Section 12, "Operations Involving Enclosed Facilities", for some topics that may be used in training personnel for enclosed facilities work. Refer to Pars. 9.17 and 9.18 for further precautionary information on entry into confined spaces (including vessels) and enclosed facilities.

5.10.2 Respiratory Problems

Personnel with known physiological or psychological conditions which impair normal respiration shall not be assigned to jobs involving potential exposure to a hydrogen sulfide or sulfur dioxide environment if use of the breathing equipment or exposure will complicate their respiratory problems. Refer to OSHA's Respiratory Protection Standard (29 *Code of Federal Regulations* Part 1910.134).

Note: Personnel assigned job-related tasks requiring routine use of breathing equipment shall have a periodic review to determine their physiological and psychological adequacy for use of this equipment (refer to 29 *Code of Federal Regulations* Part 1910.134 and *ANSI Z88.2*.

5.10.3 Perforated Eardrums

There are differences of opinion[17] in the medical community about whether a person with a perforated eardrum can become overexposed to a toxic substance via the ear even when wearing properly functioning breathing apparatus (refer to Par. 6.4). Refer to Appendix A.

6 Personnel Protective Equipment

6.1 INTRODUCTION

Section 6 discusses some personnel protective equipment that can be used in oil and gas well producing and gas processing plant operations where the work atmosphere concentration of hydrogen sulfide could exceed 10 ppm or sulfur dioxide atmospheric concentration could exceed 2 ppm (refer to Par. 4.1 and Appendices A and B). Having personnel protective equipment available is not enough; training personnel in the selection, use, inspection, and maintenance of the equipment is essential.

6.2 STATIONARY HYDROGEN SULFIDE MONITORING SYSTEMS

Stationary hydrogen sulfide atmospheric monitoring systems used in oil and gas producing and gas processing plant operations shall include visual or audible alarm(s), located where the alarm can be seen or heard throughout the work area. The batteries of direct current (DC) systems should be checked daily during operation unless an automatic low voltage alarm is provided. Instrument Society of America publications, *ISA-S12.15*, Part I, and *ISA-RP12.15*, Part II, contain equipment performance requirements and

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[17] Note: Compare Poda, George A., "Hydrogen Sulfide Can Be Handled Safely"[55], *Archives of Environmental Health*, Vol. 112, 795-800, June 1966, and Ronk, Richard and White, M. K., "Hydrogen Sulfide and the Probabilities of Inhalation Through a Tympanic Membrane Defect"[56], *Journal of Occupational Medicine*, Vol. 25, No. 5, 337-340, May 1985.

recommendations for installation, operation, and maintenance of hydrogen sulfide monitoring and detection instruments, respectively. Refer to Section 10 for additional details regarding evaluation and selection of hydrogen sulfide monitoring equipment.

6.3 PORTABLE DETECTION EQUIPMENT

If the atmospheric concentration of hydrogen sulfide could reach or exceed those levels stipulated in Par. 6.1, portable hydrogen sulfide detection instruments[18] shall be available. Refer to Section 10 for details regarding evaluation, selection, maintenance, and use of hydrogen sulfide detection equipment. In those instances where the hydrogen sulfide atmospheric concentration may exceed the measurement range of the detection instruments in use, a pump and colorimetric indicator tube detector[19] (length-of-stain), with a supply of detector tubes, shall be available to take instantaneous "grab" samples to determine hydrogen sulfide concentrations in enclosed facilities, storage tanks, vessels, etc.

If sulfur dioxide levels could reach or exceed those stipulated in Par. 6.1 (e.g., during flaring or other operations producing sulfur dioxide), either portable sulfur dioxide detection instruments or length-of-stain detectors, with a supply of detector tubes, shall be available for determining the sulfur dioxide concentration in the area and to monitor areas impacted by sulfur dioxide gas when fluids containing hydrogen sulfide are burned. Personnel shall wear appropriate personal breathing equipment (refer to Par. 6.4) unless it is established that the work area atmosphere is safe.

6.4 BREATHING (RESPIRATORY PROTECTION) EQUIPMENT

Site specific contingency plans shall be prepared to specify the quantity and location of breathing equipment to be available. Respirators shall meet the requirements of OSHA's Respiratory Protection Standard (refer to 29 *Code of Federal Regulations* Part 1910.134) and be approved under procedures outlined in *ANSI Z88.2*. All breathing air cylinders shall meet U.S. Department of Transportation (DOT) or other appropriate regulatory requirements (refer to 30 *Code of Federal Regulations,* Part 1910.134, Chapter 1, Subchapter B, Part II, Subpart H, Par. 11.80 and 49 *Code of Federal Regulations* Part 178, Subpart C). The following types of breathing equipment with full face piece meet these requirements and should be used where the work area atmospheric concentration exceeds 10 ppm for hydrogen sulfide or 2 ppm for sulfur dioxide:

a. Self-contained, positive-pressure/pressure-demand breathing equipment that provides respiratory protection in any atmospheric concentration of hydrogen sulfide or sulfur dioxide.

b. Positive-pressure/pressure-demand air-line breathing equipment coupled with a self-contained breathing apparatus equipped with a low pressure warning alarm and rated for fifteen minutes (minimum). This equipment permits the wearer to move from one work area to another.

c. Positive-pressure/pressure-demand, air-line breathing equipment, with an auxiliary self-contained air supply (rated for a minimum of 5 minutes). This type unit can be used for entry as long as the air line is connected to a source of breathing air. *The auxiliary self-contained air supply (rated for less than 15 minutes) is suitable only for escape or self-rescue use.*

Notes:

1. Personnel assigned job-related tasks requiring routine use of breathing equipment shall have a periodic review to determine their physiological and psychological adequacy for use of this equipment (refer to *ANSI Z 88.2* and 29 *Code of Federal Regulations* Part 1910.134).
2. Positive-pressure/pressure-demand, air-line or self-contained breathing apparatus, as appropriate, with full face piece shall be worn by personnel exposed to atmospheres containing concentrations of hydrogen sulfide or sulfur dioxide above OSHA's ACCs and PELs for air contaminants (refer to 29 *Code of Federal Regulations* Part 1910.1000.

CAUTION: Gas mask canister type breathing and demand type (negative pressure) equipment shall not be used in oil and gas producing and gas processing plant operations when a hydrogen sulfide or sulfur dioxide environment could be encountered.

6.4.1 Storage and Maintenance

Personal breathing equipment shall be strategically located so that this equipment is quickly and easily available to essential personnel. Essential personnel are those required to provide proper and prudent safe operations activities and those required to effect control of the hazardous hydrogen sulfide or sulfur dioxide conditions (refer to Par. 7.5). Additional breathing equipment may be required by site specific contingency plans (refer to Section 7). Breathing equipment shall be maintained and stored in a convenient, clean, and sanitary location, in accordance with OSHA's Respiratory Protection Standard (refer to 29 *Code of Federal Regulations* Part 1910.134). All breathing equipment shall be checked before and after each use and inspected at least monthly to ensure that it is maintained in satisfactory condition. A record of the monthly inspections, including dates and findings, shall be retained [refer to 29 *Code of Federal Regulations* 1910.134(f)]. These records should be retained for a minimum of twelve (12) months and longer if dictated by company policy. Equipment needing repair shall be appro-

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[18] A gas detection instrument is an assembly of electricl, mechanical, and chemical components designed to sense and respond continuously to the presence of chemical gases (hydrogen sulfide or sulfur dioxide) in atmospheric mixtures.

[19] A pump and colorimetric indicator tube detector (length-of-stain), with a supply of detector tubes, is an assembly of specially designed pump and detector tubes that operates by using the pump to pull a known volume of air or gas through a detector tube. The tubes contain chemical reagents that are designed to detect the presence and display the concentration of hydrogen sulfide or sulfur dioxide in the sample. The length of the resultant color band in the tube indicates an instantaneous quantitative concentration of the specific chemical in the sample.

priately tagged and removed from equipment stock until it is suitably repaired or replaced. Proper storage, maintenance, handling, and inspection is essential to the integrity of personal breathing equipment. Personnel with assigned breathing equipment should be instructed in proper maintenance of this equipment, or other steps shall be taken to ensure its integrity. NIOSH, OSHA, and manufacturer's recommendations shall be followed.

6.4.2 Face Piece Restrictions

Full face piece breathing equipment meeting requirements of Par. 6.4 should be used where the work area atmosphere concentration exceeds 10 ppm for hydrogen sulfide or 2 ppm for sulfur dioxide. Personnel shall not wear eyeglasses with temple bars that extend through the sealing edge of the face piece. Using approved adapters, corrective prescription lenses may be mounted inside the breathing apparatus face piece.

As of this writing, U. S. Department of Labor (OSHA) does not permit wearing contacts when using respirator breathing equipment [refer to 29 *Code of Federal Regulations* Part 1910.134(e)(5)(ii)]. OSHA has investigated the prohibition of contact lenses used under respirator breathing equipment and issued a field memorandum (February 8, 1989, Thomas Shepich, Director, Directorate of Compliance Programs) stating their intent to modify the rule and issuing an interim enforcement policy as follows:

a. Violations of the Respiratory Protection Standard (29 *Code of Federal Regulations* Part 1910.134) involving the use of gas permeable and soft contact lenses shall continue to be documented in the case file and recorded as de minimis; citations shall not be issued.

b. Evidence indicating any negative effect(s) associated with the use of contact lenses with respirator breathing equipment should be provided to U. S. Department of Labor (DOL), Occupational Safety and Health Administration (OSHA), Directorate for Compliance Programs, Washington, D. C. 20210. Benefits associated with the use of contact lenses with respirator breathing equipment would be useful to OSHA. The issue of use of non-gas-permeable hard contact lenses will be resolved in OSHA's revision of 29 *Code of Federal Regulations* Part 1910.134.

Note: Companies should review available information and provide employee guidance regarding the use of contact lenses under respirator breathing equipment.

Personnel shall not wear facial hair that may prevent proper sealing of the face mask. Personnel shall be satisfied that a face seal can be obtained with the assigned equipment or randomly selected unassigned equipment before they use the equipment. If a seal cannot be obtained, either satisfactory equipment must be provided or the individual shall be disqualified from working in areas where hazardous conditions are anticipated or existent.

6.4.3 Air Supply

Breathing air quality shall meet requirements set forth in OSHA's Respiratory Protection Standard, 29 *Code of Federal Regulations* Part 1910.134, and shall at least meet Grade D requirements as described in *ANSI CGA G-7.1*.

6.4.4 Compressors

All breathing air compressors used shall meet the requirements set forth in 29 *Code of Federal Regulations* Part 1910.134 of OSHA's Respiratory Protection Standard. The air intake for such compressors must be located in a contaminant-free area that is unclassified by *API RP500*, Section B. Inlet air for such compressors shall be monitored when conditions arise which permit possible contamination of the inlet air by toxic, flammable, or combustible gases.

6.4.5 Breathing Equipment Use

Personnel shall use breathing equipment prior to entering an area where OSHA ACCs and PELs for hydrogen sulfide and sulfur dioxide, respectively, are exceeded (refer to Par. 4.1, Appendices A and B, and 29 *Code of Federal Regulations* Part 1910.1000, Subpart Z, Table Z.1) until either the area is made or tested safe or they return to a safe area. *Breathing equipment shall be put on in a safe area prior to either beginning a rescue operation or entering a hazardous environment.*

6.5 STANDBY RESCUE PERSONNEL

When personnel work in locations with hydrogen sulfide or sulfur dioxide concentrations considered immediately dangerous to life or health (IDLH) (refer to Appendices A and B) in the working breathing zone, a standby rescue person trained in rescue techniques and with suitable rescue equipment, including appropriate breathing apparatus (refer to Par. 6.4), shall be provided.

6.6 RESCUE EQUIPMENT

At locations with hydrogen sulfide, sulfur dioxide, or oxygen concentration considered immediately dangerous to life or health (IDLH), suitable rescue equipment [for example, appropriate breathing equipment, lifeline(s), and harness(es)] shall be provided. Types of rescue equipment required will vary and will depend on the type of job and work being performed. Appropriate counsel with qualified health and safety professional personnel should be effected to determine what rescue equipment should be available for site-specific job and work conditions.

6.7 WIND DIRECTION INDICATORS

Consideration should be given to locating windsocks, streamers, flags, or other suitable devices for indicating wind direction at the producing or gas processing site. These devices shall be readily visible to personnel on or approaching the work location.

Note: Regulatory requirements for wind direction indicators shall be observed.

6.8 WARNING SIGNS

Legible warning signs, such as "HYDROGEN SULFIDE OPERATIONS—ENTER ONLY WHEN MONITORING SHOWS THE AREA TO BE SAFE" or "RESPIRATORY PROTECTION EQUIPMENT MUST BE WORN BEYOND THIS POINT," should be prominently posted at appropriate locations (e.g., entrance points) for facilities where produced fluids containing hydrogen sulfide (refer to Par. 4.1 for applicability) are being processed or handled.

Note: Regulatory requirements for sign posting shall be observed.

7 Contingency Planning Including Emergency Procedures

7.1 INTRODUCTION

Operators shall evaluate existing and new operations involving hydrogen sulfide and sulfur dioxide to determine if contingency plans, special emergency procedures, and/or training are required. The evaluation process shall identify potential emergencies and their impact on operating personnel and the general public. The contingency plan, if required, shall conform to all applicable local, state, and federal regulations regarding notifications, precautions, evacuations, and other requirements (refer to 40 *Code of Federal Regulations* Part 264, Subpart D; 29 *Code of Federal Regulations* Part 1910.120; and 29 *Code of Federal Regulations* Part 1910.38 for EPA and OSHA requirements, respectively, for contingency plans and emergency procedures).

7.2 SCOPE

The contingency plan should contain emergency response procedures that provide an organized immediate action plan for alerting and protecting operating personnel and the public. Contingency plans should be site specific for the facility operations and should consider the severity and extent of the anticipated atmospheric hydrogen sulfide and sulfur dioxide concentrations. Contingency plans should consider the dispersion characteristics of hydrogen sulfide and sulfur dioxide (refer to Appendix C or other recognized dispersion modelling techniques). Contingency plans should contain provisions for all applicable items listed in this section. (Refer to *Hazardous Materials Emergency Planning Guide, NRT-1*, and *Technical Guidance For Hazards Analysis*. In addition to the contingency plan, Sections 302 and 303 of the *Superfund Amendments and Reauthorization Act of 1986* (SARA Title III) can require a facility operator to name a facility emergency coordinator to work with a local emergency planning committee (LEPC) in the development of an emergency response plan (refer to 40 *Code of Federal Regulations* Part 355).

7.3 AVAILABILITY OF PLAN

The contingency plan shall be available to all personnel responsible for implementation, regardless of their normal location assignment.

7.4 PLAN INFORMATION

Contingency plans should contain, but not be limited to, information on the following subjects, as appropriate:

a. Emergency Procedures:
   1. Responsibilities of personnel (refer to Par. 7.5).
   2. Immediate action plan (refer to Par. 7.6).
   3. Telephone numbers and communication methods (refer to Par. 7.7).
   4. Locations of nearby residences, businesses, parks, schools, churches, roads, medical facilities, etc.
   5. Evacuation routes and road block locations.
   6. Safety equipment and supplies available (e.g., number and location of breathing equipment).
b. Characteristics of Hydrogen Sulfide and Sulfur Dioxide:
   1. Refer to Appendix A for hydrogen sulfide characteristics.
   2. Refer to Appendix B for sulfur dioxide characteristics.
c. Facility Description, Maps, and Drawings:
   1. Plants.
   2. Water injection stations.
   3. Wells, tank batteries, gas conditioning facilities, flowlines.
   4. Compression facilities.
d. Training and Drills (refer to Par. 7.8):
   1. Responsibilities and duties of essential personnel.
   2. On-site or classroom (tabletop) drills.
   3. Informing nearby residents on protective measures in emergency situations, as appropriate.
   4. Training and attendance documentation.
   5. Briefing of public officials on issues such as evacuation or *shelter-in-place*[20] plans.

7.5 RESPONSIBILITIES OF PERSONNEL

The contingency plan shall outline responsibilities and duties of all essential personnel. Visitors and other non-essential personnel should be prohibited from remaining in or entering an area contaminated by hydrogen sulfide exceeding an atmospheric concentration of 10 ppm or a concentra-

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[20] Shelter-in-place refers to the concept of providing the public additional protection by having residents stay indoors until emergency evacuators arrive or the emergency is over (refer to References *62, 63, 64, 65, 66*, and *67*).

tion of sulfur dioxide exceeding 2 ppm in the atmosphere (refer to Par. 4.1 and Appendices A and B).

7.6 IMMEDIATE ACTION PLAN

Each contingency plan should contain a condensed "Immediate Action Plan" to be followed by designated personnel any time they receive notice of a potentially hazardous hydrogen sulfide or sulfur dioxide discharge. For the protection of personnel (including the general public) and abatement of the discharge, this "Immediate Action Plan" should include, but not be limited to, the following provisions:

a. Alert and account for facility personnel.
  1. Move away from the hydrogen sulfide or sulfur dioxide source and get out of the affected area.
  2. Don proper personal breathing equipment.
  3. Alert other affected personnel.
  4. Assist personnel in distress.
  5. Proceed to the designated emergency assembly area.
  6. Account for on-site personnel.

b. Take immediate measures to control the present or potential hydrogen sulfide or sulfur dioxide discharge and to eliminate possible ignition sources. Emergency shutdown procedures should be initiated as deemed necessary to correct or control the specific situation. When the required action cannot be accomplished in time to prevent exposing operating personnel or the public to hazardous concentrations of hydrogen sulfide or sulfur dioxide, proceed to the following steps, as appropriate for the site specific conditions.

c. Alert the public (directly or through appropriate government agencies) that may be subjected to an atmosphere exposure exceeding 30 ppm[21] of hydrogen sulfide or 10[21] ppm of sulfur dioxide.

d. Initiate evacuation operations.

e. Contact the first available designated supervisor on the call list (refer to Par. 7.4.a). Notify the supervisor of circumstances and whether or not immediate assistance is needed. The supervisor should notify (or arrange for notification of) other supervisors and other appropriate personnel (including public officials) on the call list.

f. Make recommendations to public officials regarding blocking unauthorized access to the unsafe area and assist as appropriate.

g. Make recommendations to public officials regarding evacuating the public and assist as appropriate.

h. Notify, as required, state and local officials and the National Response Center to comply with release reporting requirements (i.e., 40 *Code of Federal Regulations Parts* 302 and 355) (refer to Par. 4.4).

i. Monitor the ambient air in the area of exposure (after following abatement measures) to determine when it is safe for re-entry.

Note: This sequence (Par. 7.6) should be altered to fit the prevailing situation. Certain actions, especially those dealing with the public, should be coordinated with public officials.

7.7 EMERGENCY TELEPHONE LISTS

A list of emergency telephone numbers should be prepared and maintained as a part of the contingency plan, considering the need to contact any of the following:

a. Emergency Services
  1. Ambulances
  2. Hospitals
  3. Medical personnel (e.g., doctors)
  4. Helicopter services
  5. Veterinarians

b. Government Agencies and Contacts
  1. Local Emergency Planning Committee
  2. National Response Center
  3. State Emergency Response Commission
  4. State and Local Law Enforcement Agencies
  5. Civil Defense
  6. Fire Departments
  7. Other applicable government agencies.

c. Operator and Contractors
  1. Operator personnel
  2. Contractor personnel
  3. Applicable service companies

d. Public

7.8 TRAINING AND DRILLS

The value of training and drills in emergency response procedures for oil and gas operations involving hydrogen sulfide or sulfur dioxide cannot be over emphasized. All personnel identified in the plan shall have appropriate training. It is important that the training conveys a full appreciation of the importance of each role and the effect that each person has on implementing an effective emergency response.

Exercises or drills that simulate an emergency in which personnel perform or demonstrate their duties are important tools that can convey the importance of contingency plans and result in their being kept current. The exercise can be a tabletop or classroom discussion; or can be a realistic drill in which equipment is deployed, communication equipment is tested, and "victims" are sent to hospital facilities with simulated injuries. Public officials should be informed of (and preferably involved in) these exercises. After a plan is tested, it should be revised and retested until those responsible for the plan are confident the plan is operational. Refer to *NRT-1: Hazardous Materials Emergency Planning Guide.*

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[21] Emergency Response Planning Guide Level 2 (ERPG-2), refer to Reference 27. ERPG-2 is defined as the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.

7.9 UPDATING PROVISIONS

A contingency plan shall be periodically reviewed and updated any time its provisions or coverage change (refer to Par. 9.24).

8 Design and Construction Practices

8.1 DESIGN GUIDELINES

Recommendations presented in Section 8 apply to producing and gas processing plant operations where the fluids handled contain sufficient hydrogen sulfide to be within the scope of *NACE Standard MR0175*. *NACE Standard MR0175* may also be a useful reference when designing and constructing other facilities handling hydrogen sulfide. Refer to Appendix D for information on defining a sour environment. All pressure vessels should be designed and constructed in accordance with *ASME Boiler and Pressure Vessel Code* [refer to *Synopsis of Boiler and Pressure Vessel Laws, Rules, and Regulations by States, Cities, Counties, and Provinces (United States and Canada)*]. All piping systems should be designed and constructed in accordance with applicable provisions of *ANSI B31.3*, *ANSI B31.4*, OR *ANSI B31.8*.

Manufactured equipment shall be designed, constructed, tested, and approved to meet or exceed system requirements for hydrogen sulfide service and should be installed in compliance with applicable codes and industry-accepted standards.

8.1.1 Process and Mechanical Considerations

Factors to be considered in facility design include, but are not limited to, the hydrogen sulfide concentration and impact of atmospheric and operating temperatures, system pressures, pH and water content of system fluids, mechanical stresses imposed on system components, operating and physical strength changes of system components resulting from corrosion and scale deposits, and conditions peculiar to individual processes that could be of a detrimental nature to the system.

8.1.2 Design Considerations

To minimize internal corrosion, piping and vessels should be designed and installed in such a way that areas of insufficient flow (including dead-end piping) are eliminated. Where this cannot be accomplished, provisions should be made for draining of accumulated fluids. Drain systems for hydrogen sulfide laden fluids should be designed to prevent migration of hydrogen sulfide from one point in the facility to another.

8.1.3 Materials Considerations

When exposed to an environment containing hydrogen sulfide, many materials may suddenly fail in a brittle manner. Failure occurs by a form of embrittlement known as sulfide stress cracking (SSC). Susceptibility of a given material to sulfide stress cracking increases as strength and tensile stress (residual or applied) increase. Material hardness frequently is used as an indirect measure of strength and sometimes is referenced as a limiting parameter. The failure of certain producing and gas processing plant equipment components used in the sulfide stress cracking regime could result in the uncontrolled release of hydrogen sulfide to the atmosphere. Such components should be made from sulfide stress cracking resistant materials (refer to Par. 8.1.4).

8.1.4 Materials Selection

Metallic materials satisfactory for use in hydrogen sulfide environments and the conditions under which they should be used are described in *NACE Standard MR0175*. The latest revision of this standard should be consulted when selecting materials for use in hydrogen sulfide environments. The provisions of *NACE Standard MR0175* should be considered minimum standards, with the equipment user free to apply more stringent specifications. The material requirements of *NACE Standard MR0175* offer resistance to sulfide stress cracking (SSC); however, other forms of corrosion and modes of failure (such as pitting, hydrogen-induced cracking, and chloride cracking) should be considered in the design and operation of equipment. Control of failures by mechanisms other than SSC should be mitigated by chemical inhibition, material selection, and environmental controls (refer to *NACE Standard MR0175*, Par. 1.1). Appendix D includes excerpts from *NACE Standard MR0175*, providing the definition of a sour environment and graphs that may be used to determine when sulfide stress cracking resistant materials should be used. Users of this publication should check the latest edition of *NACE Standard MR0175* for revisions to the defining criteria for a sour environment.

8.1.4.1 Manufacturer certification of compliance with *NACE Standard MR0175* for equipment intended for hydrogen sulfide service may be required by the user, depending on severity of the service. Adequate quality assurance procedures should be followed to verify compliance by the manufacturer for the original equipment and for any subsequent equipment modifications.

8.1.4.2 Materials not covered in *NACE Standard MR0175* that have been qualified for hydrogen sulfide environment service by the user or manufacturer, using recognized and acceptable testing procedures, may be used. A written agreement between the manufacturer and user may be appropriate. Recognized and acceptable testing procedures are those that demonstrate that the material(s) performs as well as or superior to similar material(s) set forth in *NACE Standard MR0175*, using laboratory procedures or procedures for which testing has been completed under actual or simulated environmental conditions. The suitability of materials must be supported by appropriate documentation that should include a complete description of the materials, processing, and testing procedure. Laboratory, field, or other environmental testing results or service performance should be recorded in writing. Full documentation supporting the suitability of the material(s) for the selected service should be maintained by the user, manufacturer, or both. Materials use is subject to compliance with applicable regulations.

8.1.5 Site Selection

In selecting a facility site, consideration should be given to taking advantage of the prevailing wind direction, climatic conditions, terrain, transportation routes, and the proximity of populated or public areas. Site selection should consider maintenance of clear entrance and exit routes and should minimize existence of confined spaces. Applicable regulatory requirements concerning location, spacing, and height of flares or vent stacks shall be considered in site selection.

8.1.6 Warning Method

Facility design should incorporate a means to provide a warning of a hazardous upset or condition. Devices and equipment such as hydrogen sulfide monitoring equipment, hazardous warning equipment (audible or visual), and process monitoring devices (such as pressure and flow rate sensors) should be considered. The operator should specify, and the design should consider, the physical and environmental conditions that will be present at the installation site.

8.2 CONSTRUCTION GUIDELINES

Construction of facilities within the scope described in Paragraph 8.1 should be conducted in accordance with the following recommendations, as applicable.

8.2.1 Fabrication and Joining System Components

Welding rods of proper composition and size, applied at recommended temperature and rate, should be used to join pipe and system components by welding. Preheating, postheating, stress relieving, and hardness control requirements should be in accordance with a welding procedure specification (WPS). Proper bolting and gasket materials should be selected in accordance with *NACE Standard MR0175*. Proper alignment should be maintained for all piping, and all system components should be adequately supported to reduce stresses.

8.2.2 Qualification of Personnel

Fabrication of system components and joining of pipe should be done by experienced and qualified workers. Piping system welders should have passed a performance qualification test in accordance with Section IX, *ASME Boiler and Pressure Vessel Code* or *API Standard 1104*. Qualification under *API Standard 1104* will satisfy U. S. Department of Transportation (DOT) requirements for pipelines. Welders shall be permitted only to weld on materials, and to use only procedures, for which they are currently qualified.

8.2.3 Handling and Storage of Equipment

Materials and equipment used in facility construction, reconstruction, repair, or in routine maintenance should be stored and handled in a manner that will not jeopardize their integrity. Where equipment storage is required or where use after installation is delayed, adequate precautionary measures against corrosion, fouling, deterioration, and other harmful effects should be employed. Reliable warehouse control methods shall be employed to assure that material and equipment unsuitable for hydrogen sulfide service is not inadvertently used in hydrogen sulfide service.

8.2.4 Inspection

Pressure-containing components should be thoroughly cleaned and pressure tested in accordance with applicable construction codes. Welded connections should be tested by non-destructive tests (such as ultrasonic or radiographic methods). Final facility inspection should be conducted by knowledgeable personnel to determine that the completed facility complies with design specifications and material records and that markings indicate materials used are suitable for the intended service. Refer to *API 510* and *API Recommended Practice 12R1*.

8.2.5 Repairs

Equipment or systems damaged or worn to the extent that their safety and reliability are doubtful shall not be placed or retained in service. Vessel, piping, and equipment repairs shall be made by qualified and, where required, certified personnel in accordance with applicable codes and good work practices. Only compatible materials, suitable for use in the existing hydrogen sulfide environment shall be used to repair or replace equipment for use in this service. Refer to *API 510*.

8.3 ELECTRICAL DESIGN CONSIDERATIONS

In addition to being toxic, hydrogen sulfide is flammable at concentrations of 4.3 to 46 percent (by volume) in air. Electrical equipment installed in areas subject to exposure to a methane-hydrogen sulfide mixture composed of 25% or more (by volume) of hydrogen sulfide should be suitable for Class I, Group C classified areas (refer to Par. 3.5, "National Electric Code Grouping of Atmospheric Mixtures," in *API Recommended Practice 500*).

9 Operating Practices

9.1 INTRODUCTION

Section 9 discusses operating practices that should be followed to provide integrity of equipment and continuity of work practices in operations involving the design and handling of materials in hydrogen sulfide service (refer to Par. 4.1 and applicable regulatory requirements). Each equipment installation or work procedure should be reviewed and observed as often as necessary to detect when changes may be needed in operating practices or equipment. *Water injection and other enhanced recovery operations may result in the introduction of bacteria that can cause water soluble hydrogen sulfide to develop over time and be present in produced fluids.*

9.2 EMERGENCY PROCEDURES

Emergency operating and shutdown procedures shall be posted or readily available to operating personnel.

9.3 TEST PROCEDURES

Tests of the gas phase of produced fluids shall be conducted periodically to determine the hydrogen sulfide concentration. Procedures should be established and routine operational tests should be conducted periodically for hydrogen sulfide detection and monitoring equipment and alarm devices, forced air ventilation systems, and similar safety devices. Results of these tests should be recorded.

9.4 SAFE WORK PRACTICES

Safe operating procedures should be developed for performing operations and maintenance (e.g., tank gauging, water line blowdown, line repair, valve replacement, and sampling) so hazards due to the release of hydrogen sulfide can be avoided. A safety review of the work should be performed prior to beginning any maintenance or operating work activities requiring personnel to be in areas that could contain concentrations of hydrogen sulfide or sulfur dioxide exceeding the levels stipulated in Par. 4.1. Legible warning signs, such as "HYDROGEN SULFIDE OPERATIONS—ENTER ONLY WHEN MONITORING SHOWS THE AREA TO BE SAFE" or "RESPIRATORY PROTECTION MUST BE WORN BEYOND THIS POINT", should be prominently posted in the area where produced fluids containing hydrogen sulfide (refer to Par. 4.1 for applicability) are being handled or processed.

Note: Regulatory requirements for sign posting shall be observed.

9.5 LEAK DETECTION

In produced fluids handling systems containing hydrogen sulfide in concentrations capable of causing atmosphere concentrations in excess of 10 ppm, monitoring techniques or procedures (for example, visual observation, soap bubble test, portable detection equipment, fixed monitoring equipment) should be employed to detect leaks. Particular attention should be given to enclosed facilities (refer to Section 12).

9.6 SAFE WORK PERMITS

For activities without previously established operating procedures, special safety review documentation (e.g., hot work permits and check-off lists) outlining specific safety precautions with specific authorization should be used. Documentation should include personnel protective equipment required; equipment that should be properly blinded, blanked, or disconnected; equipment and piping that should be properly vented; procedures for excavation of buried lines in processing areas; etc.

9.7 VALVES, CONNECTIONS, AND GAUGES

Valves, flanges, gauges, connections, and other components should be observed for evidence of needed inspection, repair, or maintenance. The cause of equipment failure should be investigated and determined. If failure is caused by exposure to hydrogen sulfide, alternate methods or equipment should be considered.

9.8 ARTIFICIAL LIFT WELLS

Artificial lift wells should be observed for any change in operating conditions that could cause leaks or failures. Significant changes in wellhead pressure, gas-oil-water ratios, flow rates, and similar parameters should be evaluated to prevent leaks or failures.

9.9 FLOWING WELLS

Annuli of flowing wells should be tested at regular intervals for any pressure changes. Such pressure changes may indicate a downhole failure of the packer, tubing, or casing. Changes in fluid volumes or ratios, fluid corrosiveness, and surface pressures should be evaluated to determine the need for corrective measures.

9.10 FLOW/GATHERING LINES

Flow line and gathering line right-of-ways should be observed for conditions conducive to pipeline failures, such as those caused by excavation, construction, trespassing, or surface erosion.

9.11 PRESSURE VESSELS

Relief valves and other applicable components on pressure vessels shall be tested according to regulatory requirements or company policy. Refer to *API 510* and *API*

Recommended Practice 576.

9.12 PRESSURE RELIEF AND NORMALLY VENTING DEVICES

The discharge of pressure relief and normally venting devices should be located away from work areas and designed to maximize dispersion and minimize personnel exposure to hydrogen sulfide. Refer to Par. 8.1.4 for considerations for materials applications in hydrogen sulfide service.

9.13 STORAGE TANKS

Produced liquids storage tanks should be observed for needed repairs or maintenance. The tank thief hatch seals, inspection and clean-out plate seals, vent line back-pressure valves, etc., should be serviced or replaced as appropriate. Refer to *API Recommended Practice 12R1.*

9.14 FLARE SYSTEMS

Ignition devices for flare systems handling hydrogen sulfide in hazardous concentrations should be inspected and serviced regularly to ensure proper operation.

9.15 MONITORING EQUIPMENT—MAINTENANCE, TESTING, AND CALIBRATION

Monitoring equipment used to detect occupational exposure levels of hydrogen sulfide shall be serviced and tested at intervals recommended by the manufacturer, and possibly more frequently under extreme humidity, temperature, dust, or other adverse environmental operating conditions. The monitoring equipment should be calibrated by qualified individuals at intervals frequent enough to enable the user to determine an acceptable calibration schedule. The equipment should be calibrated once every three (3) months, at intervals not exceeding 100 days. Refer to *ISA Recommended Practice 12.15,* the equipment manufacturer's instruction manual, and Section 10.

9.16 CORROSION MONITORING

A corrosion monitoring program should be established to detect and mitigate internal and external corrosion activity that can affect equipment in hydrogen sulfide service.

9.17 CONFINED SPACE ENTRY

Enclosures with known or potential hydrogen sulfide hazards and restricted means of entrance and exit deserve special attention. These enclosures are not normally occupied by people nor well ventilated. Examples of such enclosures in the oil and gas producing and gas processing plant industries may include tanks, cellars, process vessels, tank trucks, temporary and permanent pits and trenches, and barges. A confined space entry permit shall be required for entry into a confined space. A confined space entry permit should as a minimum:

a. identify the job site.
b. indicate the date and duration of the permit.
c. specify testing requirements and other conditions to safely perform the job.
d. ensure that sufficient monitoring is conducted to ascertain that the hydrogen sulfide, oxygen,[22] or hydrocarbon concentrations do not become a health or fire hazard, and
e. bear the approval specified in the operator's procedure.

As an alternate to foregoing Par. 9.17, Item d, proper personal protective breathing equipment may be worn during the work operation; however, sufficient monitoring of the enclosure atmosphere shall be performed to ensure that it is free of an ignitable mixture of hydrocarbons. Refer to OSHA's Confined Space Entry Standard (29 *Code of Federal Regulations* Part 1910.146)

9.18 ENCLOSED FACILITY ENTRY

Personnel shall use extreme caution before entering enclosed facilities such as buildings housing oil, gas, or produced water processing and handling equipment containing hazardous concentrations of hydrogen sulfide. Personnel shall either establish that entry without personal protective breathing (respiratory protection) apparatus will be safe or shall wear protective breathing equipment. Refer to Section 12 for additional details and precautions.

9.19 IRON SULFIDE PRECAUTIONS

Iron sulfide, a reaction product of hydrogen sulfide and iron or spent iron sponge (a treating material), when exposed to air, can autoignite (spontaneous combustion) and burn. Iron sulfide, when exposed to air, should be kept wet until it can be disposed of in accordance with applicable regulations. Iron sulfide scale can accumulate on inside surfaces of vessels and on filter elements used in amine systems and become an autoignition hazard if exposed to atmospheric oxygen. One of the products of burning iron sulfide is sulfur dioxide; proper safety procedures must be effected to deal with this toxic substance.

9.20 DRILLING OPERATIONS

Refer to *API Recommended Practice 49* for recommended procedures for drilling and drill stem testing operations involving hydrogen sulfide.

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[22] *API PUBL 2217A: Guidelines for Work in Confined Spaces in the Petroleum Industry* specifies an oxygen content of less than 19.5% as oxygen deficient and an oxygen content of less than 16% is considered immediately dangerous to life and helath (IDLH).

9.21 SAFETY PRECAUTIONS FOR SAMPLING AND TANK GAUGING OPERATIONS

When it is known or suspected that the system to be sampled or gauged may contain hydrogen sulfide, special precautions shall be observed. Production tanks shall be tested to determine their hydrogen sulfide content (refer to Par. 9.3). Tests should also be conducted within the normal worker breathing zone to determine if the levels stipulated in Par 4.1 may be exceeded and if engineering controls, administrative procedures, or personal protective breathing equipment (refer to Par. 6.4) may be required for sampling or tank gauging operations. The tests should be conducted under operating and atmospheric conditions to determine the maximum hydrogen sulfide exposure level.

If the hydrogen sulfide level in the worker breathing zone exceeds IDLH level (300 ppm), in addition to appropriate personal protective breathing equipment (refer to Par. 6.4), rescue precautions and procedures (refer to Pars. 6.5 and 6.6) shall be utilized.

9.22 FACILITIES ABANDONMENT—SURFACE EQUIPMENT

Precautions should be taken to ensure that hazardous quantities of hydrogen sulfide do not remain in abandoned surface equipment, including buried pipelines and flow lines. Pipelines and flow lines left in place should be purged, bullplugged, or otherwise capped. Vessels should be flushed with water, purged, drained, and left open to the atmosphere. Precautions should be taken to prevent an iron sulfide fire (refer to Par. 9.19).

CAUTION: Prior to abandonment, vessels should be checked for the presence of naturally occurring radioactive material (NORM) and appropriate safety and handling procedures should be exercised. Refer to *API Bulletin E-2* for guidance on management of NORM.

9.23 WELL ABANDONMENT

The following recommended practices are not intended to supersede federal, state, or local regulations for well abandonment. Where not covered by applicable regulations, the practices and well conditions should be considered in planning and effecting permanent well abandonment. It is recommended that cement be set across formations that are known to produce or could produce hydrogen sulfide in hazardous concentrations. Refer to *API Bulletin E-3* for guidance and procedures for plugging and abandoning wells.

9.24 CONTINGENCY PLAN REVISIONS

Operating personnel should be observant for changes that would make reconsiderations and possible revisions advisable in contingency plan coverage, location(s) of monitoring equipment, and location(s) of lease equipment. Some changes that should be observed and considered are new residences or residential areas, stores, businesses, parks, schools, or roads; changes in well operations; and changes in lease facilities. Refer to Section 7 for suggested procedures for planning and implementing contingency plans and emergency procedures.

10 Guidelines for Evaluation and Selection of Continuous Hydrogen Sulfide Monitoring Equipment

10.1 INTRODUCTION

Section 10 is provided to make users of hydrogen sulfide monitoring equipment aware of some equipment limitations and certain desirable features of such equipment. There are a number of detection principles and analytical procedures available for monitoring the concentration of hydrogen sulfide in ambient air where the potential exists for exposure to levels that may be hazardous to health. These guidelines are intended to aid in the selection and application of continuous monitoring equipment for use in production operations involving hydrogen sulfide. The term "continuous hydrogen sulfide monitoring equipment" as used herein is defined as equipment capable of continuously measuring and displaying the concentration of hydrogen sulfide in ambient air. Section 10 is not applicable to personnel monitoring badges or length-of-stain or color-comparison type detector devices (refer to *ANSI/ISEA 102*).

10.2 GENERAL

All monitors, both portable and stationary, shall be designed on sound engineering and scientific principles and constructed of materials suitable for the application. Their design and construction should allow for ease of maintenance and repair. Instruments should be verified by a national recognized testing laboratory (NRTL) as meeting the minimum performance requirements of *ISA-S12.15*, Part I. Equipment should be installed, operated, and maintained in accordance with *ISA Recommended Practice 12.15*, Part II.

It generally is recommended (and frequently required) that electrical controls for safety systems such as hydrogen sulfide monitoring equipment and other gas detector systems be installed normally-energized ("fail-safe"). This means that power is supplied continuously during normal operations to devices which provide alarm(s) and corrective action if concentrations corresponding to specific alarm set points are reached. Under these conditions, interruption of power due to either deliberate safety device actuation or loss of power will initiate corrective action. It is desirable to provide a test means that will allow the system to be tested (and calibrated) without shutting in producing or gas processing plant operations (or other corrective action), but it should be evident to operating personnel that the system is in the test (bypass) mode.

To better ensure proper application, it is recommended that an environmental and application checklist (similar to the example shown in Appendix 1, *ISA Recommended Practice 12.15*, Part II) be provided to prospective vendors by the user.

10.3 CONSTRUCTION CHARACTERISTICS

The following construction and useability characteristics are desirable for hydrogen sulfide monitoring equipment.

10.3.1 Portability

Portable monitors, including all required parts and accessories, should weigh a maximum of ten (10) pounds and have a maximum volume of one (1) cubic foot.

10.3.2 Power Supply, Portable Monitoring Equipment

Portable hydrogen sulfide monitoring equipment is defined as self-contained, battery-operated, carriable or transportable instruments capable of operating within specifications from integral batteries for a period of eight hours minimum, including a 15 minute period of maximum load conditions (with alarms, lights, etc. activated), while exposed to clean air at a nominal temperature of 14°F (-10°C). Applications requiring in excess of eight hours of continuous operation or operation at lower temperatures should be specified by the end user.

10.3.3 Readout

Monitors should provide a direct readout of hydrogen sulfide concentration in parts per million (ppm) by volume.

10.3.4 Recorder Output

For certain applications, it may be desirable for monitors to provide an output signal (e.g., 4-20 ma) proportional to hydrogen sulfide concentration for use in connection with recorders or for other purposes.

10.3.5 Simplicity of Operation

Monitoring and detection equipment should be readily operable by personnel without scientific background or training in instrumentation.

10.3.6 Instruction Manuals

An instruction manual should be provided by the manufacturer with each instrument. The instruction manual should contain complete operating instructions, including procedures for startup, warm-up time, zero checks, calibration, alarm setting and testing, preventive maintenance, performance checks, and trouble-shooting. Monitors with rechargeable power supplies should be furnished with instructions for charging, storing, and maintaining the power supply. Information also should be included regarding instrument recovery time after the exposure of sensor(s) to hydrogen sulfide. The manufacturer should provide response time data and a list of interfering, desensitizing, or contaminating substances or water vapor concentrations known to the instrument manufacturer which may adversely affect proper operation and performance of the instrument (refer to Par. 10.4.7). Instruction manuals should include wiring diagrams and estimates of the life expectancy of all consumables. The manual should include a complete parts list suitable for identification of all replaceable parts and sources for procurement of these parts.

10.3.7 Electrical Approval

Any portion of a stationary hydrogen sulfide monitoring instrument intended for installation or use in a hazardous (classified) location and all portable monitoring instruments shall be approved for use in such a hazardous (classified) location and marked accordingly. Refer to *NFPA 70*, Article 500-3, FPN No. 2.

10.3.8 Ruggedness

Portable monitoring units should be sufficiently rugged to withstand routine transporting, handling, and use in the field environment, as specified by the user. Refer to *ISA-S12.15* for details of a recommended "drop test" to evaluate portable unit ruggedness and a "vibration test" to evaluate ruggedness of fixed and portable monitors.

10.3.9 Calibration Equipment

All accessories required to calibrate the instruments should be made available by the manufacturer. The life expectancy and any special handling required of any hydrogen sulfide test concentrations should be provided by the supplier.

10.3.10 Zero and Span Adjustments

Zero and span adjustment controls should be readily accessible for field adjustment, and the monitor design should include provisions to apply zero and calibration gases to the sensor(s) in a non-laboratory environment. All accessories for calibration and zero should be made available with the monitor and should be useable under field conditions.

10.3.11 Alarm Systems

Fixed monitors shall have provisions for external alarms. Portable monitor units should contain integral audible, visual, or physical presentation (e.g., vibrator signal) alarms as specified by the user. Hydrogen sulfide alarms should be unique to the location.

10.3.12 Testing Alarm Circuitry

Provisions should be included for the testing of alarms and alarm outputs. The test procedure should be included in the equipment instruction manual.

10.3.13 Remote Sampling

A remote sampling accessory (such as a probe) may be desirable for use with a portable monitoring unit.
CAUTION: Optional probe attachments for portable monitoring units, which allow the user to manually draw samples from remote locations, inherently prevent continuous monitoring of the immediate local environment. Users should consult the manufacturer's instruction manual to determine the proper number of bulb strokes required to draw samples when non-continuous monitoring attachments are used. The remote sampling attachment should be removed after use to restore the instrument to the normal continuous monitoring mode.

10.3.14 Equipment Trouble (Malfunction) Alarm

A trouble (malfunction) signal (indicator or output) should be provided for all monitors.

10.3.15 Detection Range Indication

The range(s) of detection should be conspicuously marked on the instrument.

10.4 PERFORMANCE GUIDELINES

The following recommended performance parameters are applicable to fixed and portable hydrogen sulfide monitoring equipment.

10.4.1 Accuracy

Instruments should meet requirements of the accuracy test specified in *ISA-S12.15,* Part I. Users are cautioned that the class of instruments suitable for field use are not "laboratory-grade" instruments, and *an equivalent degree of precision should not be expected.*

10.4.2 Zero Drift

Instruments should meet the requirements of the "Long-term Stability Test" specified in *ISA-S12.15,* Part I. Excessive zero drift is undesirable and can require instrument calibration at unreasonably short intervals.

10.4.3 Warm-up Time

The minimum warm-up time when power is first applied should be stated in the equipment instruction manual. A monitor ready-status indicator is a desirable feature.

10.4.4 Response Time

ISA-S12.15, Part I specifies monitoring equipment minimum response time to input step changes. The toxicity of hydrogen sulfide requires that monitoring equipment have rapid response time to alert personnel of potentially dangerous concentrations. Hence, response time of monitoring equipment is an important parameter for consideration in evaluation and selection of such equipment.

10.4.5 Operating Humidity Range

Monitoring equipment should meet the "Humidity Variation Test" specified in *ISA-S12.15,* Part I. Users should advise equipment manufacturers of the humidity ranges expected for specific equipment applications.

10.4.6 Operating Temperature Range

Monitoring equipment should be suitable for viable use in an ambient temperature range of 14°F to 122°F (-10°C to 50°C). Applications requiring equipment exposure to temperatures outside this range should be specified by the user.

10.4.7 Interferences

A list of interfering, desensitizing, and contaminating substances (e.g., carbon monoxide, sulfur dioxide, aromatic mercaptans, methanol, oxides of nitrogen, aldehydes, carbon sulfide, monoethanolamine, carbon dioxide, benzene, and methane) known by the manufacturer should be listed in the equipment instruction manual. Also, water vapor concentrations which may adversely affect proper equipment operation should be included in the instruction manual.
CAUTION: Monitoring and detector equipment and sensors should be protected from exposure to liquid spray or wash down. Such exposure can affect equipment performance and reliability.

10.4.8 Functional Field Test

Functional field testing of monitoring equipment should be conducted under "as installed" or "as used" conditions. All instrument and system accessories normally used with this equipment should be installed and operated during functional field tests. Functional field tests may include, but are not limited to, exposing the sensor to a sample containing sufficient hydrogen sulfide to cause response of the system. Functional field testing *does not* necessarily include zero and span adjustments. The hydrogen sulfide concentration used in functional field testing of monitoring equipment should not exceed the maximum operating range of the equipment being tested.

10.4.9 Air Velocity

Monitoring equipment should meet the "Air Velocity Variation Test" specified in *ISA-S12.15,* Part I. Accessories are often available and may be desirable for use with detector equipment installed in areas of high air velocity.

10.4.10 Electromagnetic Interference (EMI)

Some monitoring equipment may be susceptible to electromagnetic interference (EMI), particularly radio frequency interference (RFI). Caution should be taken when using monitoring equipment in close proximity to a radio transmitter or other EMI generators. Refer to *ISA-S12.15*, Part I, Sections 9.5 and 11.6.

11 Offshore Operations

11.1 INTRODUCTION

Section 11 presents some additional recommendations that are needed offshore due to the uniqueness of offshore operations. Many recommendations in other sections of this publication also are applicable to offshore operations. Refer to Appendix F, "Toxic Gases", *API Recommended Practice 14C.*

11.2 UNIQUENESS OF OFFSHORE OPERATIONS

Problems that might be considered minor in onshore operations can be more critical in offshore operations. This is due to the remoteness of offshore operations, compactness of facilities, limited escape and evacuation routes, and sophisticated escape and evacuation equipment.

11.3 FEDERAL REGULATORY REQUIREMENTS

Refer to 30 *Code of Federal Regulations* Parts 250 and 256 for Minerals Management Service, U. S. Department of Interior (DOI) requirements for Outer Continental Shelf (OCS) oil and gas producing operations involving hydrogen sulfide. These regulations include requirements for training personnel involved in OCS oil and gas producing operations and for hydrogen sulfide contingency plans for OCS oil and gas producing operations.

11.4 CONTINGENCY PLANNING

Where potentially hazardous atmospheric concentration of hydrogen sulfide could occur offshore, contingency planning is particularly essential due to the uniqueness of facilities as discussed in Par. 11.2. Although the recommendations for contingency planning presented in Section 7 are applicable to offshore operations, there are additional items that should be addressed. These include, but are not limited to, the following:

a. Training. All personnel shall be familiar with the location and use of emergency escape equipment and routes. Personnel regularly assigned to offshore facilities shall be trained in the requirements of Par. 5.2, as well as be proficient in the use of oxygen resuscitation equipment.

b. Evacuation Procedures. The U. S. Coast Guard's (Department of Transportation) requirements for emergency evacuation plans for manned Outer Continental Shelf facilities are contained in 33 *Code of Federal Regulations* Parts 140, 143, and 146 (refer to 54 *Federal Register*, May 18, 1989, 21566). Surface and/or air transportation to the site should be available since it may be necessary to evacuate visitors and other non-essential personnel and to bring in specialists or equipment if a hazardous hydrogen sulfide condition is suspected or does occur. Monitoring for combustible gases (primarily methane) and hydrogen sulfide should be provided to avoid unnecessarily exposing personnel and equipment to the dangers of a fire, explosion, or hazardous concentration during transport or transfer operations. If a hazardous hydrogen sulfide condition is known or suspected to be imminent, boats and helicopters should approach the site from an upwind direction, when possible.

Proper personal protective breathing equipment must be provided for helicopter and boat crew members and all passengers. Evacuation routes and deboarding procedures shall be well planned and posted. Evacuation drills shall be regularly performed.

11.5 SIMULTANEOUS OPERATIONS

Particular emphasis must be given to coordination between drilling, well servicing, producing, and construction operations when two or more of these activities are conducted simultaneously. An individual shall be designated to be the person-in-charge for simultaneous operations, and the chain of command shall be communicated to all applicable personnel.

12 Operations Involving Enclosed Facilities

12.1 INTRODUCTION

Section 12 presents some additional recommendations that are unique to oil and gas producing and gas processing plant operations in enclosed facilities[23] and involving hydrogen sulfide (refer to Par. 4.1). An enclosed facility may be as simple as a single piece of equipment within an enclosure or as complicated as complex onshore or offshore enclosed facilities located in cold climates.

12.2 UNIQUENESS OF OPERATIONS INVOLVING ENCLOSED FACILITIES

The uniqueness of oil and gas producing and gas processing plant operations in enclosed facilities is due to the potential that escaping quantities of hydrocarbon gases containing hydrogen sulfide can be contained in an enclosed space[23], particularly if ventilation is inadequate. This space may be entered by personnel. A small leak of product containing hydrogen sulfide gas that would normally dissipate as it escaped can be contained in the enclosed space surrounding the leak and increase the hazard to entering personnel unless adequate ventilation is provided to reduce the hazard.

12.3 DESIGN CONSIDERATION

The design and construction practices of Section 8 generally apply to enclosed facilities, but there are areas of design that should be considered due to the unique operating situations they present. Additional design considerations for enclosed facilities can include, but are not limited to, the following:

a. Means to prevent flammable liquids and gases from coming into contact with surfaces hot enough to cause ignition. The autoignition temperature for natural gas is approximately 900°F (482°C). The autoignition temperature for other natural gas mixtures ranges from 700°F to 900°F (371°C to 482°C). The autoignition temperature for hydrogen sulfide is approximately 500°F (260°C).
b. Ventilation.
c. Onsite respiratory protection equipment.
d. Electrical equipment (possibly Group C versus Group D equipment required). Refer to Par. 3.5, "National Electrical Code Grouping of Atmospheric Mixtures", of *API Recommended Practice 500.*
e. Emergency relief and depressuring devices and their discharge points.
f. Hydrocarbon vents from diaphragm valves, machinery, and regulators.
g. Compressor depressuring and blowdown lines.
h. Floor drains.
i. Process drains, manual and automatic.
j. Vents from gas conditioning equipment (glycol and amine).
k. Hydrogen sulfide monitoring system.

12.4 FIXED HYDROGEN SULFIDE MONITORING SYSTEM

In many locations where personnel enter frequently, on a regular basis, or occupy enclosed facilities for relatively long periods of time, fixed hydrogen sulfide monitoring systems (with adequate alarms) can enhance safety. In some locations, an alternative to fixed monitoring systems may be implementation of personnel entry procedures (refer to Pars. 9.18 and 12.5).

Fixed hydrogen sulfide monitoring systems should be installed in facilities containing process equipment (vessels, machinery, etc.) handling gases or fluids containing hydrogen sulfide when a release of these gases or fluids is capable of causing atmospheres with hydrogen sulfide in concentrations exceeding 10 ppm when the locations are both:

a. an enclosed area (room, building, or space) as defined by Par. 12.1 and *API Recommended Practice 500.*
b. inadequately ventilated. [*Inadequately ventilated* is defined as ventilation (natural or artificial) which is *not* sufficient to prevent the accumulation of significant quantities of hydrogen sulfide-air mixtures in concentrations exceeding 10 ppm]. Adequacy of ventilation should be assessed on a site-specific basis.

Fixed monitoring systems shall contain audible alarm devices (and visual alarm devices in high noise areas, refer to Par. 10.3.11) activated by hydrogen sulfide concentrations at preset levels (not to exceed 10 ppm), as required to alert personnel. Hydrogen sulfide monitoring equipment should be calibrated in accordance with Par. 9.15.

It is recognized in specific instances that a fixed combustible gas detection system may detect the existence of a potentially hazardous atmospheric condition before a fixed hydrogen sulfide monitoring system that is set to alarm at 10 ppm of hydrogen sulfide would be activated. For example, in a release of a 300 ppm hydrogen sulfide in methane mixture, a combustible gas detector set to alarm at 20% lower explosive limit (LEL) would activate and sound an alarm at a hydrogen sulfide concentration of approximately 3 ppm.

In such instances, a regular testing program should be established to monitor content of the process stream to ensure that the concentration of hydrogen sulfide has not increased. If an increase in the hydrogen sulfide concentration is confirmed, the user should verify adequacy of the detection system in use. This verification should consider all variable criteria that will affect performance of the detection equipment as well as factors that could increase the concentration of hydrogen sulfide in the work atmosphere should a malfunction or equipment failure occur.
CAUTION: This option is limited in its scope and should be used only when all applicable limitations and site specific parameters have been duly considered.

Fixed monitoring systems are also desirable to monitor the air intake for enclosed areas when the air is used for makeup or for pressurizing the enclosed facilities (refer to *NFPA 496*).

12.5 PERSONNEL PROTECTION TECHNIQUES

A method of protecting personnel from exposure to atmospheric concentrations of hydrogen sulfide exceeding 10 ppm should be provided in all enclosed facilities containing process equipment (vessels, machinery, etc.) handling hydrogen sulfide bearing fluids and capable of causing hydrogen sulfide atmospheric concentrations in excess of 10 ppm. Acceptable methods include:

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[23] An enclosed facility (room, building, or space) is defined as a three-dimensional space enclosed by more than two-thirds ($^2/_3$) of the possible projected plane surface and of sufficient size to allow the entry of personnel. For a typical building, this would require that more than two-thirds ($^2/_3$) of the walls, ceiling, and/or floor be present. Refer to *API Recommended Practice 500.*

a. Requiring personnel to wear proper protective breathing apparatus (refer to Par. 6.4) before entering and when in the facility.
b. Installing fixed hydrogen sulfide monitoring equipment (refer to Par. 6.2, Section 10, and Par. 12.4).
c. Properly ventilating the facility to maintain hydrogen sulfide concentrations in the work atmosphere less than 10 ppm, confirmed by monitoring with a fixed hydrogen sulfide monitoring system. Recirculation of air is allowed, but recirculated air streams should be monitored with fixed monitoring systems to alarm when concentrations of hydrogen sulfide exceed 10 ppm in the recirculated air.
d. Testing the facility before entry and continuously while in the facility, using portable hydrogen sulfide detection equipment (refer to Par. 6.3), to ensure that hydrogen sulfide concentration in the work area atmosphere does not exceed 10 ppm.

Note: Personnel shall either establish that entry without protective breathing (respiratory protection) equipment will be safe or shall wear appropriate personal protective breathing equipment (refer to Par. 6.4).

12.6 WARNING SIGNS

Legible warning signs, such as "HYDROGEN SULFIDE OPERATIONS—ENTER ONLY WHEN MONITORING SHOWS THE AREA TO BE SAFE" or "RESPIRATORY PROTECTION EQUIPMENT MUST BE WORN BEYOND THIS POINT", shall be prominently posted outside all access doorways leading into enclosed facilities where produced fluids or gases containing hydrogen sulfide (refer to Par. 4.1 for applicability) are being processed or handled.

Note: Regulatory requirements for sign posting shall be observed.

13 Gas Processing Plant Operations

13.1 INTRODUCTION

Section 13 presents some additional recommendations that are unique to gas processing plant operations involving hydrogen sulfide (refer to Par. 4.1.). Some recommendations in other sections of this publication also are applicable to gas processing plant operations.

13.2 GENERAL CONSIDERATIONS

Gas processing plant operations typically include more complex processes than field operations (e.g., gas conditioning facilities). Some differences include:

a. potentially higher volumes of gas containing hydrogen sulfide,
b. potentially higher concentrations of hydrogen sulfide,
c. generally a greater number of personnel and more equipment, and
d. the assignment of personnel on a more regular basis.

These differences often require special considerations to ensure safe operations involving activities such as vessel and line openings and confined space entry. When such activities are to take place, a coordinating meeting between operations, maintenance, contractor, and other involved parties should be held to ensure that facility personnel are aware of the activities involved, their effect(s) on plant operations, and the necessary safety precautions that are to be followed.

13.3 GAS CONDITIONING FACILITIES

Many gas treating and sulfur recovery processes are employed in gas processing plants. These processes can be classified into chemical reaction, physical solution, and adsorption processes, and can be further subdivided into regenerable and non-regenerable processes. Regenerable type processes include amine solvents, hot potassium carbonate, molecular sieve, and chelants. Non-regenerable type processes include iron sponge, caustic scrubbers, metal oxides, direct oxidation, and various other sulfur recovery processes. Because most of these methods result in a concentrated hydrogen sulfide stream or reaction product, operators shall be familiar with the various chemical and physical characteristics of the process(es) at the particular facility. The amount of hydrogen sulfide in residence within a process may be sufficient to require implementation of requirements contained in 29 *Code of Federal Regulations* Part 1910.119.

13.4 MATERIALS OF CONSTRUCTION

The failure of gas processing plant equipment components can permit the uncontrolled release of hydrogen sulfide to the atmosphere. Those equipment components in the sulfide stress cracking regime should be made from sulfide stress cracking resistant materials (refer to Par. 8.1.3).

13.5 CORROSION MONITORING

A corrosion monitoring program should be established to minimize internal and external corrosion activity which can affect equipment in hydrogen sulfide service.

13.6 LEAK DETECTION

In gas or liquid handling systems containing hydrogen sulfide in concentrations capable of causing atmospheric concentrations of 10 ppm or more of hydrogen sulfide, monitoring techniques or procedures (for example, visual observation, soap bubble test, portable detectors, or fixed monitoring equipment) should be employed to detect leaks. Particular attention should be given to enclosed facilities, such as control rooms, compressor buildings, cellars, and sumps (refer to Section 12). Regularly scheduled inspection of equipment for leaks, such as pump seals, is recommended. Results should be retained for a minimum of one year as a part of the facility or equipment operating and maintenance records. Fixed hydrogen sulfide ambient air monitoring systems are recommended (refer to Section 10 and Appendix C) in gas processing plants located near populated areas to facilitate early detection and necessary warning to the general public.

13.7 CONTINGENCY PLANNING

Contingency plans for gas processing plant facilities shall cover plant personnel and the general public that could be exposed to a release of hydrogen sulfide (refer to Appendix B of *API Recommended Practice 750*. Operating personnel must be familiar with emergency plant shutdown procedures, rescue operations, notification procedures, briefing areas, and locations of emergency equipment (refer to Section 7). Visitors shall be briefed on the physical layout of the gas processing facility, applicable warning signals, and how to respond in the event of an emergency.

APPENDIX A—PHYSICAL PROPERTIES AND PHYSIOLOGICAL EFFECTS OF HYDROGEN SULFIDE

A.1 Physical Data

Chemical Name: Hydrogen Sulfide

CAS Number: 7783-06-4

Synonyms: Sulfureted hydrogen, hydrosulfuric acid, dihydrogen sulfide.

Chemical Family: Inorganic sulfide.

Chemical Formula: H_2S.

Normal Physical State: Colorless gas, slightly heavier than air. Vapor density (specific gravity) at 59°F (15°C) and 1 atmosphere = 1.189.

Autoignition Temperature: 500°F (260°C).

Boiling Point: -76.4°F (-60.2°C).

Melting Point: -117.2°F (-82.9°C).

Flammable Limits: 4.3 - 46 percent vapor by volume in air.

Solubility: Soluble in water and oil; solubility decreases as the fluid temperature increases.

Combustibility: Burns with a blue flame to produce sulfur dioxide (SO_2). Refer to Appendix B.

Odor and Warning Properties: Hydrogen sulfide has an extremely unpleasant odor, characteristic of rotten eggs, and is easily detected at low concentrations. However, due to rapid onset of olfactory fatigue and paralysis (inability to smell) ODOR *SHALL NOT* BE USED AS A WARNING MEASURE.

A.2 Exposure Limits

The Occupational Safety and Health Administration (OSHA) has established 20 ppm by volume as an acceptable ceiling concentration (ACC) and 50 ppm by volume as an acceptable maximum peak above the ACC for an 8-hour shift for hydrogen sulfide (refer to 29 *Code of Federal Regulations* Part 1910.1000, Subpart Z, Table Z-2). The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a Threshold Limit Value (TLV)®(1) of 10 ppm (eight-hour TWA) and a short term exposure limit (STEL) of 15 ppm averaged over fifteen minutes. Exposure at the STEL should not be repeated more than four times per day with at least sixty minutes between successive exposures in this range. For Outer Continental Shelf (OCS) oil and gas producing operations, exposure levels exceeding 20 ppm instantaneous exposure require use of personal protective breathing equipment pursuant to U. S. Department of Interior, Minerals Management Service Final Rule, 30 *Code of Federal Regulations* Part 250.67, as published at 53 *Federal Register* 10596-10777, April 1, 1988(2). The *NIOSH Recommended Standard for Occupational Exposure to Hydrogen Sulfide* should be consulted for additional detailed information. Refer to Table A-2 for additional information on exposure values. CHECK WITH THE EMPLOYER CONCERNING EXPOSURE LIMITS FOR PARTICULAR CIRCUMSTANCES.

A.3 Physiological Effects

INHALATION AT CERTAIN CONCENTRATIONS CAN LEAD TO INJURY OR DEATH (refer to Table A-1). Hydrogen sulfide is an extremely toxic, flammable gas that may be encountered in the production and processing of gas well gas, high-sulfur-content crude oil, crude oil fractions, associated gas, and waters. Since hydrogen sulfide is heavier than air, it can collect in low places. It is colorless and has a foul, rotten-egg odor. In low concentrations, it is detectable by its characteristic odor. However, smell cannot be relied on to forewarn of dangerous concentrations because exposure to high concentrations (greater than 100 ppm) of the gas rapidly paralyzes the sense of smell due to paralysis of the olfactory nerve. A longer exposure to lower concentrations has a similar desensitizing effect on the sense of smell. IT SHOULD BE WELL UNDERSTOOD THAT THE SENSE OF SMELL WILL BE RENDERED INEFFECTIVE BY HYDROGEN SULFIDE, WHICH CAN RESULT IN AN INDIVIDUAL FAILING TO RECOGNIZE THE PRESENCE OF DANGEROUSLY HIGH CONCENTRATIONS. Excess exposure to hydrogen sulfide causes death by poisoning the respiratory system *at the cellular level*. There is some indication that the presence of alcohol in the blood aggravates the effects of hydrogen sulfide in acute poisoning cases. Even at low concentrations (10-50 ppm) hydrogen sulfide is irritating to the eyes and respiratory tract. Closely repeated short-term exposures at low concentrations may lead to irritation of the eyes, nose, and throat. Symptoms from repeated exposures to low concentrations usually disappear after not being exposed for a period of time. Repeated exposures to low concentrations that do not produce effects initially may eventually lead to irritation if the exposures are frequent.

A.4 Respiratory Protection

The National Institute for Occupational Safety and Health (NIOSH) has examined the criteria for respirator tests and sources of respirator leakage and recommends that positive pressure, either supplied-air or self-contained breathing apparatus, as appropriate, with a full face piece be worn by

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(1) "TLV" is a trademarked term of the American Conference of Governmental Industrial Hygienists (ACGIH). Refer to *Threshold Limit Values and Biological Exposure Indices* and companion documents available from ACGIH, 1330 Kemper Meadow Drive, Cincinnati, OH 45240 (check latest edition).

(2) Available from Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402.

anyone exposed to atmosphere containing hydrogen sulfide concentrations above OSHA's ACC (refer to 29 *Code of Federal Regulations* Part 1910.1000, Subpart Z, Table Z-2) Refer to Par. 6.4 for proper breathing equipment recommendations for oil and gas producing and gas processing plant operations involving hydrogen sulfide.

Note: There are differences of opinion in the medical community about whether a person with a perforated eardrum can become overexposed to a toxic substance via the ear, even when wearing proper personal breathing apparatus, and whether they should be excluded from work in a hydrogen sulfide environment(3). Theoretical calculations by Richard Ronk and M. K. White(3) have led the authors to conclude that tympanic membrane (eardrum) defects do not significantly compromise respiratory protection against hydrogen sulfide and that individuals with perforated tympanic membranes should not be excluded from work in a hydrogen sulfide environment. The validity of these calculations is supported by the absence of case reports of hydrogen sulfide poisoning due to tympanic membrane defect.

Ronk and White(3) also concluded that wearers of positive-pressure, either supplied-air or self-contained personal breathing apparatus, with a full face piece, as recommended by the National Institute for Occupational Safety and Health (NIOSH), who have a tympanic membrane defect and a concurrent tympanomaxillary shunt or a patulous eustachian tube (the tube remains open) may experience the sensation of outward air flow which can be annoying.

In 1982, the Minerals Management Service (MMS), U. S. Department of Interior, amended requirements of the Outer Continental Shelf (OCS) Hydrogen Sulfide Standard, *MMS-OCS-1*, "Safety Requirements for Drilling Operations in a Hydrogen Sulfide Environment, Outer Continental Shelf", Section 5.2, February 1976. MMS rescinded the requirement for personnel eardrum examinations and rescinded the prohibition against persons with perforated eardrums working in a hydrogen sulfide environment (refer to 47 *Federal Register* 28888-28890, July 1, 1982).

The U. S. Occupational Safety and Health Administration may address this subject in future revision of its Respiratory Protection Standard (29 *Code of Federal Regulations* Part 1910.134).

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(3)Compare Poda, George A., "Hydrogen Sulfide Can Be Handled Safely", *Archives of Environmental Health*, Vol. 12, 795-800, June 1966, and Ronk, Richard and White, M. K., "Hydrogen Sulfide and the Probabilities of Inhalation Through Tympanic Membrane Defect", *Journal of Occupational Medicine*, Vol. 25, No. 5, 337-340, May 1985.

Table A-1—Hydrogen Sulfide

Concentration in Air				
Percent by Volume	Parts Per Million By Volume	Grains Per 100 Std. Cubic Feet	Milligrams Per Cubic Meter(4)	Typical Characteristics Regarding Hydrogen Sulfide Exposure(5)
0.000013	0.13(6)	0.008(6)	0.18(6)	Obvious and unpleasant odor generally at 0.13 ppm and quite noticeable at 4.6 ppm. As the concentration increases, the sense of smell fatigues and the gas can no longer be detected by odor.(6)
0.001	10	0.63	14.41	Unpleasant odor. Possible eye irritation. ACGIH recommended Threshold Limit Value (TLV)® (eight-hour TWA).(7)
0.0015	15	0.94	21.61	ACGIH STEL averaged over 15 minutes.(7)
0.002	20	1.26	28.83	Burning sensation in eyes and irritation of the respiratory tract after one hour or more exposure. OSHA ACC (refer to 29 *Code of Federal Regulations* Part 1910.1000, Subpart Z, Table Z-2).
0.005	50	3.15	72.07	Loss of sense of smell after about 15 or more minutes exposure. Exposure over one hour may lead to headache, dizziness, and /or staggering. Pulmonary edema reported following extended exposure to greater than 50 ppm.(8) Exposure at 50 ppm or greater can cause serious eye irritation or damage.
0.01	100	6.30	144.14	Coughing, eye irritation, loss of sense of smell after 3 to 15 minutes. Altered respiration, pain in eyes, and drowsiness after 15 to 20 minutes, followed by throat irritation after one hour. Prolonged exposure results in a gradual increase in the severity of these symptoms.
0.03	300	18.90	432.40	Marked conjunctivitis and respiratory tract irritation. Note: Concentration considered immediately dangerous to life or health (IDLH)(9) (refer to *DHHS No. 85-114, NIOSH Pocket Guide to Chemical Hazards.*(10))
0.05	500	31.49	720.49	Unconsciousness after short exposure, cessation of breathing if not treated quickly. Dizziness, loss of sense of reasoning and balance. Victims need prompt artificial ventilation and /or cardiopulmonary resuscitation (CPR) techniques.
0.07	700	44.08	1008.55	Unconscious quickly. Breathing will stop and death will result if not rescued promptly. Artificial ventilation and/or cardiopulmonary resuscitation (CPR) is needed immediately.
0.10+	1000+	62.98+	1440.98+	Unconsciousness at once. Permanent brain damage or death may result. Rescue promptly and apply artificial ventilation and /or cardiopulmonary resuscitation (CPR).

Note: Data in Table A-1 are approximate values for guidance. There are published data that show slightly different values.

(4) Based on 1% hydrogen sulfide = 629.77 gr/100 SCF @ 14.696 psia and 59°F (101.325 KPa and 15°C).

(5) Hydrogen sulfide has physiological effects on humans. These effects vary from person to person. FOR ADDITIONAL INFORMATION, CONSULT WITH THE EMPLOYER AND RESEARCH THE MATERIAL SAFETY DATA SHEETS (MSDS).

(6) There are wide variations in reported odor thresholds for hydrogen sulfide. A U.S. Environmental Protection Agency draft report states a range for the odor threshold of 0.1-0.2 ppm (refer to Review Draft: *Health Assessment Document for Hydrogen Sulfide*, EPA/600/8-86/026A, August 1986). A Petroleum Association for Conservation of the Canadian Environment (PACE) report, *Review of Ambient Hydrogen Sulfide Standards in Canada*, No. 85-5, December 1985, cites an odor threshold range of 0.005-0.05 ppm from the National Resource Council of Canada (1981) at Table 3.1 (page 3-10). The PACE document also cites reports of wider ranges of odor threshold from 0.0005-1.4 ppm at Table 4.1 (page 4-4).

(7) "TLV" is a trademarked term of the American Conference of Governmental Industrial Hygienists (ACGIH). Refer to *Threshold Limit Values and Biological Indices* and companion documents available from ACGIH, 1330 Kemper Meadow Drive, Cincinnati, Ohio 45240 (check latest edition).

(8) EPA Draft Review Document, supra Note *(6)*, page 1-2.

(9) IDLH means an atmospheric concentration of any toxic, corrosive, or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere (refer to 29 *Code of Federal Regulations* Part 1910.120). NIOSH considers 300 ppm or more to be the IDLH concentration for hydrogen sulfide (refer to *NIOSH Pocket Guide to Chemical Hazards*).

(10) Available from Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402.

Table A-2—Summary of Occupational Exposure Values for Hydrogen Sulfide

OSHA ACCs(11)				ACGIH TLVs(12)				NIOSH RELs(13)			
ACC		Maximum Peak Above ACC For 8-hours		TWA		STEL		TWA		CEIL(C)	
ppm	mg/m^3	ppm	mg/m^3	ppm	mg/m^3	ppm	mg/m^3	ppm	mg/m^3	ppm	mg/m^3
20	29	50	72	10	14	15	21	N/A	N/A	C10	C15

ACC	Acceptable Ceiling Concentration.
TLVs	Threshold Limit Values.
RELs	Recommended Exposure Limits.
TWA	Eight-hour Time Weighted Average (refer to specific reference document for different methods of weighting used).
STEL	Short Term Exposure Limit averaged over a period of 15 minutes.
N/A	Not Applicable.
CEIL(C)	NIOSH Ceiling Exposure Limit averaged over a period of 10 minutes.

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(11)Refer to 29 *Code of Federal Regulations* Part 1910.1000, Subpart Z, Table Z-2.

(12)Refer to *Threshold Limit Values and Biological Exposure Indices, 1993-94.*

(13)Refer to *NIOSH 77-158: Criteria for a Recommended Standard for Occupational Exposure to Hydrogen Sulfide.*

APPENDIX B—PHYSICAL PROPERTIES AND PHYSIOLOGICAL EFFECTS OF SULFUR DIOXIDE

B.1 Physical Data

Chemical Name: Sulfur Dioxide.

CAS Number: 7446-09-05.

Synonyms: Sulfurous anhydride, sulfurous oxide.

Chemical Family: Inorganic.

Chemical Formula: SO_2.

Normal Physical State: Colorless gas appreciably heavier than air. Vapor density (specific gravity) at 32°F (0°C) and 1 atmosphere = 2.26.

Boiling Point: 14°F (-10.0°C).

Flammable Limits: Non-flammable (produced from burning hydrogen sulfide).

Solubility: Readily soluble in water and oil; solubility decreases as the fluid temperature increases.

Odor and Warning Properties: Sulfur dioxide has a pungent odor associated with burning sulfur. It produces a suffocating effect and produces sulfurous acid on membranes of the nose and throat.

B.2 Exposure Limits

The Occupational Safety and Health Administration (OSHA) has established a permissible exposure limit (PEL) of 5 ppm as an 8-hour TWA for sulfur dioxide (refer to 29) *Code of Federal Regulations* Part 1910.1000, Subpart Z, Table Z-1. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends 2 ppm as an eight-hour TWA Threshold Limit Value (TLV)® and 5 ppm as a STEL averaged over 15 minutes for sulfur dioxide.(14) Refer to Table B-2 for additional information on exposure values. CHECK WITH THE EMPLOYER CONCERNING EXPOSURE LIMITS FOR PARTICULAR CIRCUMSTANCES.

B.3 Physiological Effects

B.3.1 ACUTE TOXICITY

INHALATION AT CERTAIN CONCENTRATIONS CAN LEAD TO INJURY OR DEATH (refer to Table B-1). Exposure to concentrations below 20 ppm can cause eye irritation, throat irritation, respiratory tract irritation, chest constriction, and some nausea. Exposure to concentrations above 20 ppm can result in marked coughing, sneezing, eye irritation, and chest constriction. Exposure to 50 ppm causes irritation to the nose and throat, running nose, coughing, reflex broncho-constriction with possible increase in bronchial mucous secretion, and increased pulmonary resistance to air flow (breathing congestion) occurs promptly. This atmosphere (50 ppm or more) will not be tolerated by most persons for more than 15 minutes. Some reported acute reactions of exposure to high concentrations include, but are not limited to, inflammation of the eyes, nausea, vomiting, abdominal pain, and sore throat. These symptoms are sometimes followed by bronchitis, pneumonia, and /or complaints of weakness for a period of weeks.

B.3.2 CHRONIC TOXICITY

It has been reported that prolonged exposures to sulfur dioxide may lead to increased risk of chronic nasopharyngitis, alteration in sense of smell and taste, shortness of breath on exertion, and a higher frequency of respiratory tract infections compared to unexposed persons. It has also been postulated that sulfur dioxide in the work environment "possibly enhances" the suspected carcinogenic (cancer) effect of arsenic or other cancer agents(15). No definite evidence is available regarding co-carcinogenesis or promotion of cancer by sulfur dioxide exposure. A few persons apparently have or develop a hypersusceptibility to sulfur dioxide. Decrements in pulmonary function tests have been noted after both acute and chronic exposures.

B.3.3 EXPOSURE RISKS

It is not yet clear what concentrations of low level exposure or lengths of exposure increase the risks, nor by how much the risks are increased. Sulfur dioxide exposures should be minimized. Smoking by persons exposed to sulfur dioxide should be strongly discouraged.

Note: Any pre-existing chronic respiratory impairment must be considered in regard to job placement since these conditions can be aggravated by exposure to sulfur dioxide.

B.4 Respiratory Protection

The National Institute for Occupational Safety and Health (NIOSH) has examined the criteria for respirator tests and sources of respirator leakage and recommends that positive pressure, either supplied-air or self-contained personal breathing apparatus, as appropriate, with a full face piece be worn by anyone exposed to atmosphere containing sulfur dioxide concentrations above OSHA's permissible exposure limit (PEL) (refer to 29 *Code of Federal Regulations* Part 1910.1000, Subpart Z, Table Z-1). Refer to Par. 6.4 for proper breathing equipment recommendations for oil and gas producing and gas processing operations involving sulfur dioxide.

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(14) "TLV" is a trademarked term of the American Conference of Governmental Industrial Hygienists (ACGIH). Refer to *Threshold Limit Values and Biological Exposure Indices* and companion documents available from ACGIH, 1330 Kemper Meadow Drive, Cincinnati, OH 45240 (check latest edition).

(15) *Criteria for a Recommended Standard for Occupational Exposure to Sulfur Dioxide*, NIOSH, 1974, P. 26. Refer also to the 1977 edition.

Table B-1—Sulfur Dioxide

Concentration in Air				
Percent by Volume	Parts Per Million By Volume	Grains Per 100 Std. Cubic Feet	Milligrams Per Cubic Meter(16)	Typical Characteristics Regarding Hydrogen Sulfide Exposure(17)
0.0001	1	0.12	2.71	Pungent odor, may cause respiratory changes.
0.0002	2	0.24	5.42	ACGIH TLV®(18), and NIOSH REL.
0.0005	5	0.59	13.50	Burning eyes, breathing irritation, and minor throat irritation. Note: OSHA PEL (refer to *29 CFR* 1910.1000, Table Z-1; ACGIH and NIOSH STEL as averaged over 15 minutes.
0.0012	12	1.42	32.49	Throat-irritating cough, constriction in chest, watering eyes, and nausea.
0.010	100	12.0	271.00	Concentration considered immediately dangerous to life or health (IDLH).(19) Refer to *DHHS No. 85-114, NIOSH Pocket Guide to Chemical Hazards.*(20)
0.015	150	17.76	406.35	Extreme irritation. Can be tolerated for only a few minutes.
0.05	500	59.2	1354.50	Causes a sense of suffocation, even with the first breath. Rescue promptly and apply artificial ventilation and/or cardiopulmonary resuscitation (CPR) techniques.
0.10	1000	118.4	2708.99	Death may result unless rescued promptly. Artificial ventilation and/or cardiopulmonary resuscitation (CPR) techniques should be immediately applied.

Note: Data in Table B-1 are approximate values for guidance. There are published data that show slightly different values.

(16) Based on 1% sulfur dioxide = 1184 gr/100 SCF @ 14.696 psia and 59°F (101.315 kPa and 15°C).

(17) Sulfur dioxide has physiological effects on humans. These effects vary from person to person. FOR ADDITIONAL INFORMATION, CONSULT WITH THE EMPLOYER AND RESEARCH THE MATERIAL SAFETY DATA SHEETS (MSDS).

(18) *TLV is a trademarked term of American Conference of Governmental Industrial Hygienists (ACGIH). Refer to *Threshold Limit Values and Biological Indices* and companion documents available from ACGIH, 1330 Kemper Meadow Drive, Cincinnati, Ohio 45240.

(19) IDLH means an atmospheric concentration of any toxic, corrosive, or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere (refer to 29 *Code of Federal Regulations* Part 1910.120). NIOSH considers 100 ppm or more to be the IDLH concentration for sulfur dioxide (refer to *NIOSH Pocket Guide to Chemical Hazards).*

(20) Available from Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402.

Table B-2—Summary of Occupational Exposure Values for Sulfur Dioxide

OSHA PELs(21)				ACGIH TLVs(22)				NIOSH RELs(23)			
TWA		STEL		TWA		STEL		TWA		STEL	
ppm	mg/m³	ppm	ppm	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³
5	14	N/A	N/A	2	5	5	13	2	5	5	13

PELs	Permissible Exposure Limits.
TLVs	Threshold Limit Values.
RELs	Recommended Exposure Limits.
TWA	Eight-hour Time Weighted Average (refer to specific reference document for different methods of weighting used).
STEL	Short Term Exposure Limit averaged over a period of 15 minutes.
N/A	Not Applicable.

(21) Refer to 29 *Code of Federal Regulations* Part 1910.1000, Subpart Z, Table Z-1.

(22) Refer to *Threshold Limit Values and Biological Exposure Indices, 1993-94* (check latest edition).

(23) Refer to *NIOSH 77-158: Criteria for a Recommended Standard for Occupational Exposure to Sulfur Dioxide.*

APPENDIX C—A SCREENING APPROACH TO DISPERSION OF HYDROGEN SULFIDE

Note: The exposure radii shown in Figures C-1 through C-4 represent estimates developed by API's Air Modeling Task Force (AQ7) using simple screening models and modeling techniques. These models should be reasonably accurate for low velocity releases of neutrally-buoyant mixtures of hydrogen sulfide and carrier gas. Figures C-1 through C-4 are useful as a conservative screening tool for high velocity releases and for light hydrogen sulfide carrier gas mixtures. Figures C-1 through C-4 are not recommended for low velocity releases of heavier-than-air hydrogen sulfide/carrier gas mixtures or of potential aerosol-generating mixtures, since these illustrations sometimes will underpredict exposure radii for these mixtures. Site specific conditions should be assessed to determine the need for additional, more rigorous modeling techniques. Users should evaluate their operations and select proper modeling applications for their specific emergency planning purposes.

C.1 Introduction

The material presented in Appendix C is generic in nature and is intended for emergency response planning purposes to arrive at conservative hydrogen sulfide dispersion estimates. Figures C-1 through C-4 present the screening-level, model-predicted radius of exposure (ROE) for atmospheric concentrations of hydrogen sulfide at 10, 30, 100, 300, and 500 ppm for both continuous and puff (instantaneous) releases of pure hydrogen sulfide. The ROE represents the distance from the emission source to the concentration of interest measured along the plume's centerline at ground level. Equations were developed for predicting the ROE as a function of the quantity/rate of hydrogen sulfide released for each of the hydrogen sulfide concentrations modeled and the type of release (continuous and puff). The equations and corresponding coefficients are presented in Par. C.8 and Table C-1. Meteorological conditions typical of worst-case daytime and nighttime conditions were modeled.

Various regulations dealing with hydrogen sulfide operations prescribe a method(s) or technique(s) for ROE predictions. Such methods must be taken into account because specific compliance actions may require use of a method(s) specified by the regulation, unless use of other methods are allowed.

C.2 Methodology

The ROEs shown in Figures C-1, C-2, C-3, and C-4 were predicted using standard EPA-approved modeling procedures based on Gaussian dispersion theory. The ROEs shown in Figures C-1 and C-2 were predicted by modeling a continuous, steady-state point source release of 100 percent hydrogen sulfide. The ROEs shown in Figures C-3 and C-4 were predicted by modeling an instantaneous hydrogen sulfide release. Both hydrogen sulfide release types were modeled as releases of a neutrally-buoyant material under steady-state meteorological conditions. An effective plume height (release height plus plume rise) of 10 feet was used in all the modeling work. It was assumed that the predicted ROEs do not vary significantly with effective plume height in the range of 0-50 feet.

Table C-1—Linear Regression Coefficients for Mathematical Predictions of ROE as a Function of Downwind Hydrogen Sulfide Concentration and Release Quantity/Rate

Time*	Type of Release	Concentration, ppm	Coefficients	
			A	B
Day	Continuous	10	0.61	0.84
Day	Continuous	30	0.62	0.59
Day	Continuous	100	0.58	0.45
Day	Continuous	300	0.64	-0.08
Day	Continuous	500	0.64	-0.23
Night	Continuous	10	0.68	1.22
Night	Continuous	30	0.67	1.02
Night	Continuous	100	0.66	0.69
Night	Continuous	300	0.65	0.46
Night	Continuous	500	0.64	0.32
Day	Puff	10	0.39	2.23
Day	Puff	30	0.39	2.10
Day	Puff	100	0.39	1.91
Day	Puff	300	0.39	1.70
Day	Puff	500	0.40	1.61
Night	Puff	10	0.39	2.77
Night	Puff	30	0.39	2.60
Night	Puff	100	0.40	2.40
Night	Puff	300	0.40	2.20
Night	Puff	500	0.41	2.09

*Day Meteorological Conditions: Stability Class PG D (Neutral)—5 mph Wind Speed.

*Night Meteorological Conditions: Stability Class PG F (Stable)—2.2 mph Wind Speed.

For the purposes of dispersion modeling, the amount of turbulence in the ambient air is categorized into defined increments or stability classes. The most widely used categories are the Pasquill-Gifford (PG) Stability Classes A, B, C, D, E, and F (Pasquill, F., *Atmospheric Difusion*, Second Edition, John Wiley & Sons, New York, New York, 1974). PG Stability Class A denotes the most unstable (most turbulent) air conditions and PG Stability Class F denotes the most stable (least turbulent) air conditions. PG Stability Class D denotes neutral atmospheric conditions where the ambient temperature gradient is essentially the same as the adiabatic lapse rate. Under neutral conditions, rising or sinking air parcels cool or heat at the same rate as the ambient air, resulting in no enhancement or suppression of vertical air motion.

Standard Pasquill-Gifford (PG) dispersion coefficients for flat, open grassland were used in the continuous hydrogen sulfide release model. The Slade (refer to *NTIS-TID 24190:* Slade, D. H., *Meteorology and Atomic Energy*, 1968) dispersion coefficients for flat, open grassland were used in the puff (instantaneous) release model. When modeling instantaneous hydrogen sulfide releases it was assumed that the downwind (x) and the crosswind (y) dispersion coefficients

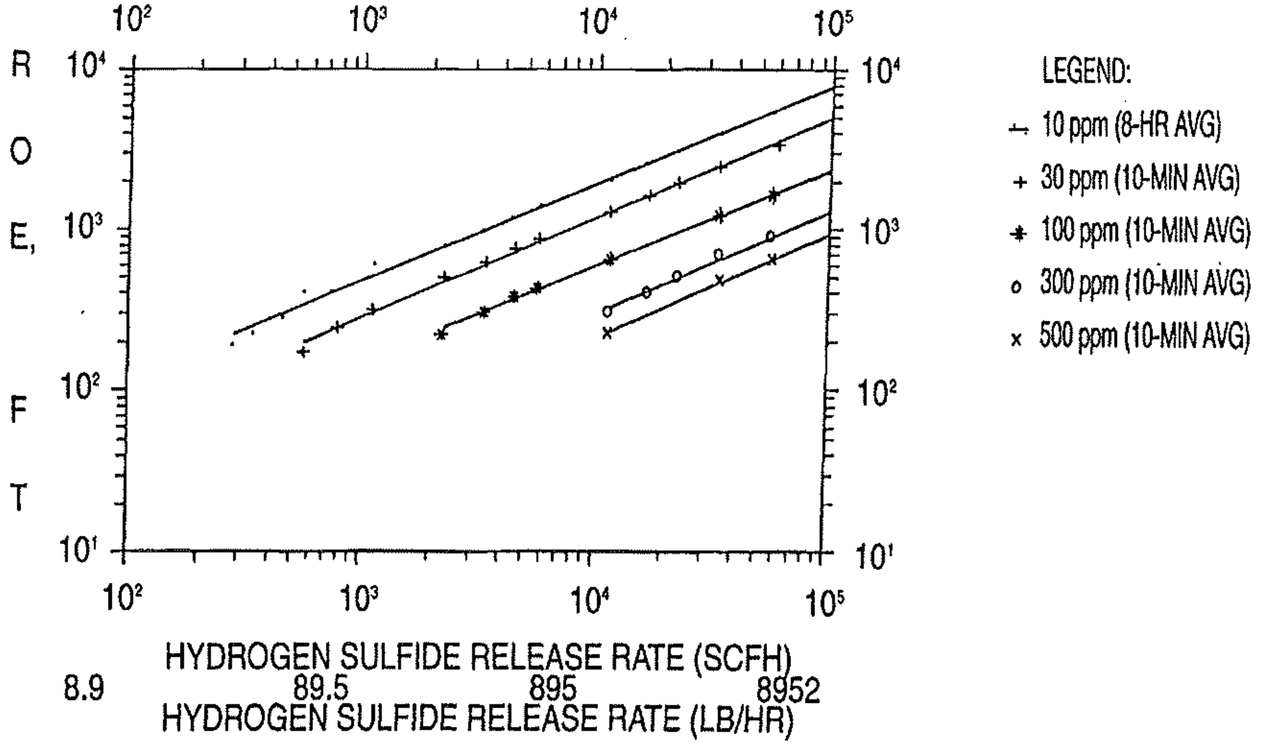

Figure C-1—Radius of Hydrogen Sulfide Exposure
Continuous Daytime Hydrogen Sulfide Releases [PG D (Neutral)—5 MPH Wind Speed]

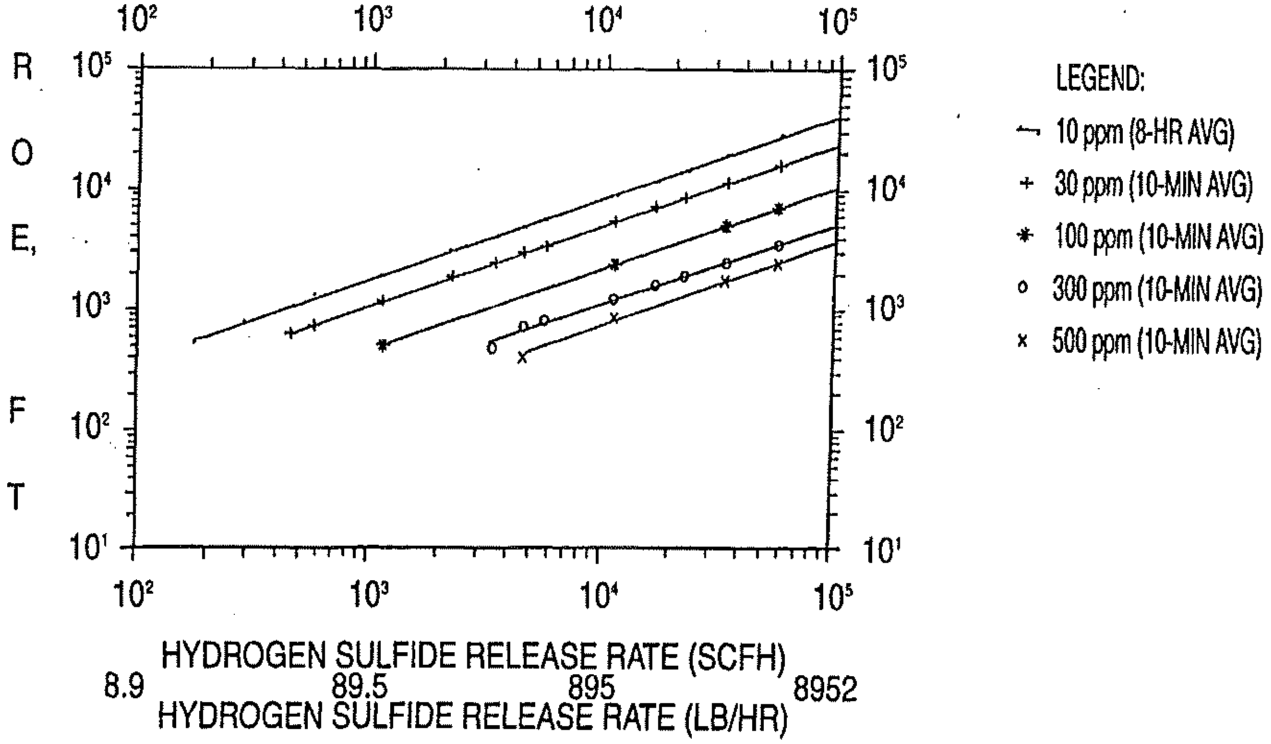

Figure C-2—Radius of Hydrogen Sulfide Exposure
Continuous Nighttime Hydrogen Sulfide Releases [PG F (Stable)—2.2 MPH Wind Speed]

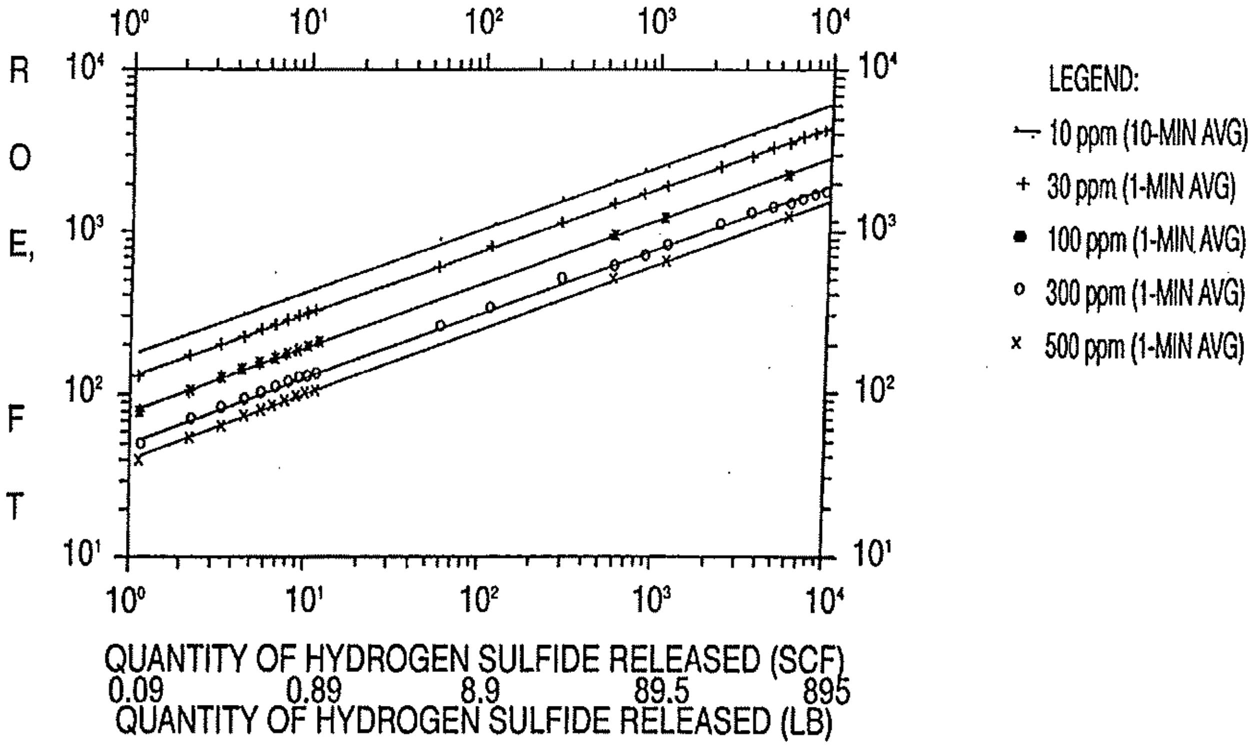

Figure C-3—Radius of Hydrogen Sulfide Exposure
Instantaneous Daytime Hydrogen Sulfide Releases [Slade A (Slightly Unstable)—5 MPH Wind Speed]

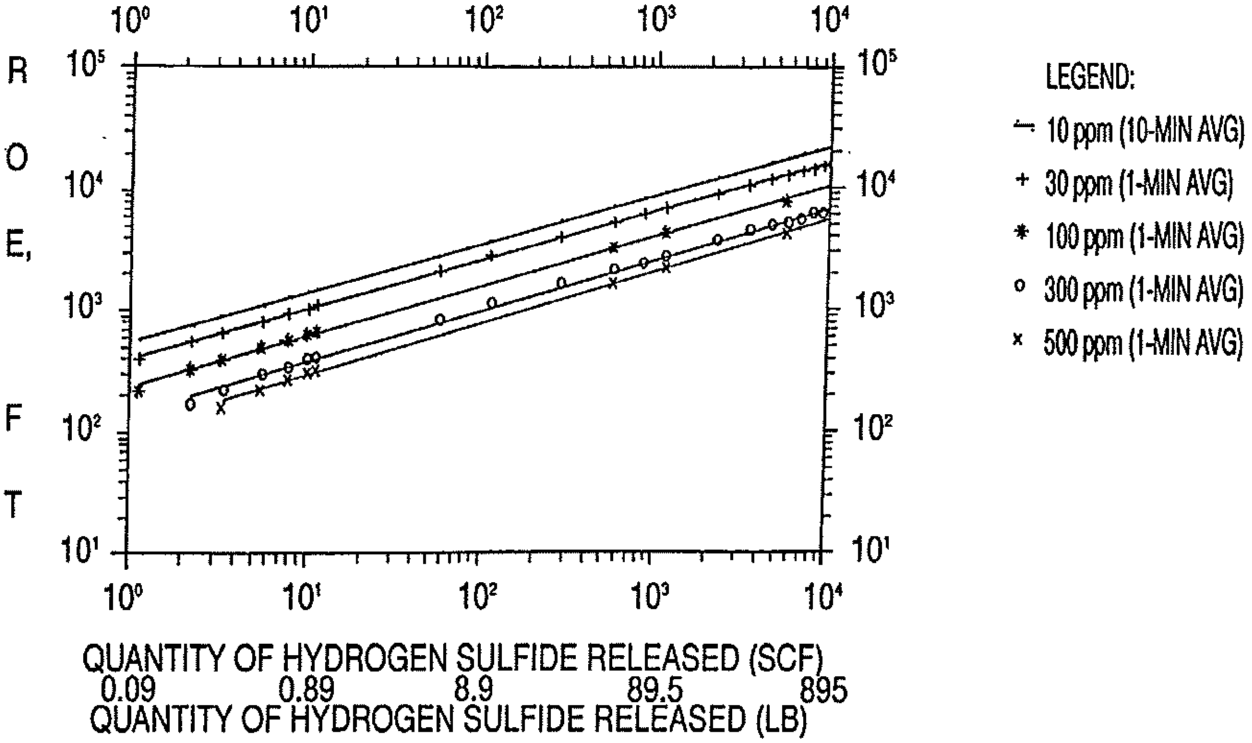

Figure C-4—Radius of Hydrogen Sulfide Exposure
Instantaneous Nighttime Hydrogen Sulfide Releases [Slade B (Neutral)—2.2 MPH Wind Speed]

were equivalent. This assumption results in conservative (worst case) estimates of the ROEs. The following meteorological conditions were assumed to be representative of worst case daytime and nighttime conditions. For continuous daytime releases a neutral Stability Class (PG D) and 5 miles per hour wind speed were chosen. For continuous nighttime releases, a stable Stability Class (PG F) and a 2.2 miles per hour wind speed were chosen. For instantaneous (puff) daytime releases, a slightly unstable Stability Class (Slade A) and a 5 miles per hour wind speed were chosen. For instantaneous nighttime releases, a neutral-to-stable Stability Class (Slade B) and a 2.2 miles per hour wind speed were chosen.

The ROEs for continuous hydrogen sulfide releases at 30, 100, 300, and 500 ppm are valid for averaging times of 10 minutes to 1 hour. The ROEs shown for 10 ppm (continuous hydrogen sulfide release) are based on an 8-hour average concentration, since 10 ppm represents the 8-hour time weighted average (TWA) for hydrogen sulfide. To obtain the 8-hour/10 ppm average concentration a factor of 0.7 was used to convert the 1-hour concentrations (refer to EPA-450/4-88-009: *A Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants*). The ROEs for the puff (instantaneous) hydrogen sulfide releases at 30, 100, 300, and 500 ppm are valid for averaging times of 1 to 10 minutes. EPA's 0.7 conversion factor was used to obtain the 10 minute/10 ppm time averaged concentrations from instantaneous peak concentrations predicted by the model. For continuous releases, the EPA considers 10-minute and 1-hour averaging times to be equivalent. The modeling reported herein assumed that an instantaneous release would be of a very short duration (10 to 15 minutes maximum).

Brief descriptions of the models used to predict the ROEs for both continuous and puff (instantaneous) hydrogen sulfide releases are presented in Par. C.13.

C.3 Results

ROEs for atmospheric plume-centerline, ground-level concentrations of hydrogen sulfide resulting from instantaneous and continuous hydrogen sulfide releases were predicted and are presented in Figures C-1 through C-4. Figures C-1 and C-2 present the predicted ROEs for continuous hydrogen sulfide releases during worst case daytime and nighttime meteorological conditions, respectively. Figures C-3 and C-4 present the predicted ROEs for instantaneous hydrogen sulfide releases during worst case daytime and nighttime meteorological conditions, respectively. The ROEs for concentrations of 10, 30, 100, 300 and 500 ppm were modeled for both release types. The 10 ppm concentration ROEs represent an 8-hour averaging time for the continuous hydrogen sulfide release and a 10-minute averaging time for the instantaneous release. The 30, 100, 300, and 500 ppm concentration ROEs represent a 10-minute averaging time for the continuous hydrogen sulfide release and a 1-minute averaging time for the instantaneous release. A hydrogen sulfide release rate range of 10 to 10,000 lb/hr (111.8 to 111,765 SCFH) was modeled for the continuous type release. For the puff (instantaneous) type hydrogen sulfide release, a release quantity range of 0.1 to 1000 lbs (1.1 to 11,177 SCF) was modeled. If the hydrogen sulfide release is based on pounds, standard cubic feet (SCF) can be obtained by multiplying pounds by a factor of 11.2.

Note: The ROEs presented in Figures C-1 through C-4 are plotted against the amount of hydrogen sulfide released. For the release of a multi-component gas stream, the actual amount of hydrogen sulfide released should be used to determine the ROE.

Equation coefficients based on linear regression for predicting the ROE as a function of the release type (continuous/puff) and quantity/rate of hydrogen sulfide released for both daytime and nighttime meteorological conditions are presented in Table C-1. The equation is given in Par. C.8. The coefficients are applicable only over the ranges presented in Figures C-1 through C-4, and extrapolation could result in overly conservative estimates of the ROEs. Any release lasting significantly longer than 15 minutes should be interpreted as a continuous release. The modeling work presented in Appendix C assumes steady-state meteorological conditions. ROEs predicted for a long averaging time (8-hour) and long downwind distances are conservative because it is unlikely that the same meteorological conditions will persist during that time period.

C.4 Additional Considerations

The modeling work presented in Appendix C assumes a neutrally-buoyant, gaseous hydrogen sulfide release in flat, rural terrain under steady-state meteorological conditions. Also, the ROEs shown in Figures C-1 through C-4 are for a generic class of hydrogen sulfide releases covering a wide range of site and release conditions. Actual ROEs will be dependent on the specifics of the type of release, release conditions, and release site. For instance, the ROEs for a release in a more urban setting where structures, buildings, etc. are present will be reduced significantly due to structure-induced turbulence. Some other conditions that could significantly affect the actual ROE include: a liquid/aerosol release, dense cloud behavior, a buoyant cloud (plume liftoff), a jet release, time-dependent release (well blowout, pipeline ruptures, etc.), and complex terrain. If any of these phenomena are present, then more rigorous modeling may be necessary.

The ROE curves of Figures C-1 through C-4 should not be used when the mixture of hydrogen sulfide and carrier gas being dispersed is significantly heavier than air and the mixture is released at a low velocity. If the hydrogen sulfide/carrier gas mixture specific gravity exceeds approximately 1.2, Figures C-1 through C-4 may not give conservative ROEs for all release rates and meteorological conditions. Hydrogen sulfide, as encountered in the petroleum industry, is usually a minor constituent of a carrier gas, such as natural gas or carbon dioxide. Carbon dioxide has a specific gravity of 1.52. Dispersion predictions for hydrogen sulfide/carbon dioxide mixtures, using a dense gas model sometimes underpredict hydrogen sulfide ROEs for low velocity gas releases. Low velocity gas releases would include those with initial velocities less than 200 feet/second and releases greater than 200 feet/second involve impact of the gas jet from the leak with a nearby surface, thereby breaking the jet's momentum. Likewise, Figures C-1 through C-4 should not be used with any hydrogen sulfide/carrier gas release that potentially could form an aerosol.

Figures C-1 through C-4 can also substantially overpredict ROEs. In the case of hydrogen sulfide/carrier gas mixtures significantly lighter than air (i.e., specific gravity less than 0.8) released at low velocity, use of these illustrations may overpredict ROEs by a factor of 2 to 3. Use of these illustrations can result in overestimation of ROEs for high velocity hydrogen sulfide/carrier gas releases (i.e., gas release velocities greater than 200 feet/second) regardless of the orientation of the release. However, this overprediction is particularly significant in the case of vertical, high-velocity releases. In such situations, the overprediction can be two orders of magnitude. The user should consult more rigorous atmospheric dispersion models.

When calculating the ROE for dilute concentrations of hazardous gases, a significant overestimation can result. For example, it would not be practical to expect higher downwind atmospheric concentrations than are present in the released gas stream. The user should consult more rigorous atmospheric dispersion models.

In summary, the composition of the hydrogen sulfide/carrier gas and the velocity and orientation of the release are critical variables, dramatically affecting predicted hydrogen sulfide ROEs. Also, other variables, such as released gas temperature and flashing or aerosol formation involving liquid containing dissolved hydrogen sulfide, can have significant impacts on ROE predictions. Accurate atmospheric dispersion techniques are, of necessity, complex. Under some circumstances, such as those mentioned above, more rigorous modeling may be required.

References and models are available to address special release scenarios. A partial list of models that may be used in such cases is shown in Pars. C.5 and C.6. API does not endorse any one particular model. Further guidance on appropriate model selection and application can be obtained from the model developers as well as other individuals experienced in this field. A specific reference to address well blowout and pipeline ruptures is *"Release and Dispersion of Gas from Pipe Line Ruptures,"* Wilson, D. J., Department of Mechanical Engineering, University of Alberta, Edmonton, Canada.

In the event that hydrogen sulfide release quantities calculated by the user are below the ranges shown in Figures C-1 through C-4, extensions of the ROE curves are allowed to a minimum ROE of 50 feet. In some cases, ROEs of less than 50 feet may be inferred from extrapolation of the curves. Figures C-1 through C-4 were developed using an assumed release height plus plume rise of 10 feet. Actual release heights of other than 10 feet will result in different ROEs.

C.5 Proprietary Dispersion Models

Note: Users should carefully evaluate applicability of these models to prevailing conditions.

A list of some proprietary models that can be used to address special site-specific scenarios follows:

CHARM—(Radian Corporation): CHARM is a Gaussian puff model for continuous and instantaneous releases of gases or liquids. The model is configured to handle chemicals that are buoyant, neutrally buoyant, and heavier than air. Heavy gas dispersion is estimated using the Eidsvik model. Source components in the model include a modified version of Shell Oil Company's SPILLS Model. (Radian Corp., 850 MOPAC Blvd., Austin, TX 78759.)

FOCUS—(Quest Consultants, Inc.): FOCUS is a modeling package that includes both emission rate models (two-phase discharges, pool evaporation, jet vapor releases, etc.) and dispersion models for both neutrally-buoyant and dense-gas plumes. The models can be run separately or in a linked mode. (Quest Consultants, Inc., 908 26th Avenue, NW, Suite 103, Norman, OK 73069-6216.)

TRACE—(Dupont): TRACE uses a multiple Lagrangian Wall dispersion model to handle both puff and continuous releases. Wind channeling can be incorporated. Liquid evaporation and buoyancy effects are considered also. (E. I. Dupont de Nemours & Company, 5700 Corea Avenue, Westlake Village, CA 91362.)

WHAZAN—(Technica International): WHAZAN is a package of dispersion models for both neutrally-buoyant and dense-gas plumes. Submodels are included to handle two-phase discharges, evaporation, and vapor dispersion as a free jet. The model can be run both individually and in a linked mode. (Technica International Associates, Inc., Box 187, Woodstock, GA 30128-4420.)

C.6 Publicly-available Models

Note: Users should carefully evaluate applicability of these models to prevailing conditions.

A list of some publicly-available models that can be used to address special site-specific scenarios follows:

DEGADIS—(U. S. Coast Guard): DEGADIS, the Dense Gas Dispersion Model, is designed to simulate dispersion of heavier-than-air gas releases. It can handle both evaporative emissions from liquid spills and jet emissions. It is basically steady-state but simulates transient conditions by a series of steady-state calculations. Vapor generation rate, spill area, and meteorological parameters are important inputs to the model. Information available through National Technical Information Service (NTIS), U. S. Department of Commerce, Springfield, VA 22161.

HEGADAS—(Shell Research B.V.): HEGADAS is a dispersion model for neutrally-buoyant and dense gases. The basic model components are solutions to the advection/diffusion equations and are in the standard form of Gaussian dispersion models. The model can handle a wide variety of source types, including transient horizontal jets. Information available through National Technical Information Service, U. S. Department of Commerce, Springfield, VA 22161.

SLAB—(Lawrence Livermore National Laboratory): SLAB is designed for application to dense gases that are emitted from liquid spills. The model considers the concentration integrated over a cross-section perpendicular to the plume centerline. The downwind variation of the integrated concentration is calculated. The size and emission rate of the liquid spill are required inputs to the model. Information available through Lawrence Livermore National Laboratory, Box 808, Livermore, CA 94550, or contact American Petroleum Institute, Health & Environmental Sciences Department, 1220 L Street, NW, Washington, D.C. 20005.

C.7 Sample Calculations for Figures C-1 through C-4

The following calculations may be used to estimate volume and mass of hydrogen sulfide when total gas volume and its hydrogen sulfide content are known:

Continuous Release.

Assume: Release of 5,000,000 SCFD of natural gas containing 8,000 ppm (by volume) of hydrogen sulfide.

Note: The user must know both the volume (or flow rate) of natural gas and its hydrogen sulfide concentration so that Figures C-1 through C-4 can be effectively used.

To determine standard cubic feet per hour (SCFH) of hydrogen sulfide released, the following calculations should be performed using appropriate values for the conditions being evaluated:

$$\frac{5{,}000{,}000 \text{ SCFD} \times 8{,}000 \text{ ppm } H_2S}{24{,}000{,}000}$$
$$= 1{,}667 \text{ SCFH of } H_2S \text{ released.}$$

To determine the pounds of hydrogen sulfide released per hour, the following calculations should be performed using appropriate values for the conditions being evaluated:

$$\frac{5{,}000{,}000 \text{ SCFD} \times 8{,}000 \text{ ppm } H_2S}{267{,}605{,}634}$$
$$= 150 \text{ lb/hr of } H_2S \text{ released.}$$

Instantaneous Release.

Assume: Release of 100,000 SCF of natural gas containing 8,000 ppm (by volume) of hydrogen sulfide. Also, assume this example is a daytime release, 5 miles per hour wind speed (refer to Figure C-3).

To determine the volume (SCF) of hydrogen sulfide released, the following calculations should be performed using appropriate values for the conditions being evaluated:

$$\frac{100{,}000 \text{ SCF} \times 8{,}000 \text{ ppm H2S}}{1{,}000{,}000}$$
$$= 800 \text{ SCF of } H_2S \text{ released}$$

After applying the appropriate calculations and using known factors to arrive at either hydrogen sulfide release rate or quantity of hydrogen sulfide released, refer to the appropriate chart (Figs. C-1 through C-4) or the equation in Par. C.8 (example calculations in Pars. C.9 through C.12) for obtaining radius of exposure (ROE) information.

The following equation can be used to convert percent hydrogen sulfide to parts per million on a volume basis:

$$\text{Percent } H_2S \times 10{,}000 = \text{ppm } H_2S$$

C.8 Radius of Exposure (ROE) Calculation

Using the values of coefficients "A" and "B" in Table C-1, the radius of exposure (ROE) for various hydrogen sulfide release rates (H_2S) can be mathematically predicted using the following equation:

$$\text{ROE} = \text{Antilog } [A \times \log (H_2S) + B]$$

For a continuous release, enter the hydrogen sulfide release rate (H_2S) in standard cubic feet per hour (SCFH). For a puff (instantaneous) release, enter the quantity of hydrogen sulfide (H_2S) released in standard cubic feet (SCF).

C.9 Sample Calculation—Continuous Release (Daylight)

Determine the $\text{ROE}_{100\text{ ppm}}$ for a continuous release of 100 percent hydrogen sulfide gas at a rate of 11,170 SCFH in daylight (PG D stability) conditions and 5 mph wind speed. Using Table C-1, the coefficients applicable to this scenario are: A = 0.58; B = 0.45. Using the equation in Par. C.8:

$$\text{ROE}_{100\text{ ppm}} = \text{Antilog } [0.58 \times \log (11{,}170) + 0.45] = 628 \text{ feet.}$$

C.10 Sample Calculation—Continuous Release (Nighttime)

Determine the $\text{ROE}_{100\text{ ppm}}$ for a continuous release of 100 percent hydrogen sulfide gas at a rate of 11,170 SCFH in nighttime (PG F stability) conditions and 2.2 mph wind speed. Using Table C-1, the coefficients applicable to this scenario are: A = 0.66; B = 0.69. Using the equation in Par. C.8:

$$\text{ROE}_{100\text{ppm}} = \text{Antilog } [0.66 \times \log (11{,}170) + 0.69]$$
$$= 2{,}300 \text{ feet}$$

C.11 Sample Calculation—Instantaneous Release (Daylight)

Determine the ROE_{100ppm} for an instantaneous release of 100 percent hydrogen sulfide gas of 1,117 SCF in daylight (Slade A stability) conditions and 5 mph wind speed. Using Table C-1, the coefficients applicable to this scenario are: A = 0.39; B = 1.91. Using the equation in Par. C.8:

ROE_{100ppm} = Antilog [0.39 × log (1,117) + 1.91] = 1,255 feet.

C.12 Sample Calculation—Instantaneous Release (Nighttime)

Determine the ROE_{100ppm} for an instantaneous release of 100 percent hydrogen sulfide gas of 1,117 SCF in nighttime (Slade B stability) conditions and 2.2 mph wind speed. From Table C-1, the coefficients applicable to this scenario are: A = 0.40; B = 2.40. Using the equation in Par. C.8:

ROE_{100ppm} = Antilog [0.40 × log (1,117) + 2.40] = 4,161 feet.

C.13 Descriptions of Gaussian and Puff Dispersion Models

C.13.1 INTRODUCTION

The emergency response Gaussian and Puff screening models are designed to predict the downwind dispersion (plume-centerline, ground-level concentration and maximum ground-level plume width as a function of downwind distance) of a neutrally-buoyant, steady-state point source gaseous release under steady-state meteorological conditions. Classical EPA-approved Gaussian dispersion theory is applied in the models. The programs are in BASIC and are designed for use on personal computers. The models are described below. The program listings and runs should use the IDLH, ERPG-2, and TLV and STEL levels as the concentrations of interest because they usually are the concentration values of concern. Both models can be run for other concentrations by substituting the values of interest in place of the values for IDLH, ERPG-2, and TLV and STEL in the computer programs. Copies of the example program listings and computer runs are available on request from American Petroleum Institute, Exploration & Production Department, 700 North Pearl Street, Suite 1840, Dallas, Texas 75201-2845.

C.13.2 Gaussian Model

This model calculates the plume-centerline, ground-level concentration, and maximum ground-level plume width for a single, steady-state, continuous-point release at user-specified, steady-state meteorological conditions and downwind distances. The model uses standard Gaussian dispersion modeling with Pasquill-Gifford dispersion coefficients. The user inputs the release rate, effective release height (release height plus plume rise), nominal wind speed, incremental downwind distance for which calculations are to be made, type of material released, and the stability class. A total of eight compounds are currently accepted by this model. Additional compounds can be entered by replacing compounds presently in the model. The model uses a default D Stability Class; but, can be run with any of the standard six Pasquill-Gifford Stability Classes (A, B, C, D, E, or F—with A being the most unstable and F being the most stable).

C.13.3 Puff Model

This model calculates the plume-centerline, ground-level concentration, and maximum ground-level plume width for a single, instantaneous-point release at user-specified, steady-state meteorological conditions and downwind distances. The model uses standard Gaussian dispersion theory for an instantaneous (puff) release with Slade dispersion coefficients. User inputs to the model are the same as those used in the Gaussian model except that the total amount of material released is entered rather than the rate of release. Three values are accepted for the Stability Class (A, B, or C—with A being unstable, B being neutral, and C being stable).

APPENDIX D—DEFINITION OF A SOUR ENVIRONMENT (REPRINTED FROM *NACE STANDARD MR0175-94: STANDARD MATERIAL REQUIREMENTS SULFIDE STRESS CRACKING RESISTANT METALLIC MATERIALS FOR OILFIELD EQUIPMENT*(24))

D.1 Sour Environments

D.1.1 Sour Environments are defined as fluids containing water as a liquid and hydrogen sulfide exceeding the limits defined in Pars. D.1.1.1 and D.1.1.2; these environments may cause sulfide stress cracking (SSC) of susceptible materials.

CAUTION: It should be noted that highly susceptible materials may fail in less severe environments. The SSC phenomenon is affected by complex interactions of parameters including:

a. chemical composition, strength, heat treatment, and microstructure of the material;
b. hydrogen ion concentration (pH) of the environment;
c. hydrogen sulfide concentration and total pressure;
d. total tensile stress (applied plus residual);
e. temperature; and
f. time.

The user shall determine whether the environmental conditions fall within the scope of this standard. (*Editorial Comment:* The critical hydrogen sulfide levels in D.1.1.1 and D.1.1.2 and Figures D-1 and D-2 were developed from data derived from low alloy steel.)

D.1.1.1 Sour Gas

Materials shall be selected to be resistant to SSC or the environment should be controlled if the gas being handled is at a total pressure of 0.4 MPa (65 psia) or greater and if the partial pressure of hydrogen sulfide in the gas is greater than 0.0003 MPa (0.05 psia). Systems operating below 0.4 MPa (65 psia) total pressure or below 0.0003 MPa (0.05 psia) hydrogen sulfide partial pressure are outside the scope of this standard. Partial pressure is determined by multiplying the mole fraction (mol % ÷ 100) of hydrogen sulfide in the gas by the total system pressure. Figure D-1 provides a convenient method for determining whether the partial pressure of hydrogen sulfide in a sour environment exceeds 0.0003 MPa (0.05 psia). A few examples are provided:

a. partial pressure of hydrogen sulfide in a system containing 0.01 mol % hydrogen sulfide (100 ppm or 6.7 grains per 100 standard cubic feet [SCF]) at a total pressure of 7 MPa (1,000 psia) exceeds 0.0003 MPa (0.05 psia) (Point A on Figure D-1).
b. partial pressure of hydrogen sulfide in a system containing 0.005 mol % hydrogen sulfide (50 ppm or 3.3 grains per 100 SCF) at a total pressure of 1.4 Mpa (200 psia) does not exceed 0.0003 Mpa (0.05 psia) (Point B on Figure D-1).

D.1.1.2 Sour Oil and Multiphases

Sour crude oil systems that have operated satisfactorily using standard equipment are outside the scope of this standard when the fluids being handled are either crude oil, or two- or three-phase crude, water, and gas when:

a. the maximum gas:oil ratio is 5000 SCF:bbl (barrel of oil);
b. the gas phase contains a maximum of 15% hydrogen sulfide;
c. the partial pressure of hydrogen sulfide in the gas phases is a maximum of 0.07 MPa (10 psia);
d. the surface operating pressure is a maximum of 1.8 MPa (265 psia) (see Figure D-2); and
e. when pressure exceeds 1.8 MPa (265 psia), refer back to D.1.1.1.

The satisfactory service of the standard equipment in these low-pressure systems is believed to be a result of the inhibitive effect of the oil and the low stresses encountered under the low-pressure conditions.

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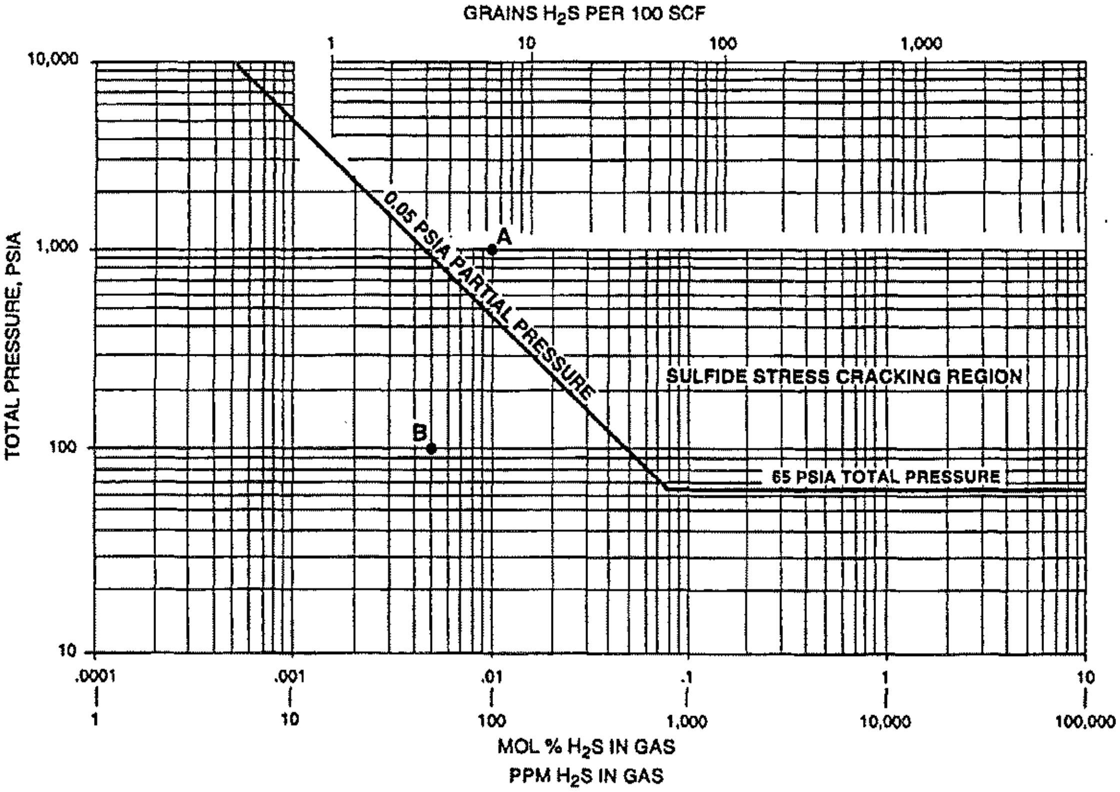
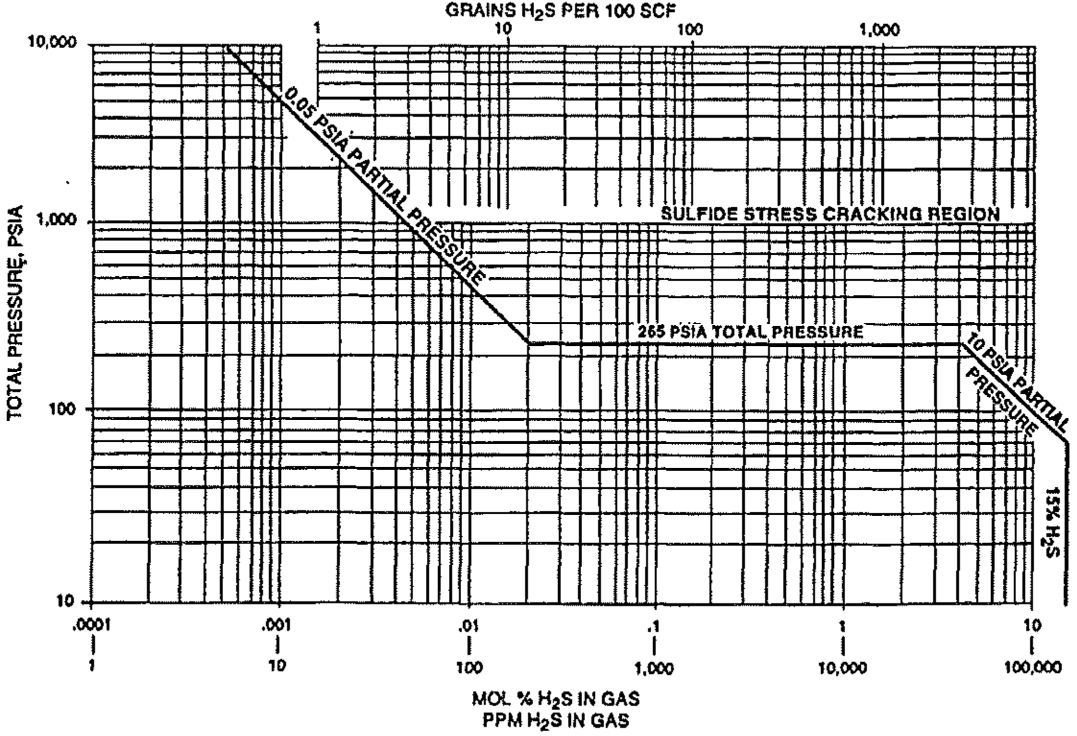


Figure D1*—Sour Gas Systems (Refer to Par. D.1.1.1)



Metric Conversion Factor: 1 MPa = 145.089 psia

Figure D2*—Sour Multiphase Systems (Refer to Par. D.1.1.2)

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APPENDIX G

CLOSURE/POST-CLOSURE CARE PLAN

Closure Plan and Closure Cost Estimate
The Big Still Oil Treatment Facility
Lea County, New Mexico

C-137 Surface Waste Management Facility Application

May 2025

Prepared for:

Moonshine Energy, LLC
3206 Ma Mar Ave
Midland, TX 79705

Souder, Miller & Associates
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505.299.0942 ♦ fax 505.293.3430 ♦ www.soudermiller.com

CLOSURE PLAN AND CLOSURE COST ESTIMATE
THE BIG STILL OIL TREATMENT FACILITY

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NM OCD C-137 Facility Application

CERTIFICATION PAGE

I, Matthew Earthman, a registered professional geologist, certify that this closure cost estimate was prepared by me or under my direct supervision, and that the data and facts stated herein are true, correct, and complete to the best of my knowledge

____

Matthew A. Earthman, P.G.

Professional Geologist License: 8881905-2250
State of Utah
Expiration: March 31, 2027

The Big Still Oil Treatment Facility
CLOSURE PLAN AND CLOSURE COST ESTIMATE
NM OCD C-137 Facility Application

1.0 GENERAL INFORMATION

The Moonshine Energy, LLC (Moonshine Energy) Big Still Oil Treatment Facility (Facility) is a proposed surface waste treatment facility which will be constructed and operated in accordance with New Mexico Oil Conservation Division (NMOCD) regulations as outlined and defined in 19.15.36 New Mexico Administrative Code (NMAC). The purpose of the facility will include processing tank bottoms, produced water, or other hydrocarbons from oil and gas operations to separate usable hydrocarbon material for sale and processing. No solid waste, contaminated media, or other hazardous materials will be accepted or processed at the Big Still Facility.

The proposed Facility will be located near mile marker 37.3 on New Mexico Highway 128, approximately 15 miles west of the City of Jal, New Mexico. The property is located within Township 24 South, Range 34 East, Section 25, and consists of a 5.4± acre parcel leased to Moonshine Energy, LLC. The facility will utilize the entire parcel, and will consist of a fenced, cleared and leveled area with caliche surface cover allowing for access and maneuvering of large trucks and equipment. Three tank batteries will be located on the facility for processing tank bottoms, hydrocarbons, or produced water delivered to the facility. Two tank batteries, located in the west-central portions of the property, will be used for the receipt of waste and for storage of reclaimed hydrocarbons prior to sale. Each of the two batteries will consist of ten (10) 500 barrel (bbl) (21,000 gallon) capacity steel frac tanks, situated within a secondary containment area constructed of 3-foot steel walls lined with a with a 40-mil High Density Polyethylene (HDPE) liner to prevent release of any spilled material. An additional tank battery consisting of four (4) 750 bbl (31,500 gallon) fiberglass tanks situated within secondary containment (also steel walls with a 40-mil HDPE liner) will be located on the southeast portion of the Facility and be utilized to store separated water until it is removed for disposal via vacuum truck. The Facility will have two skid-mounted modular buildings to function as an office/gate house and personnel facilities. The Facility will be staffed by at least one operator during all periods of operation.

2.0 PURPOSE

This document represents the Closure Plan (Plan) for the Facility. This Plan has been developed in accordance with the requirements of 19.15.36.18 NMAC regarding the Facility Closure. As indicated in 19.15.36.18.A NMAC, post-closure care is not required for oil treating facilities; as such, this plan only includes activities related to complete closure of the proposed Big Still Oil Treatment Facility. This Plan describes the steps and procedures that will be taken to close the Facility (Section 3.0) and includes a cost estimate to facilitate closure of the Facility in a manner that will protect fresh water, public health, safety and the environment (Section 4.0). The cost estimate has been prepared by Souder, Miller & Associates, a third-party contractor with personnel familiar and experienced in closure of oil and gas facilities.

3.0 CLOSURE PLAN AND IMPLEMENTATION

Should unforeseen circumstances, or a mandate by the NMOCD warrant the cessation of Facility operations, Moonshine Energy or a qualified third party will close the facility in accordance with the requirements of 19.15.36.18 NMAC and in a fashion to protect fresh water, public health and the environment. Table 1 provides the general sequence of activities which will be performed at the site in the event of closure.

TABLE 1. CLOSURE IMPLEMENTATION ACTIVITIES (19.15.36.18 NMAC)
The Big Still Oil Treatment Facility

Phase/Step	Type of Action	Purpose	Timeframe
1	Written Notification	Inform NMOCD of intent to close	60 days before closure
2	Cease Facility Operations	Stop receiving produced water, drain and remove any remaining produced water	Upon approval to proceed from NMOCD, or 60 days after written notification received at NMOCD
3	Tank Removal	Empty, clean, dismantle (if required), and remove conveyance hoses and tanks	Within 90 days of closure
4	Secondary Containment & Ski-Mounted Building Removal	Remove and level containment wall and liner disposal and remove all temporary facilities/structures.	Following tank removal
5	Site Confirmation Sampling	Sample soils within 5 Sections of facility for TPH, BTEX, RCRA 8 metals, and anions/cations and collect discreet samples from each tank battery	Following secondary containment removal
6	Revegetation	Regrading and reseeding of disturbed areas with native seed mixes	Following confirmation of no contaminated soils and approval to proceed from NMOCD
7	Final QCA Reporting	Preparation of report by NMPE documenting revegetation and restoration efforts	Within 30 days of completion of revegetation/reclamation efforts
8	Final Site Closure	Completion of requirements of the Closure Plan are satisfied, submittal	Following receipt of written verification by the NMOCD

3.1 Written Closure Notification

Phase 1

In accordance with 19.15.36.18 NMAC, the Facility will formally notify the NMOCD Environmental Bureau at least 60 days prior to cessation of permanent operations at the Facility. The notification will include a proposed schedule for closure. In accordance with 19.15.36.18.A.3 NMAC, the facility will wait 60 days for notification from the NMOCD of any additional closure or post closure requirements prior to implementing closure; if the Facility is not notified of additional requirements, the operator will proceed with closure in accordance with the final Closure Plan.

3.2 Cessation of Facility Operations and Equipment Removal

Phase 2

Upon NMOCD approval to proceed with closure activities, the operator will stop receiving waste and begin preparations for removal of all site equipment. All 10 Frac tanks within the northern battery, which may contain both hydrocarbons and water, will be emptied utilizing a vacuum truck of all separated water and any hydrocarbons/crude will be transferred to the storage tanks within the southern battery. Crude within the 10 southern tanks, which is assumed to contain only hydrocarbons will removed from the facility for sale, or if necessary, transported for disposal by a certified hauler to an approved, permitted waste management facility. Any separated water remaining in frac tanks or the water tank batteries will be removed and hauled by a certified hauler with an approved C-133 for disposal at nearby permitted saltwater disposal facilities.

Phase 3

Following removal of material, each tank will be cleaned by pressure washing and steam cleaning. Tanks which are in good condition and can be repurposed will be utilized at other Moonshine Facilities or will be sold. Tanks which are not salvageable will be dismantled and sold as scrap for recycling or disposed of at a permitted landfill facility.

Phase 4

Following the removal of tanks and associated equipment, the secondary containment areas of all three batteries will be dismantled, removed and graded. Specifically, the 3-foot steel wall will be disassembled for reuse at other facilities and the 40-mil High Density Polyethylene (HDPE) liner disposed of in a division-approved surface waste management facility.

The two skid-mounted buildings will be removed from the site for re-use at a different facility, or if in poor condition, will be dissembled and disposed of at permitted landfill authorized to accept municipal solid waste or construction and demolition debris.

3.3 Site Confirmation Sampling

Phase 5

Once all tanks, equipment and secondary containment materials have been removed, soil samples will be collected at the facility in accordance with 19.15.36.18.C.1 NMAC. Soil samples will be collected by a trained environmental professional utilizing a hand auger which will be decontaminated between advancing each soil boring in accordance with the requirements of EPA Method SW-846. Various samples at the facility will be collected as outlined below:

3.3.1 Composite Sampling

Two composite soil samples will be collected from each of the five proposed sampling Sections indicated in Figure 2, resulting in a total of 10 composite soil samples to be submitted for laboratory analysis. Each composite sample will be composited utilizing four discreet soil boring sampling points that will be advanced within the sampling section. The composite samples will be collected from soils at two distinct depths – one composite will be composited from samples taken from a depth of 10-14 inches below ground surface (bgs), and one composite sample will be composited from samples collected from 34-38 inches bgs. As a result, each of the five sampling sections on the property will report sampling results from a depth of 10-14 inches bgs, as well as the deeper 34-38 inches interval.

One composite background sample will be collected during the soil sampling investigation from areas that have not been impacted by Facility operations. The sample will be composited from two discreet samples collected from two boreholes advanced to a depth of 10-14 inches bgs along the western portion of the property in an undisturbed area that maintains native ground cover. The background collection area is also included on Figure 2.

3.3.2 Tank Area Discreet Sampling

In addition to the composite sampling collected throughout the property, 5 discreet soil samples will be collected from a depth of 10-14 inches at each of the three tank batteries (total of 15 samples). The samples will be collected from three evenly spaced soil borings which will be advanced across the footprint of each tank battery's secondary containment and from two soil borings within the loading/unloading areas of each tank battery, as indicated on Figure 2 (red circles).

3.3.3 Soil Staining

Additional discreet soil samples will be collected from any areas with visible staining identified during closure activities. One soil boring will be advanced within each 100-square-foot area (10-ftx10-ft) of staining identified. Two soil samples will be collected from each boring from a depth of 10-14 inches and 34-38 inches bgs. The results of the sampling will be utilized to determine the extent of remediation needed in the area, including removal of impacted soil as outlined in Section 3.4.

3.3.4 Sample Analysis

All samples collected at the Facility will be sampled in accordance with the procedures specified in chapter 9 of EPA SW-846 test methods for evaluating solid waste and be analyzed for:

- Total petroleum hydrocarbons (TPH) by EPA Method 8015
- Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX) by EPA Method 8260
- Major cations and anions by EPA Method 300 (anions) and EPA methods 6010/SM 2320B/120.1/SM 2540C (cations)
- RCRA 8 metals by EPA Method 6010B or SW-846 Method 1311 (TCLP)

Sample results will be submitted to the Environmental Bureau in the Division's Santa Fe office per 19.15.36.18.C NMAC. Any exceedances will be discussed with the NMOCD Environmental Bureau and addressed per 19.15.29 and/or 19.15.30 NMAC.

3.4 Reclamation and Revegetation

Phase 6

If contamination is identified during soil sampling activities, impacted soil will be removed from the facility for disposal at a landfill permitted to accept the impacted soil and remediation will be completed in accordance with NMOCD requirements. Following removal activities, confirmation samples will be collected to confirm all impacted soil has been removed from the facility.

Upon NMOCD approval to proceed with reclamation, all caliche ground cover will be scraped and hauled away from the facility for disposal or reuse at other facilities. Perimeter berms will be removed and leveled to match existing grades and minimize impacts to future surface water flow. Perimeter fencing will be left in-place to prevent access from livestock and ensure the area is not impacted by overgrazing, fire, or other intrusions. The entirety of the property will be seeded with native vegetation in accordance with 19.15.36.18.A(6) and per permit requirements. A tentative, potential seed mixture, which has been utilized in the Lea County area, is included below.

Grasses:

Black Grama	10%
Blue grama	10%
Sideoats grama	30%
Sand dropseed	20%
Alkali sacaton	10%
Little bluestem	7.5%

Forbs:

Firewheel	5%

Shrubs:

Fourwing saltbush	5%
Common winterfat	2.5%

The Facility will coordinate with the Bureau of Land Management Carlsbad office, Natural Resources Conservation Service (NRCS), or the Lea County Soil Conservation District on the appropriate re-vegetation species to ensure correct seed mixtures, application rates, and the use of mulch prior to initiating revegetation. The recommended seed mixture will be provided to the NMOCD for approval as part of the formal notification detailed in Section 3.1.

If possible, the reseeding will be initiated during the monsoon season (July-September) to maximize seeding establishment. The Facility will monitor the site until vegetative cover is established to 70% of the native perennial vegetative cover or scientifically documented ecological description consisting of at least three native plant species, including grass and excluding noxious weeds. In accordance with NMAC 19.15.36.18.A6, the Facility will maintain the cover through two successive growing seasons.

3.5 Final Closure QCA

Phase 7

Following completion of the re-vegetation and reclamation, the Facility will submit a final closure quality control/quality assurance (QCA) report documenting site activities. The report will be certified by a New Mexico Professional Engineer with experience in environmental remediation and will be submitted to the NMOCD within 30 days of completion of activities.

4.0 CLOSURE COST ESTIMATE

SMA has prepared a cost estimate for closure of the facility, which is summarized in Table 2. Detailed costs breakouts for each phase of the closure are included in Attachment 1. The cost estimate will be adjusted as necessary for inflation or other factors that could affect the costs. The financial assurance amount will be increased if changes to the Facility warrant such an increase (e.g., costs increase by> 3%). In addition, financial assurance may be reduced with approval from the NMOCD.

TABLE 2. CLOSURE/POST-CLOSURE CARE COST ESTIMATE
The Big Still Oil Treatment Facility

Phase No.	Task	Total
1	NMOCD Notification	$2,000.00
2	Cessation of Operations/Emptying Tanks	$53,387.00
3	Tank Cleaning and Removal	$26,292.00
4	Secondary Containment & Building Removal	$6,325.00
5	Site Confirmation Sampling	$25,980.00
6	Site Restoration & Revegetation	$33,875.00
7	CQA Reporting	$8,200.00
	10% Contingency	$15,605.00
	TOTAL COST	**$171,664.00**

4.1 Cost Estimate Assumptions

The following assumptions were utilized to develop this closure cost estimate:

- The Facility is in compliance with the conditions of the issued permit
- No materials, equipment, or infrastructure associated with the facility or its operations are to remain on-site
- Closure will be completed entirely by a third-party; none of the operator's equipment or personnel will be available to assist in the closure
- The facility will be closed as outlined in 19.15.36.18 NMAC, and as the facility is an oil-treating facility, will not require post-closure care

- The facility closure occurs at a time when all waste storage tanks are 100% full of waste and that 10% of the material will be solid basic sediment and water (BS&W)/sludge which will require disposal at a permitted facility and cannot be reclaimed. Assumed quantities are below:
    - Usable crude – 6,250 bbl (10 frac tanks within southern tank battery and 25% of the 10, north battery frac tanks)
    - Separated water – 6,750 bbl (4 750-bbl fiberglass tanks plus 75% of the 10, north battery frac tanks)
    - Sludge/solids – 270 yd^3 (10% of the 13,000 bbl total storage volume on site)
- All waste will be disposed of at authorized off-site commercial waste disposal facilities. For the preparation of the cost estimate, the following facilities will be utilized:
    - Separated Water (saltwater) Disposal:
      MooMaw Salt Water Disposal Site No. 1
      Well API 30-025-44661
      NM-128, Jal NM
    - Solids and potential contaminated soil:
      North Ranch Solid Waste Management Facility and Landfill.
      Permit No. NM1-66
      476 Battle Axe Road
      Jal, NM 88252
- Separated hydrocarbons/crude/oil has value and can be sold and therefore not incur disposal costs
- Steel Frac Tanks utilized at the facility can be sold for reuse or recycled and therefore will not incur disposal costs
- A 10% contingency factor has been included in this estimate
- Unit prices used in this estimate are based on professional judgement, and previous experience with similar projects

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CONDITIONS

Action 472024

CONDITIONS

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	Action Number: 472024
	Action Type: [C-137] Non-Fee SWMF Submittal (SWMF NON-FEE SUBMITTAL)

CONDITIONS

Created By	Condition	Condition Date
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