ConocoPhillips

H_2S CONTINGENCY PLAN

PLAN APPLIES TO H2S CONCENTRATIONS BETWEEN 10 TO 100 PPM

BP

Reid #22M
Surface Location: 990' FSL & 915' FWL, Section 8, T-28-N, R-9-W
Bottom Hole Location: 710' FSL & 1930' FWL, Section 8, T-28-N, R-9-W
San Juan, New Mexico
Latitude 36° 40' 18.872" N, Longitude 107° 49' 4.636" W (Nad 83)

Drilling Engineer
Lee Murphy

Drilling Superintendent
Jim Fodor

Drilling Manager
Mark Chambers

for MCHAMBERS 9/19/12

TABLE OF CONTENTS

INTRODUCTION

ConocoPhillips is permitting to drill and complete the Reid #22M well for the purpose of evaluating and exploiting hydrocarbon reservoirs.

Production data from offset wells indicates that hydrogen sulfide (H_2S) may be present from the shallow formations, as well as from producing formations. Hydrogen sulfide (H_2S) is a flammable and highly toxic gas, which in relatively small concentrations, can have adverse effects on people and equipment (refer to the section - Effects of H_2S). During drilling operations on these offset wells, no H_2S was detected.

These measures are to be in effect prior to drilling out surface casing.

Precautionary measures concerning H_2S in this plan have been formulated based on the following assumptions:

1. ConocoPhillips is expecting negligible levels of H_2S from this location, but has been informed that offset wells, such as the such at the Johnston LS #8 produces H_2S at levels at or below 6 ppm. Please note that ConocoPhillips does not expect H_2S levels to be greater than 10 ppm during drilling operations. This contingency plan will be in affect during drilling operations based on offset production of H_2S.

2. Radius of Exposure (ROE) calculations, as detailed in the Department of Interior, Bureau of Land Management, Part II, 43 CFR Part 3160, Onshore Order No. 6, Hydrogen Sulfide Operations, do not apply at concentrations below 100 ppm. H_2S levels are not expected to equal or exceed 100 ppm, and as such, there is no radius of exposure at 100 or 500 ppm.

3. No residences, schools, business, parks or other areas where the public could reasonably be expected to frequent fall within a 500 ft radius of the location. As such, exposure to the general public is considered negligible.

This plan has been designated as a guide for well requirements and special considerations to provide for safe and efficient drilling (or servicing) operations in the anticipated presence of hydrogen sulfide.

H_2S equipment required on location for the Reid #22M:

Less than 100ppm & greater than 10ppm	◦ 5 Escape Packs ◦ Fixed Monitor & at least 3 H_2S sensors ◦ Personal Monitors for All Crew on Location ◦ Well Condition Sign ◦ 3 Windsocks ◦ No Smoking Signs ◦ Fire Extinguisher ◦ Flare System ◦ Emergency Response Numbers

GENERAL EMERGENCY ACTION

In the event an emergency situation occurs, the following action shall be initiated:

1. If the H_2S alarm sounds, stop the rotation of the drill pipe, secure rig, and close well in as time and conditions permit.

2. Evacuate quickly to the "Safe Briefing Area".

3. Account for all personnel and take appropriate action as necessary for personnel safety.

4. Raise appropriate color warning flag to describe the type of emergency.

The ConocoPhillips Onsite Supervisor will assess the situation and assign duties to various persons to bring the situation under control. Those who must enter the hazard area must wear self-contained breathing apparatus and use other appropriate safety equipment. (Use the "buddy system" at all times.) If self-contained breathing apparatus will ne required, ConocoPhillips Onsite Supervisor will be responsible to order such equipment out to location.

The Onsite Supervisor will advise the ConocoPhillips Drilling Manager as soon as the emergency will permit. In the event of a well kick, procedures outlined in the Operations Plan for Drilling will be followed.

Notification of local law enforcement agencies, residents and emergency vehicles as per the following Communications Directory, will be assigned by the ConocoPhillips Onsite Supervisor.

Any press inquiries are to be referred to the Acting Implementation Manager of ConocoPhillips (Larry Dillon).

ConocoPhillips

(505) 326-9700
ALL AREA CODES ARE (505) UNLESS OTHERWISE INDICATED

Drilling Department

Name	Office	Home	Pager/Cellular
Drilling Managers:			
Mark Chambers	326-9570	436-2447	Cell: 215-2354
Drilling Superintendent:			
Jim Fodor	599-4031	324-0999	Cell: 320-6810
Tom Lee	326-9785	947-3335	Cell: 793-7460
Drilling Engineering:			
Lee Murphy			Cell: 320-7002
Rig Consultants:			
Craig Lingo			Cell: 210-1212
Howell Winter			Cell: 215-0059
Roger Day			Cell: 406-860-0863
Caitlin Clancy			Cell: 548-5940

Health, Safety & Environmental Department

HSE Representatives:	Office	Home	Pager/Cellular
Smith, Robert (WSER Supervisor)	599-4052	334-8618	Cell: 947-8282
Marquez, Michael (Drilling WSER)	599-4019		Cell: 419-6120
Bettale, Mark (Drilling WSER)	324-6103	327-7512	Cell: 320-0617
Davenport, Peter (Completions WSER)	326-9815	327-3795	Cell: 320-5650
Serrano, Leroy (1st Delivery WSER)		632-2648	Cell: 320-1364
Zubrod, Sharon (BU HSE Manager)	326-9793		Cell: 330-5395
Carpenter, Mike (Emergency Response)	326-9815		Cell: 320-5650
Cook-Cowden, Shelly (Environmental)	324-5140	334-5140	Cell: 320-0699

Contract Safety

(Farmington, New Mexico)	Office	Home	Pager/Cellular
DXP Safety Alliance:			
Martinez, Steve	325-7233		320-0544
Norton, Jermaine			320-8753
Advance Safety LLC:			
Smith, Bill	324-0575		793-0904

Well Control Companies

Cudd Well	**Control Co.**	24 HR.	(713) 849-2769

ConocoPhillips
Emergency Contact Agencies (Cont.)

State Police/Sheriff/City Police:

San Juan County, NM	
State Police	325-7547
Sheriff's Department	911 or 334-6622
Police Department	911 or 334-6622
Ambulance	911 or 334-6622
Fire Dept.	911 or 334-6622
Air Care 1	911 or (505) 599-6046 or 1-800-452-9990
Rio Arriba County, NM	
Sheriff's Department	911 or 588-7271
Ambulance	911 or 753-5555
Fire Dept.	911 or 753-5555
Air Care 1	911 or (505) 599-6046 or 1-800-452-9990
Bureau of Land Management:	
Farmington, NM Office	505-564-7750
Back Up BLM Phone Numer	505-564-7746
New Mexico Oil Conservation Division:	
Aztec, NM Office	505-334-6178

Hospitals

San Juan Regional Medical Center, Farmington, NM	(505) 325-5011
Mercy Medical Center, Durango, CO	

LIST OF RESIDENTS / BUSINESSES / SCHOOLS

No residences, schools, business, parks or other areas where the public could reasonably be expected to frequent were found to be exposed to levels that can be expected to exceed 100 ppm. No Federal, State, County, or municipal road or highway owned and principally maintained for public use is located within any area that could be reasonably expected to reach or exceed 500 ppm. Included are topographic maps indicating a 500 ft radius, which far exceeds any potential exposure areas. All land within the radius is Bureau of Land Management lands.

RESPONSIBILITIES

All Personnel

1. All Personnel who spend over one day on the ConocoPhillips location shall be familiarized with the procedures outlined in this directive.

2. All personnel will attend to their personal safety first.

3. If it can be done safely, help anyone who may be injured or overcome from toxic gases by administering first aid.

4. Report to the "Safe Briefing Area" and follow the instructions of the supervisor.

ConocoPhillips Onsite Supervisor (Contract or Direct Employee)

1. It is the responsibility of the ConocoPhillips Onsite Supervisor to see that all personnel on the ConocoPhillips location observe these safety and emergency procedures.

2. The Onsite Supervisor will advise the Drilling Manager whenever the procedures as specified herein are complied with or cannot be followed. A checklist (attached) will be utilized. One (1) completed copy of the checklist will be forwarded to the Drilling Manager and one copy to ConocoPhillips HSE Department.

3. The ConocoPhillips Onsite Supervisor shall keep the number of personnel on location to a minimum during hazardous operations.

4. The Intermediate section of the well should be kept full with mud to surface at all times, including while tripping & circulating. A lost circulation event can reduce the fluid level & hydrostatic column, permitting higher concentrations & volume of gas inflow. Well flow observation & control processes should be applied at all times.

5. The Onsite Supervisor shall be trained in the use of all safety equipment and completely briefed on safety and emergency procedures. This shall include full knowledge of the requirements in this contingency plan.

6. It is the responsibility of the ConocoPhillips Onsite Supervisor to see that the Contractor has adequately trained the drilling crews in handling emergency situations. He should satisfy himself that this is the case. He should notify the ConocoPhillips Drilling Manager if the Contractor fails to fill this responsibility.

7. If an unexpected emergency occurs, or the H_2S alarm sounds, the Supervisor (either ConocoPhillips or Contractor) will assess the situation and will advise all personnel what conditions exist. Action to be taken under each of three possible conditions is as follows:
   CONDITION I - POTENTIAL DANGER TO LIFE (such as hazardous amount of toxic gasses detected at surface)

   a. Order nonessential personnel out of the potential danger area.

b. Display the YELLOW CONDITION I warning sign and flag.

c. Order all essential personnel to check their safety equipment to see that it is working properly and in the proper location (see supervisor's checklist). Persons without respiratory protection cannot work in the hazard area.

d. Notify Drilling Manager of condition and action taken.

e. Increase gas monitoring activities and continue operations as appropriate.

CONDITION II - MODERATE DANGER TO LIFE (such as circulating out a potentially toxic gas kick). In addition to Condition I requirements:

a. Display only the ORANGE CONDITION II warning sign and flag.

b. Direct corrective action to control flow of gas.

c. Set up roadblocks and restrict personnel movements to minimum.

d. Notify other appropriate personnel listed on emergency telephone list.

CONDITION III - EXTREME DANGER TO LIFE (when it appears that well control will be lost). In addition to Conditions I and II requirements:

a. Contact and request local police to evacuate people and to control traffic within the danger zone. Should the condition be immediately dangerous to the public, take necessary life saving action until local police arrive. Display only the RED CONDITION III warning sign and flag.

b. Ignite the well if necessary. (See the following section - Igniting the Well.)

NOTE: **The Drilling Manager will dispatch additional ConocoPhillips personnel and/or additional professional safety personnel to the well site as needed to assist the Onsite Supervisor.**

Contractor Onsite Supervisor (Toolpusher)

1. In the absence or incapacitation of the Contractor Onsite Supervisor, the ConocoPhillips Onsite Supervisor will assume all responsibilities designated herein to the Contractor Onsite Supervisor.

2. Assist the ConocoPhillips Supervisor and Safety Representative in training crews for handling emergency situations.

3. Will be trained for all well control or emergency situations as contained herein and how to properly use all safety equipment.

Driller

1. In the absence or incapacitation of both Onsite Supervisors (ConocoPhillips and Contractor), the Driller will assume their responsibilities as designated herein.

2. In the event of any emergency, the Driller if trained, will don respiratory equipment and secure the rig if time permits.

3. Assist Contractor supervisor in crew preparation.

HSE Department

1. Shall provide safety and environmental information and guidance when required.

2. Shall review and approve any changes in safety or environmental procedures.

3. Shall assist as appropriate with operating and maintenance procedures for the safety equipment called for in this plan.

4. Shall assist with arranging initial training on safety procedures and equipment. Shall provide assistance as needed for follow up training.

Rig Contractor

1. Shall have personnel properly trained in First Aid/CPR and H_2S Awareness

2. Shall keep personnel trained in use of safety equipment and safety procedures.

Visitors, Service Personnel (Vendors) and Others

1. Only personnel authorized by ConocoPhillips Onsite Supervisor shall be permitted to enter area when an emergency condition exists.

2. Third parties shall be permitted to enter area under an emergency condition only if needed, and then, only after being properly instructed in use of safety equipment and have necessary equipment issued or available.

3. Vendors must have all of their personnel trained in H2S procedures who will be on location from 1,000' above the expected H2S zone through rig release.

Igniting the Well

1. Responsibility

The decision to ignite the well is the responsibility of the ConocoPhillips Drilling Manager. However, the decision should be made only as a last resort and in a situation where it is clear that:

a. Human life or property is endangered.

b. There is no hope of controlling the blowout under the prevailing conditions at the well.

In all cases, an attempt should be made to notify the Drilling Manager of the plans to ignite the well, if time permits. However, the Drilling Manager and Onsite Supervisor must not delay a decision if human life is threatened.

REMEMBER, if the well is ignited, the burning H_2S will be converted to sulfur dioxide (SO2), which is also highly toxic. Do not assume that the area is safe after the well is ignited. Follow through with all plans to evacuate endangered persons.

2. Means of Ignition

a. In preparation for igniting the well, keep unnecessary persons in the "Safe Briefing Area". A two person team is required for the actual ignition. Both team members will wear self-contained breathing units and will have 200 feet retrieval ropes attached to safety harnesses. One team member is responsible for checking the atmosphere for explosive gasses with the explosimeter. The other member is responsible for igniting the well. Persons remaining in the "Safe Briefing Area" will closely watch the ignition team; and should either man be overcome, they will immediately pull him to safety by the retrieval ropes and apply revival measures.

b. The primary method for igniting the well will be with a 25 mm meteortype flare gun to be kept on location (preferably in the company man's trailer). Flare guns can be obtained from DXP Safety Alliance. These guns have a range of approximately 500 feet. If this method fails or well conditions are such that a safer or better method is apparent, then an alternate method should be used.

c. Always ignite the well from upwind and do not approach the well any closer than warranted.

d. Select a location to fire the flare gun that provides maximum protection to the ignition team (behind equipment) while keeping in visible site by personnel in the "Safe Briefing Area".

e. Choose a location that has good accessibility and from which retreat can easily be made.

f. **REMEMBER**, before firing the flare gun or igniting flammable material, check the atmosphere at your location for combustible gasses with explosimeter.

PRECAUTIONARY MEASURES

These measures are to be in effect prior to drilling out surface casing.

General

1. **Two areas** shall be designated as safe briefing areas, each located, as a minimum: 150 feet from the wellhead and vent discharge area; spaced 160 degrees apart on an arc, with the wellhead as the center point; and as best suited for topographical considerations and prevailing winds.

2. Emergency equipment shall be on location as described in the H_2S Contingency Equipment Checklist.

3. A copy of all emergency telephone numbers shall be posted on the doghouse bulletin board, at the "Safe Briefing Areas", in the ConocoPhillips Onsite Supervisor's office, and in the Contractor Supervisor's office.

4. Wind direction indicators shall be located where at least one can be viewed from any position on the location.

5. An automatic hydrogen sulfide (H_2S) 4-channel monitor shall be provided, with detectors placed at the flow line, mud pit, rig floor & substructure (near rotating head). Either of these detectors shall be capable of sensing a minimum of 5 ppm H2S in air and shall be able to independently activate visual and audio alarms. Both the visual alarm and the audible alarm will be activated at 10 ppm. The audible alarm must be capable of alerting people at any point on the location.

6. All personnel on location shall wear a Single Gas Personal Monitor with alarm set at 10ppm.

7. A sign that reads, "Caution - Poisonous Gas May be Present", will be posted at the last intersection leading to location.

8. The well-site shall be equipped with commercial communications. The equipment should be located for safe access and should not be an ignition source.

9. The ConocoPhillips Onsite Supervisor's vehicle should always be parked a safe distance (at least 100 feet) from the rig, and in an upwind direction when feasible.

10. For all well kicks, the Operations Plan will be followed. All drilling contractor personnel shall be trained, and drills shall be conducted to insure proper well control procedures.

11. The checklist of all emergency equipment (see Onsite Supervisor's checklist) shall be completed prior to drilling our surface casing, as identified in the introduction. The Onsite Supervisor shall inspect the equipment with assistance, as needed, from ConocoPhillips HSE personnel as to working condition, proper placement, etc. The inspection will be noted on the checklist. ***A copy of the checklist will be placed in the Onsite Supervisor's files and one copy each will be provided to the Drilling Manager and HSE Department.***

12. To ensure proper hole filling during tripping operations, a stroke counter and pit level sensor will be utilized at all times.

13. ConocoPhillips Contractor Onsite Supervisor will be on-site security monitoring head count, enforcing that all personnel on location will have no facial hair, keeping only essential personnel on location, and all personnel on location are trained on H_2S Emergency Response.

SPECIAL SAFETY TRAINING

The minimum training for personnel working in affected areas shall include the following elements:

1. Hazards, characteristics and symptoms of hydrogen sulfide (H_2S), sulfur dioxide (SO_2), carbon monoxide (CO), methane gas, and other hazardous substances as may be appropriate. Effects of these substances are discussed in a section that follows.

2. Effect on metal components of the system.

3. Safety precautions to include possible sources at the site.

4. Operation of safety equipment and life support means and systems.

5. Corrective action and shutdown procedures.

6. Detection and measurements of H_2S, CO and combustible gas.

THE CONOCOPHILLIPS SUPERVISOR ON LOCATION SHALL BE RESPONSIBLE FOR THE OVERALL ON-SITE OPERATION, INCLUDING THE SAFETY AND TRAINING PROGRAM.

All personnel, contracted or employed on an unscheduled basis, shall be trained as a minimum in the severity of H_2S and other toxic gasses, safety precautions, evacuation procedures, and as appropriate, the use of respiratory protection equipment. This training shall be completed prior to entering the H_2S location. Visitors shall also be instructed regarding these matters.

To promote efficient safety procedures, an on-site toxic gas safety program, which includes **a drill** and training session, shall be established for all crews. Records of attendance shall be maintained on the drilling facility.

EQUIPMENT AND MATERIAL SPECIFICATIONS

1. Wellhead and blowout equipment is to conform as per Operations Plan.

2. BOP equipment will be tested to pressure rating prior to drilling out from the surface casing, with all testing witnessed and recorded by the ConocoPhillips Onsite Supervisor.

3. The BOP will be operationally tested on every trip. ***BOP drills will be held each tour prior to drilling all potential H_2S bearing formations and recorded on the tour sheets.***

4. The casing planned for this well is listed in the Operations' Plan. If H2S levels warrant as such, this casing has been designed in accordance with ConocoPhillips' requirements for sour service.

Mud Requirements

1. The pH of the mud system will be maintained above 9.0 to neutralize (disassociate) any H_2S encountered. The pH will be maintained with Lime, no caustic soda and/or soda ash will be kept on location.

2. While drilling from all potential H_2S bearing formations to total depth, the Mud Engineer is to test daily for filtrate sulfide using a "Hach H_2S Test Kit" and following the procedures of API Standard RP13B (copy in a following section). The results of this test are to be reported on the daily report.

3. Small concentrations of sulfide are expected and can be tolerated. However, concentrations which result in "Hach Tests" of greater than **50 ppm** are potentially more serious and should be treated with H_2S scavenger to reduce the concentration of acceptable levels.

4. The Hach Test will be routinely "doubled-checked" by means of the Garrett Gas Train.

5. Prior to dumping any significant quantities of drilling fluid (changing over, cleaning pits, cementing, etc.), it may be necessary to treat out sulfides with H_2S scavenger in order to preclude formation of H_2S gas in the reserve pit.

ConocoPhillips
H_2S CONTINGENCY EQUIPMENT CHECKLIST

Well: Reid #22M Rig N/N: AWS 711

Date: _____ Supervisor: _____

_____(All) **Personnel must be H_2S trained** & provide record of training (cards, certificates, etc.)
_____(2) **Muster Points** for use as "Safe Briefing Areas", 150' from wellhead, and 160° apart.
_____(1) **Warning sign** with current well condition indicator (yellow, orange, red flags), located at last intersection to location so vehicles may have turn-around area.
_____(3) **Wind direction indicators,** located to provide visibility from any place on location.
_____(3) **No Smoking signs** on drive posts.
_____(3) **Safe Briefing Area signs** on drive posts.
_____(1)) **H_2S monitor & Alarm system** (continuous) located on rig floor with detectors (sensitivity of 5 ppm in air) located at the flow line, mud pits discharge, and on the rig floor capable of individual activation by any detector with maximum settings as follows: visual and audible alarms at 10 ppm (audible must be capable of alerting personnel at any point on location).
_____(5) **Escape Packs** for individual use of each rig floor hand, located at dog house.
_____(1) **Flare system** with continuous pilot and remote ignitor.
_____(1) **Fire extinguisher** (rated 60:BC).
_____(4) **Emergency telephone number lists,** as shown in "COP Emergency Response Plan" folder, located in doghouse, company man's trailer, and both safe briefing areas.
_____(*) **Single Gas Personal Monitor** for all personal on location.

EFFECTS OF HYDROGEN SULFIDE AND OTHER GASSES ON DRILLING OPERATIONS

Toxic Effect

1. Hydrogen Sulfide - H_2S

Hydrogen sulfide is a colorless, flammable, extremely poisonous gas. It is 1.2 times as heavy as air and will accumulate in low areas. It forms an explosive mixture with air between 4.3 and 46.0 percent by volume. It can be detected by smell at a concentration in air of only 0.02 ppm. Exposure to 10 ppm can be tolerated up to 8 hours without respiratory equipment. Respiratory equipment is required to protect workers should conditions exceed the foregoing allowable exposure limit. Concentrations in excess of 20 ppm have an effect on the olfactory nerve which deadens the sense of smell. Unconsciousness can occur without warning within seconds of inhalation at concentrations above 500 ppm.

Physical Effects of Hydrogen Sulfide

Concentration Percent (%)	ppm	Physical Effects
0.001	10	Obvious and unpleasant odor.
0.001	10	Current ACGIH TLV allowed for 8 hour exposure.
0.01	100	Kills smell in 3 to 15 minutes, may sting eyes & throat.
0.02	200	Kills smell shortly, stings eyes & throat.
0.05	500	Dizziness, breathing ceases in a few minutes. Needs prompt artificial respiration.
0.07	700	Unconscious quickly; death will result if not rescued promptly.
0.10	1000	Unconscious at once; followed by death within minutes.

2. Sulfur Dioxide - SO_2

Sulfur dioxide is a colorless, nonflammable, intensely irritating gas and 2.2 times heavier than air. It is a by-product of combustion of hydrogen sulfide and is highly toxic. Exposure to 2 ppm can be tolerated for a maximum of 8 hrs. Respiratory equipment will be available and should be used by personnel measuring SO_2 concentration downwind from a flare.

3. Methane - CH_4

Methane is the major component of natural gas and is colorless, odorless and extremely flammable. The chief danger from methane is explosion. Mixture of CO_2, H_2S and CH_4 will burn if the total H_2S and CH_4 content, in any ratio, is above 25 percent. Also the presence of methane causes an oxygen deficient environment and requires adequate ventilation for breathing.

5. Carbon Monoxide - CO

Carbon monoxide is a colorless, odorless toxic gas. Its toxicity results from preferential reaction with the hemoglobin in the blood; however, it has no unique toxic action on any of the bodily

tissues. CO displaces oxygen from hemoglobin and reduces the oxygen carrying capability of the blood.

The primary danger from CO is that it binds with hemoglobin within the blood, thereby preventing oxygen / blood transfer. Respiratory equipment should be considered for atmospheres containing greater than 25 ppm. Exposure to 25 ppm is allowed up to 8 hours; however, at higher levels it will tend to cause headaches, dizziness and nausea. Concentrations above 1200 ppm are considered immediately dangerous to life and health.

In addition to the toxic effects of CO, carbon monoxide burns readily in air. The flammability limits of CO in air change with pressure. At atmospheric pressure, however, the lower limit is ±12.5% and upper limit is ±74%.

6. Properties of Various Gasses

Common Name & Chemical Formula	Specific Gravity Air=1	Time Weighted Average*	IDLH**	Lethal Concentration***	Flammability
Hydrogen Sulfide (H_2S)	1.18	10 ppm	100 ppm	600 ppm	4.3% to 46% by volume in air
Sulfur Dioxide (SO_2)	2.21	2 ppm	---	1000 ppm	
Methane (CH_4)	0.55	Simple Asphyxiate	---	--------	5.3% to 14.0% by volume in air
Carbon Monoxide (CO)	0.97	25 ppm	1200 ppm	--------	12.5% to 74% by volume in air

* Time Weighted Average (TWA) - Employee's average exposure in any eight-hour work, of a 40-hour work week that shall not be exceeded.
** Hazardous - Concentration that may cause death.
*** Lethal - Concentration that will cause death with short term exposure.

CORROSION EFFECTS OF H2S ON STEEL

1. Hydrogen Sulfide (H_2S)

The three forms of hydrogen sulfide corrosion of steel are as follows:
(a) general or weight loss,
(b) localized or pitting, and
(c) sulfide stress cracking.

In both general and localized corrosion, hydrogen sulfide reacts with the steel to produce iron sulfide. General corrosion is characterized by the formation of an iron sulfide film on the surface of the steel. After long periods of exposure, weight loss can lead to a significant reduction in strength. Localized corrosion is much more serious and predominantly occurs in the pH range below six. Chloride or similar ions must be present for pitting to occur. Iron chloride accumulates at the metal to iron sulfide film interface and promotes a localized attack. Pitting corrosion has not presented a significant problem in drilling operations.

Of foremost concern is sulfide stress cracking or hydrogen embrittlement where failure may take place without warning or significant metal loss. This problem is related to strength of the steel, hydrogen sulfide concentration, pH, exposure time, and temperature and stress level of the steel. Hydrogen sulfide absorbed on the metal surface promotes the entry of atomic hydrogen into the metal. The atomic hydrogen that enters the steel matrix diffuses to positions of high stress where it can induce hydrogen embrittlement. Thus, brittle failure can occur at stress levels significantly less than normal yield stress. A high total dissolved sulfide concentration can be tolerated if the pH is high enough (9.5 or greater).

EFFECTS OF H_2S ON DRILLING FLUID

1. Hydrogen Sulfide - H_2S

When H_2S is entrained in a drilling fluid, it will disassociate to some degree depending on the pH of the system.

Undisassociated hydrogen sulfide is the molecule that attacks steel surfaces and causes corrosion and embrittlement. At a low pH, nearly all of the H_2S in a system is in this molecular state. With increasing pH, H_2S disassociation increases so that above pH 10, effectively all of the H_2S is disassociated into bisulfide and sulfide ions. These ions are relatively harmless in the mud as long as the high pH is maintained. If pH is lowered, the reaction will be reversed and hydrogen sulfide gas will be evolved.

In addition to sulfide ions, disassociation of H_2S in drilling mud produces hydrogen ions, which will react with hydroxyl ions in a high pH mud to form water. With sufficient H_2S contamination, excess lime, if any, can be depleted and pH will begin to drop. A sufficient decrease in pH will, as previously stated, evolve H_2S gas.

It is therefore desirable to know whether H_2S has been encountered at the least possible time. This can be accomplished by testing the mud for sulfide ions daily, as described in the sulfide testing procedures that follow (API RP 13B).

SULFIDE TESTING PROCEDURE
HACH TEST

PROCEDURE FOR ESTIMATING FILTRATE SULFIDE

Equipment: The following materials are required to estimate the sulfide concentration in the mud filtrate:

a. Special test vial with vented cap
b. Lead acetate test paper to fit cap
c. Color comparison chart

(NOTE: THE HACH HYDROGEN SULFIDE TEST KIT (MODEL HS-7) CONSISTS OF ITEMS a, b, and c ABOVE.)

d. Distilled water
e. Hypodermic syringe
f. Defoamer (such as octyl alcohol or sulfated castor oil)
g. 0.1N acid, sulfuric or hydrochloric

Procedure: Place one disk of dry lead acetate test paper inside the dry cap of the test vial.

Measure 2.5 cm3 of freshly collected mud filtrate into the test vial. Dilute to the 25 cm3 with distilled water.

Add 2 cm3 of 0.1N acid, immediately add a fresh seltzer tablet, and quickly place the cap with the test paper on the vial. Allow the seltzer tablet to dissolve and then wait one minute.

Remove lead acetate paper and observe for brown coloration. If no coloration can be detected, then report the soluble sulfide as zero. If brown coloration is present, compare the test paper with color comparison chart. Read the appropriate ppm value (0.1, 0.3, 0.5, 1, 2, or 5) from the color chart and multiply by 10 to obtain the test result (1, 3, 5, 10, 20, or 50).

If the test paper matches the darkest color (5 ppm) on the color chart, the test result must be interpreted as greater than 50 ppm.

To extend the test range to higher concentration, dilute the filtrate as follows:

a. For a test range of 10 to 500 ppm, dilute 1.0 cm3 of filtrate with 9.0 cm3 of distilled water. Use 2.5 cm3 of the diluted filtrate for the sulfide determination. Multiply the color chart value by 100 to obtain the test result.

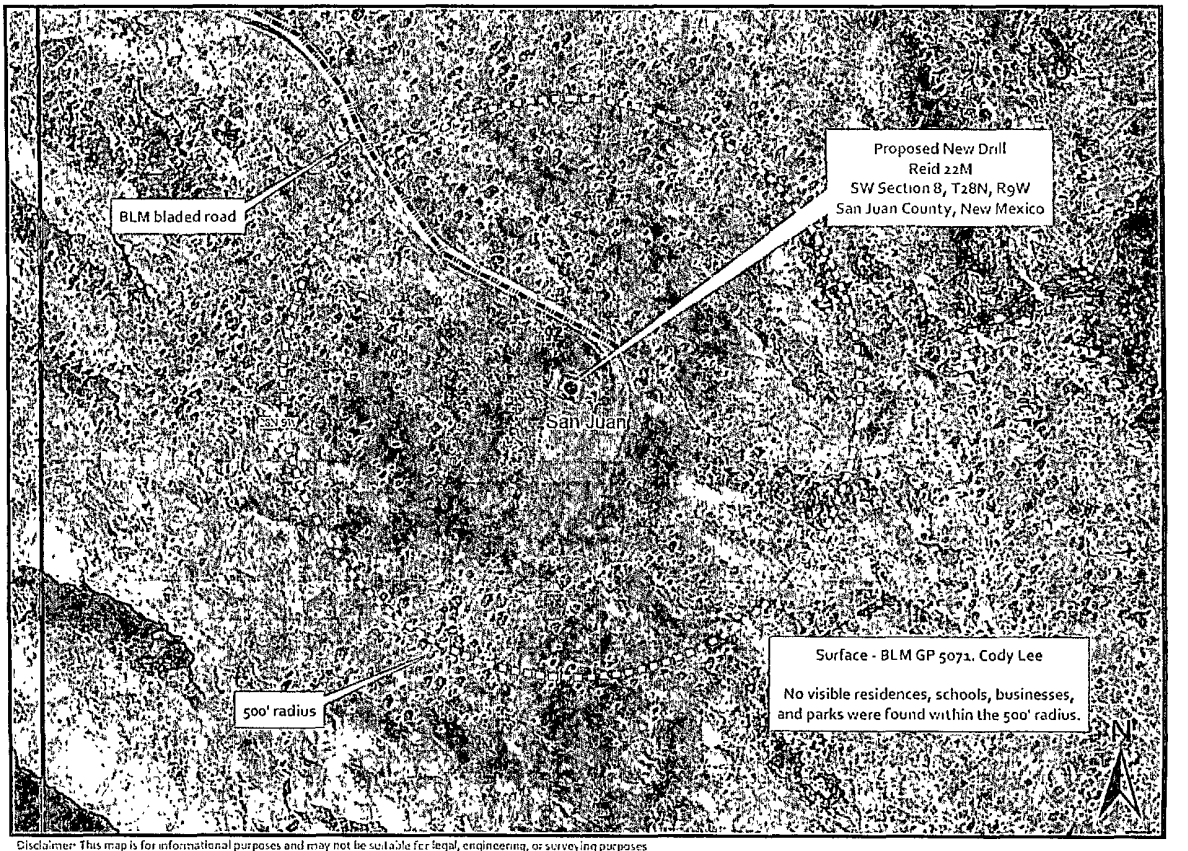
Report the test result as filtrate sulfide in ppm.

NOTE 1: **IT IS IMPORTANT TO NOTE THAT THIS TEST IS NOT HIGHLY ACCURATE. THE RESULTS SHOULD BE INTERPRETED AS ROUGH ESTIMATES.**

NOTE 2: **THE METHOD MAY BE USED FOR WATER USING 25 CM3 SAMPLES OR THE SAME DILUTION PROCEDURE USED FOR MULLED FILTRATE. THIS METHOD MAY ALSO BE USED FOR MUD BUT THE PROBABLE MEANING OF THE RESULTS IS VERY UNCERTAIN. THERE COULD ALSO BE CONSIDERABLE DIFFICULTY IN OBTAINING A REPRESENTATIVE SAMPLE OF DILUTED MUD.**

ATTACHMENTS

REID 22M - H2S CONTINGENCY PLAN MAP



Disclaimer: This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes

Features were identified based on USDA Aerial Photography. If an on site is necessary, please contact PRRC

S:\gis\rrc\New Mexico - ADM 095\ArcGIS - ADM 095\H2S Contingency Plan\Reid 22M\Reid 22M - H2S Contingency Plan Map

Austin Barton @ (505) 215-8009 or Maclovia Blakley @ (505) 320-2560

1 inch = 200 feet

0 100 200 400 Feet

LIST OF REFERENCES

1. "API Recommended Practices for Safe Drilling of Wells Containing Hydrogen Sulfide", (API RP 49) American Petroleum Institute, Dallas, Texas, 1974.

2. "API Recommended Practice: Standard Procedure for Testing Drilling Fluids", (API RP 13B) American Petroleum Institute, Dallas, Texas, 1976.

3. Clark, R. K., "Hydrogen Sulfide in Water-Base Drilling Fluids - I: Chemistry, Corrosion and Treatment", Technical Progress Report BRC 35-77, Shell Development, Houston, Texas, 1977.

4. "Contingency Plan for Drilling, Completion and Workover, Sour Gas Wells, Safety Regulations and Emergency Procedures", Shell Oil Company, Michigan Operations, Traverse City, Michigan, 1974.

5. "Contingency Plan for the Drilling of Taylor DT 653, Ventura Avenue Field, Ventura County, California; Safety Procedures and Precautionary measures", Shell Oil Company, West Coast Division, Los Angeles, California, 1973.

6. "Drilling Contingency Plan for McElmo Dome Area", Shell Oil Company, Midland Operations, Midland, Texas, 1976.

7. "Drilling Fluid Engineering Manual", Magcobar Operations, Dresser Industries Inc., Houston, Texas, 1972.

8. "Rule 36: Oil, Gas or Geothermal Resource Operation in Hydrogen Sulfide Areas", Railroad Commission of Texas, Oil and Gas Division, Austin, Texas, 1976, as amended effective September 15, 1985.

9. "Safe Practices for Drilling and Well Servicing Operations", Volumes I and II, Shell Oil company Exploration and Production.

10. "Sulfide Stress Cracking Resistant Metallic Material for Oil Field Equipment", NACE Standard MR-01-75, National Association of Corrosion Engineers, Katy, Texas, 1978.

11. "Onshore Order No. 6, Hydrogen Sulfide Operations", Department of the Interior, Bureau of Land Management, 43 CFR Part 3160.