REVISED HYDROGEN SULFIDE DRILLING CONTINGENCY PLAN

OCEAN DRILLING PROGRAM
TEXAS A&M UNIVERSITY

Technical Note 19

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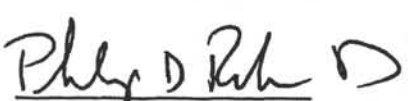

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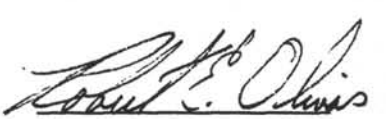

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PREFACE

Attached is the **"REVISED HYDROGEN SULFIDE DRILLING CONTINGENCY PLAN"** that will be used for ODP coring and drilling operations on legs where hydrogen sulfide is likely to be encountered. Prior to commencing operations on such legs, all safety equipment and procedures described herein will be in place and operational. The H_2S Technicians will be required to confirm that each person working in the designated hazardous areas (rig floor, core receiving deck, core lab and core reefer(s)) has read his/her copy of the contingency plan. Each person will be required to sign a log that states that he/she has read and understands the document.

During coring operations at all sites where there is a H_2S hazard as defined by geological considerations and past drilling experience, the procedures and policies outlined in this contingency plan will be implemented fully. Provisions also are included for implementation of interim safety procedures on legs wherein hydrogen sulfide is encountered unexpectedly. This document is not intended to facilitate continued operations for any extended periods of time under emergency Conditions I, II, or III. Rather, this plan defines safety equipment and procedures that must be in place in the event H_2S and/or steam-flash conditions are encountered.

This plan is based upon, is a revision of ODP Technical Note 16, "HYDROGEN SULFIDE - HIGH TEMPERATURE DRILLING CONTINGENCY PLAN" (1991) by S. Howard and D. Reudelhuber.

Additional information on metallurgical considerations with regard to H_2S environments, as well as detailed information on steam-flash conditions, is provided in the "LEG 139 ENGINEERING AND PLANNING DOCUMENT". The document was produced by S. Howard and D. Reudelhuber (12/17/90) and is available from the ODP Engineering/Operations Department.

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I. INTRODUCTION

This plan defines the precautionary measures, safety equipment, emergency procedures, responsibilities, and duties pertaining to drilling/coring operations aboard *Sedco/BP 471*. Specifically, safety measures and actions are defined for the rig floor, core walk, core lab, core storage area, and living quarters with regard to hydrogen sulfide (H_2S) that may be encountered during operations in areas where H_2S may be present in the sediments or fluids to be sampled. This document describes procedures for handling the core barrels on the rig floor, removing and handling the cores on the core receiving deck, and processing the cores in the core lab. H_2S detection equipment is described and the location in each area is defined. The type, quantity and location of the air breathing equipment is described. Contained in this document are the definitions of the occupational exposure limits, scales, initial response to H_2S and toxicity limit values as defined by the Canadian occupational health and safety legislation and the American National Standards Institute (ANSI).

The plan also defines special operational procedures that will be required for working in H_2S environments. Methods of circulation during routine coring operations are specified to minimize chances of formation fluids entering the drill string during wireline and other special downhole operations. Situations wherein H_2S and CO_2 scavengers and inhibitors should be mixed with the drilling fluid are also included. The drill string safety valve and its operation are described.

It should be noted that drilling and coring operations conducted aboard *Sedco/BP 471* by the OCEAN DRILLING PROGRAM are not conventional. Drilling and coring are done without a marine riser (no return circulation), drilling normally is done with seawater instead of mud as the drilling fluid, and there is no blowout-prevention system.

ODP does not intend to operate for any extended period of time under Emergency Conditions I, II or III as defined in Section IV. Rather, this plan defines safety equipment and emergency procedures that must be ready in the event H_2S conditions are encountered.

***Overseas Drilling, Ltd. (ODL) is an affiliate of Sedco-Forex, a Schlumberger Technology Company.**

The contingency plan is intended to be used as a means to recognize, recover from, and eliminate potentially dangerous situations. Drilling and coring operations are to be suspended during Emergency Conditions I, II and III and may not be resumed until the source of H_2S has been identified and atmospheric H_2S has been suppressed or dissipated below 10 ppm (parts per million).

Concentration levels in interior compartments can be minimized by allowing the H_2S to diffuse out of split cores outside the core lab in a well-ventilated area and by providing forced ventilation in areas where H_2S is present.

II. SAFETY EQUIPMENT LIST AND LOCATION

Before drilling and coring operations commence in areas where H_2S is likely to be encountered, the procedures set forth and equipment described in this document will be in place and operational.

A. SAFE-BRIEFING AREA

The primary safe-briefing areas will be the **port and starboard lifeboat stations** located forward on the fo'csle deck. The location of the designated safe-briefing area will be posted by the Captain or Mates next to the ship's station bills. The port and starboard lifeboat stations have been designated as the safe-briefing areas because when the drillship is in the dynamic-positioning ("DP") mode, the bow of the ship is nearly always oriented into the prevailing wind. However, if for some reason the stern of the ship was oriented into the wind, the Captain would notify all ship personnel that the safe-briefing area would be the **heliport. Note: the designated safe-briefing area will be posted on the station bills by the Captain. Signs also will be posted at the location of the designated safe-briefing area. The signs will identify the area clearly as the designated safe-briefing area.** Drawings of the ship showing those designated areas are included in Appendix G.

If a H_2S concentration in excess of 10 ppm is detected at any one of the <u>fixed H_2S sensors</u>, the ship's Captain or the Mate on duty will determine the appropriate course of action and the alarm state/condition that applies. The location and emergency state (Conditions I, II, and III described later in Section IV) will be broadcast using coded bell signals and verbally over the ship's public address system. It is important that the location of the H_2S source be broadcast so that personnel can avoid the H_2S danger area as they make their way to the safe-briefing areas. All personnel aft of the rig floor not assigned emergency duties will proceed forward to the safe-briefing stations along the mezzanine or main deck on the windward side of the ship. Personnel aft must avoid entering areas designated as potential H_2S danger areas as they proceed forward to the safe-briefing areas. **Note: rig floor activity, weather, and sea conditions will dictate the best routes to be taken to the safe-briefing area from each particular location on the ship. The routes will be decided by the Captain and reviewed in safety meetings held with personnel working in each area of the ship.**

B. WIND DIRECTION INDICATORS

Windsocks and streamers (bright-colored) will be installed on the derrick, bow, and stern and positioned as to be seen from any location above the main deck. (See drawing SK9002, Appendix G.)

C. H_2S WARNING SIGNS

The following warning will be posted at the entrance(s) to potential H_2S areas during operations at sites where H_2S may be encountered:

WARNING--HAZARDOUS AREA
HYDROGEN SULFIDE H_2S
UNAUTHORIZED PERSONNEL KEEP OUT
NO SMOKING

Specifically, warning signs are to be posted in the following areas:

1. RIG FLOOR
2. CORE RECEIVING PLATFORM
3. CORE LAB - in all areas where cores will be processed.
4. CORE STORAGE REEFER - including reefer entrance(s).
5. BOTTOM OF CORE LAB STAIRWELL - H_2S gas may accumulate in that area.
6. LIVING QUARTERS EXITS THAT ARE ENTRANCES INTO DESIGNATED H_2S DANGER AREAS - all deck levels.

D. H_2S DETECTORS AND ALARMS

FIXED SENSORS

A fixed continuous "wireless" multi-point gas monitoring system having sensors located on the rig floor, core lab, core receiving deck and core reefer storage area(s) will be installed. The detector system owned by ODP was manufactured in Canada by BW Technologies. TOTCO provides field service for the system. The detector units have two sensors that can be placed strategically in each of the hazardous areas. Each detector unit has a transmitter that sends a signal back to the main alarm panel. The detector units have an alarm response of less than 8 seconds. That is based on an alarm setting of 10 PPM and exposure to 20 PPM of H_2S gas. A central alarm panel for **all** sensors will be installed on the bridge. Warning lights and horn units will be installed in each of the designated hazardous working areas (rig floor, core lab, core

reefer areas). A **local** audible and visual alarm will sound in the hazardous area where H_2S is detected. That is, if H_2S is detected on the rig floor, an audible alarm and warning light will flash on the rig floor. At the same time, an audible and visual alarm will be triggered on the central alarm panel. **The Captain then will determine the appropriate course of action and which alarm state/condition applies.** For detailed operating instructions and specifications, see the TOTCO/BW factory manual. See drawing SK9004 (Appendix G) for locations of the gas monitoring system equipment. **Note: All fixed H_2S sensors will be set to alarm at 10 ppm.**

FIXED SENSORS - RIG FLOOR/CORE WALK

A fixed continuous multi-point gas monitoring system (wireless), capable of sensing a minimum of 10 PPM in air, will be mounted in the vicinity of the rig floor. The remote sensors are to be strategically placed on the rig floor and core receiving platform. (See drawing SK9004, Appendix G.) Any sensor can activate the alarm. The sensors will be located as follows:

1. Rig Floor - A sensor will be placed in the vicinity of the drawworks on line with well center or attached to the iron roughneck. A second sensor will be placed on the forward side of the rig floor where the core barrel is broken out and the cores are pulled from the core barrel.

2. Core Receiving Platform - Two sensors will be mounted in the area where the core is cut into 1.5 meter-long sections on the core receiving deck.

FIXED SENSORS - CORE LAB AREA

A fixed continuous multi-point gas monitoring system (wireless) will be installed in the core lab. (See drawing SK9004, Appendix G.) Sensors are to be installed in the following locations:

1. Core Storage Rack - A sensor will be mounted in the vicinity of the core storage rack. Core sections 1.5 meters long are stored on that rack prior to splitting. A secondary rack will be located outside the lab stack on the core receiving platform for storage of whole cores.

2. Core Splitting Room - A sensor is required in that area because that is where the cores are initially split and exposed to the atmosphere. Until that time the 1.5-meter core sections are in sealed plastic liner sections.

3. Core-Processing Area - Two sensors will be placed in the description and core-sampling areas. One will be placed adjacent to the storage of "working" halves and the second between the core photo and description table.

FIXED SENSORS - CORE REEFER STORAGE AREA(S)

A fixed continuous multi-point gas monitoring system (wireless) will be mounted in the core reefer located on the lower 'tween deck used for storing the cores (those that contain H_2S). One sensor will be mounted inside the reefer and a second sensor will be mounted in the lower 'tween landing just outside the core storage door. (See drawing SK9004, Appendix G.)

Note: If numerous cores containing significant levels of H_2S are anticipated, a separate reefer container located above decks may be provided. In such cases, one sensor will be mounted inside the container and a second sensor will be mounted just outside the container door. If all the H_2S cores are stored in the above-deck reefer container, the sensors in the lab reefer located on the lower 'tween deck may not be needed.

Additional sensors will be located in the lab stairwell. A fixed continuous multi-point gas monitoring system will be mounted in the hold deck landing. That system will have two sensors connected to a single alarm monitor. One will be mounted inside the forward hold storage area and the second at the bottom of the stairwell. Emergency air escape packs (3 ea) will be located inside the elevator. Consideration should be given to disabling the ability on the elevator control to select the lowermost two decks in the lab stack from inside the elevator car. (The ODP and ODL Superintendents are to decide on the best way to handle that situation.)

Fixed sensors also will be located in the living quarters fresh air intake vent and the core lab fresh intake vent.

Note: Fixed sensors will be stored aboard the vessel for temporary installation on "routine" legs if H_2S is encountered unexpectedly. As a minimum, one monitor on the rig floor and one on the core receiving platform will be installed in such cases. The central alarm panel will not be required.

PORTABLE PERSONAL MONITORS

In addition to the fixed sensor systems described above, portable personal monitors will be placed in strategic locations in the hazardous areas as follows:

1. Core Splitting Room - A portable personal monitor will be placed in the core splitting room. The portable monitor will be used for checking for localized gas concentrations around groups of freshly split core sections.

2. Core Processing Area - Two portable personal monitors will be placed in the main lab areas where the cores are initially handled. Those monitors can be moved to the areas (different lab stack levels as required) where cores are being processed.

3. Rig floor - Two portable personal monitors will be placed on the rig floor for taking localized readings when the drill string is opened and when core catchers are broken out. Because the pump room is located low in the ship and is a potential H_2S collection point, a personal monitor will be carried by the derrickman whenever he is working in that area.

4. Core Receiving Platform - A portable personal monitor will be placed on the core receiving platform for taking localized readings when the core is cut into 1.5 meter long sections.

5. Reefer Area - A portable monitor will be placed next to the reefer fixed monitor unit located in the stairwell. That monitor is to be carried by personnel when entering the reefer and in areas such as the forward hold or stores area.

Note: A minimum of three portable personal monitors will be carried aboard the vessel at all times and will be stored in readily-accessible locations in the event of an unexpected H_2S occurrence.

E. DRILL PIPE SAFETY VALVE AND FLOAT VALVE

A safety valve (ODP part number OGO785) with 5-1/2" internal flush (I.F.) box and pin connections is kept on the rig floor. The safety valve has a 3.9" throughbore. The valve is intended to be used as an in-line blowout preventer (BOP) in the event of excessive backflow of fluid through the drill string. Such backflow could be the result of a hydrocarbon or hydrothermal fluid "kick", either of which possibly could carry H_2S to the

surface. If excessive backflow does occur, the valve is to be installed in the drill string. Once the valve is in place and closed, a second sub containing a float valve assembly can be made up on top of the safety valve. The Baker model G (5F-6R) float valve acts as a check valve allowing fluid to be pumped down the drill string but prevents fluids contaminated with H_2S or hot fluids from back-flowing up the drill string. **The float valve is to be used for special operations only (*i.e.* top drive not installed or inoperable for circulation). If the float valve is installed, some downhole tools cannot be run.**

F. H_2S SCAVENGERS

Drilling fluid additives (H_2S and CO_2 scavengers) may be carried on board to help reduce downhole concentrations of H_2S and CO_2 that may enter the wellbore. Because returns are not brought back to the surface, it is not practical or economical to pump the scavengers or inhibitors continuously. A sufficient volume of H_2S scavenger will be on board to allow slugs to be pumped when there is no circulation for long periods of time and between cores if required.

G. WORK-CYLINDER RECHARGE STATION

The work-cylinder recharge station for recharging the portable air breathing cylinders will be located on the bridge deck roof behind the DP Control Room.

H. CASCADE AIR BREATHING SYSTEM

A cascade air breathing system will be installed on the rig floor, core receiving deck, inside the core lab and in the alternate core splitting area if used. Refer to drawings SK9002 and SK9050 (Appendix G) for the location and detailed layout of the equipment that will be placed in each area. The cascade breathing system will allow breathing equipment to be worn for long periods of time. The air mask units will have a 50-foot hose that connects in the cascade air supply. Each air mask unit will also have a self-contained 5-minute air supply. If it becomes necessary to evacuate the area, the 50-foot hose can be disconnected from the mask. The self-contained 5-minute air supply is turned on and used for moving to a safe area.

The cascade stations designated C1, C2, and C3 are supplied with air from an air compressor located on the bridge deck roof. See the cascade system operating manual for details of the operation and maintenance of all the cascade system components.

I. SELF-CONTAINED BREATHING APPARATUS (SCBA)

Self-contained breathing units (30-minute) will be placed in the following locations:

1. Rig Floor - SCBA units (6 ea) for the rig crew will be stored in a readily accessible location on the rig floor. The storage location(s) will be away from the immediate well center where the H_2S is likely to be emitted.

2. Core Lab - SCBA units (4 ea) for personnel assigned with emergency duties will be placed in the area. There will be 2 ea SCBA units on the core receiving deck.

3. Safe-Briefing Area - SCBA units (6 ea) will be placed and maintained in safe-briefing areas. Those air packs will be assigned to personnel with emergency duties such as rescue of personnel in hazardous areas.

4. Reefer - SCBA units (2 ea) will be placed in the vicinity of the reefer in the stairwell on the lower tween deck.

NOTE: The supply of SCBA units normally maintained aboard the vessel for fire and other emergencies is considered to be adequate for temporary measures in coping with unexpected H_2S occurrences on "normal" legs.

J. EMERGENCY AIR ESCAPE PACKS

Three (3) emergency air escape packs will be located inside the lab stack elevator. The escape packs provide a five-minute emergency supply of air.

K. LIST OF SAFETY EQUIPMENT

The location and quantity of all safety equipment (including respirators, resuscitators, H_2S detectors, etc.) will be maintained on a separate "Safety Equipment Inventory" by the designated H_2S Safety Technicians. Also a location layout drawing is provided in this section for reference.

L. VENTILATION EQUIPMENT

One electric fan ("bug blower") with an explosion-proof motor will be installed on the rig floor and one will be installed on the core receiving deck. The bug blowers are to be directed aft/downwind. Two portable smoke-ejector fans will be placed in the lab stack. The fans will be used to ventilate areas where concentrations of H_2S have been detected in areas such as the core-splitting room, main lab, etc.

In addition to the fans, positive pressure normally will be maintained in the lab stack. That will help to force air out through the exits when it is necessary to use the portable smoke-exhaust fans in localized areas in the lab stack. Note: the lab stack ventilating system is separate from the living quarters system. Scrubber fan units will be located in the core lab in the vicinity of core description tables to help control the level of H_2S in the lab.

III. STANDARD OPERATING PROCEDURES

A. PRIOR TO COMMENCING OPERATIONS

1. The list of phone numbers of shorebased personnel to be contacted concerning H_2S emergencies is included in Appendix F. A copy of the list will be posted in the following locations:

   a. ODP Operations Superintendent's office
   b. ODL Drilling Superintendent's office
   c. ODL Captain's office
   d. ODP Lab Officer's office
   e. ODL radio room

2. All safety equipment and H_2S-related hardware must be set up as outlined on the location layout drawings contained in Appendix G. All safety equipment must be routinely inspected, with particular attention to breathing apparatus and recharge stations.

3. All personnel assigned to emergency duties will be assigned self-contained breathing apparatus and notified as to where the breathing apparatus is stored. ODP and ODL personnel assigned to emergency duty in the following areas will be provided with air breathing equipment:

   a. Rig Floor
   b. Core Receiving Platform
   c. Core Lab
   d. Reefer
   e. Rescue Team in Safe-Briefing Area

4. **All personnel** aboard the drillship, without exception, will be notified of the potential dangers of H_2S and, to a lesser extent, CO_2, radon, and hydrocarbon gases. (See Appendices C and D.) All personnel, without exception, will watch the ODL H_2S video training module. All personnel (ODL crew, ODP Operations and Technical Support staff, scientists, and LDEO personnel) working in the designated hazardous areas (rig floor, core receiving platform, core lab, and core reefer) must complete a H_2S safety course taught by a qualified H_2S instructor. The course will include thorough training in the use of air breathing equipment, emergency procedures, responsibilities, and first aid for H_2S victims.

   The H_2S Safety Technicians must keep a list of all personnel who have completed the special training programs aboard the vessel. All personnel (ODL Crew, ODP Operations Personnel, Scientists and Technical Support

Staff) working in or around the designated hazardous areas will be given a copy of the H_2S contingency plan and a copy of *THE HYDROGEN SULFIDE TECHNICAL MANUAL* published by the *S.T.O.P.* division of *Camco, Inc.* The H_2S Technician must keep a list of all persons who have copies of the plan and signatures verifying they have read and understand the contingency plan and technical manual thoroughly.

B. ON-SITE OPERATIONS

1. The H_2S detection equipment will be maintained by designated H_2S Safety Technicians. The detector/sensor units will be calibrated during the initial installation. As per the manufacturer's recommendation, no additional calibration is required for 90 days unless there is a specific problem with one of the units. During the first week of operation, the detector/sensor units are to be tested three times on different days. Both sensors on each of the units are to be tested. The detectors should be tested more frequently if problems with any specific detector unit occurs. After the first week of operation, the detector units are to be tested once per week. The time of tests and results will be logged by the H_2S Safety Technicians.

   If a H_2S detector or sensor on the rig floor does not test successfully, drilling will cease until the defective item is repaired/replaced and approval to proceed is given by the ODL Drilling Superintendent. Spare sensors and a spare detector will be available on board.

2. **All personnel** aboard the vessel will be instructed in the use of air breathing equipment until supervisory personnel are satisfied that they are capable of using the equipment.

3. After familiarization, personnel working in the designated hazardous areas must perform a weekly drill with the air breathing equipment. The drill should include getting the equipment, putting it on, and a short work period. A record should be kept of the crews drilled and the date.

   Blowout drills which incorporate the use of the breathing equipment with the installation of the drill-pipe safety valve will be conducted until the supervisory personnel are satisfied that rig floor personnel are capable of using the equipment effectively.

4. Along with the normal weekly fire and boat drill and safety meeting, a weekly air breathing equipment demonstration and H_2S training session must be held for all personnel who were not required to complete the in-depth H_2S safety course.

5. Rig crews, scientists and Technical Support staff will be made aware of the location of the spare air bottles, the resuscitation equipment, portable fire extinguishers, and H_2S detectors. Knowledge of the location of H_2S-detection sensors is vital to understanding the emergency conditions. Key personnel must be trained in the use of the resuscitator and personal H_2S monitors.

6. The H_2S portable personal monitors are available for working personnel as needed. After H_2S is detected by any fixed sensor, periodic inspections of all areas of poor ventilation (such as the bottom of the lab stairwell, forward hold area, etc.) will be made with a portable H_2S personal monitor.

7. All personnel on the ship must become "wind-conscious" and be aware at all times of the direction of the prevailing winds. **Remember: H_2S is heavier than air and will collect in low places when the air is still.**

8. If H_2S is detected at the surface, no welding will take place until the surrounding air is thoroughly tested with an explosimeter. **A hot-work permit will be required for all welding in the designated hazardous areas at all times, whether gas has been detected or not. (H_2S has a low ignition point of 500 degrees F and is explosive when mixed with air in concentrations between 4.3 and 46 percent.)**

9. After an H_2S zone has been penetrated, monitoring of the working areas will be increased during coring operations, special downhole measurement operations, logging, and running of subsea hardware. If the H_2S level reaches 10 PPM at a **fixed** H_2S sensor, protective breathing apparatus must be worn by all working personnel in that area.

IV. OPERATING CONDITIONS - CLASSIFICATIONS

Drilling and coring operations may encounter any of five possible conditions:

A. NORMAL OPERATIONS - H_2S NOT MEASURABLE IN ATMOSPHERE OF WORK AREA.

B. H_2S ALERT - H_2S PRESENT IN ATMOSPHERE OF WORK AREA (FIXED MONITORS) AT 1-9 PPM OR PRESENT IN CORES OR DRILL STRING IN CONCENTRATIONS ABOVE 10 PPM AS MEASURED BY PORTABLE DETECTORS.

C. EMERGENCY CONDITION I - POTENTIAL DANGER TO LIFE - H_2S PRESENT IN THE ATMOSPHERE AT 10 TO 19 PPM.

D. EMERGENCY CONDITION II - MODERATE DANGER TO LIFE - H_2S PRESENT IN THE ATMOSPHERE AT 20 TO 49 PPM.

E. EMERGENCY CONDITION III - EXTREME DANGER TO LIFE - H_2S PRESENT IN THE ATMOSPHERE AT 50 PPM OR GREATER.

V. H_2S EMERGENCY PROCEDURES

Note: drilling and coring operations will not be conducted if an Emergency Condition I, II or III exists on the rig floor, core walk or core lab. The Emergency Condition must be brought under control before drilling operations proceed.

A. NORMAL OPERATIONS - H_2S POTENTIAL BUT NOT MEASURABLE IN ATMOSPHERE

1. SPECIAL OPERATING PROCEDURES

Drilling/Coring

During coring or drilling operations wherein it is likely that H_2S gas will be encountered, the following procedure will be followed:

a. Circulation will be maintained while a core barrel is dropped or wirelined into and out of the hole.

b. After a core has been cut, circulation will be maintained while the wireline assembly is being run into the hole for retrieval of the core barrel.

c. After the core barrel has been engaged by the overshot, it may be necessary to stop the pumps momentarily while unseating the core barrel from the outer core barrel assembly (OCB). The core barrel should be pulled up slowly above the top of the bottom-hole assembly (BHA). The wireline winch should be stopped at that point and three volumes of fluid (equal to the volume required to fill the inside of the BHA) should be pumped to clear any H_2S-bearing fluid that may have been swabbed into the BHA when the core barrel was unseated.

d. Circulation should be maintained while the core barrel is wirelined to the surface. Wireline speeds are to be controlled to prevent/minimize swabbing of H_2S-bearing fluids into the drill string from the wellbore.

Logging/Downhole Measurements

As with coring operations, special measures must be taken when downhole measurement, sampling, and logging tools are run in areas where H_2S gas may be encountered. The procedures below will be followed:

a. Circulation is to be maintained while wireline tools are run into and out of the hole. **Care will be taken to ensure that excessive flow rates, sufficient to fail cablehead weak points and pump the wireline tools off the**

wireline, are not used. That has happened in the past with logging tools.

b. After the measurements or sampling have been completed and the wireline tool(s) have been retrieved inside the BHA, the sampling or measuring tool is to be stopped above the top of the BHA. Three volumes of fluid (equal to the volume of fluid required to fill the inside of the BHA) are to be pumped to clear any H_2S fluid that may have been swabbed into the BHA as the tool was pulled inside it.

c. Circulation down the drill string is to be maintained while the wireline tool(s) are retrieved to the surface. Wireline speeds are to be controlled to prevent swabbing H_2S fluids into the drill string from the wellbore.

Core handling

a. The lower end of each core will be "sniffed" at the rig floor with a portable personal monitor before the core catcher is broken off.

b. If gas is present, take samples (vacutainer) for lab analysis as requested by Science. (See Appendix B for special procedures in dealing with gas shows.)

c. Perforate the core liner as necessary to relieve accumulated free gases.

d. Measure H_2S levels of escaping gas with a portable personal monitor. If portable monitors detect H_2S levels of 10 ppm or greater:

(1) Immediately notify the Mate on watch of the situation--an "H_2S Alert" situation is indicated.

(2) Check fixed monitors for H_2S readings; verify that alarms are operational.

(3) Relocate the core to a "safe area" for degassing.

2. PRECAUTIONARY PROCEDURES FOR PERSONNEL SAFETY

Drilling/Coring

a. Periodic checks for the presence of H_2S will be made with portable personal monitors at the upper drill string connection, at the top of the inner core barrel, and at core catcher sub. If H_2S is detected at low levels (1-9 PPM) in those confined spaces, the checks will be made on

each core until H_2S is no longer considered a threat.

If the monitor registers a concentration greater than 10 PPM, an H_2S Alert condition is indicated and the Mate on watch is to be notified.

Logging/Downhole Measurements

a. The top of the drill string will be checked with a portable personal monitor as the tool is being retrieved and approaches the rig floor and also as the tool is being withdrawn from the pipe.

If the monitor registers a concentration greater than 10 PPM, an H_2S Alert condition is indicated and the Mate on watch is to be notified.

b. When water-sampling tools and pressure core barrels are run, extreme caution must be used in handling the sample chambers containing the wellbore fluids. **Prior to deployment, each tool is to be carefully inspected to determine if it is suitable for collecting water samples that may contain H_2S. If there is any question as to whether a tool is suitable for use in a H_2S environment, do not run the tool.**

Upon retrieval of a sampler containing fluids from a zone suspected to contain H_2S, the sample chamber is to be marked **"possible presence of H_2S".** The fluid contained within the sample chamber will be assumed to contain H_2S until actual measurements are made on the fluid that indicate otherwise.

In addition to the possible presence of H_2S in the wellbore, CO_2 and corrosive brine solutions may be present in some areas. The wellbore fluids may have pH levels as low as 2 to 4. Those fluids are highly corrosive. Components that are not designed for operation in H_2S and CO_2 environments are susceptible to sulfide and stress corrosion cracking. The cracking may occur downhole or at the surface over relatively short periods of time.

In the event fluids containing corrosives are stored in the sample chamber for even short periods of time, a failure may occur if the chamber is not made of the proper material.

Special precautions and extreme caution are to be observed when storing, as well as when handling, sample chambers with H_2S fluids under pressure.

Core Handling

a. Occasionally check escaping gas for H_2S with a portable personal monitor. If portable monitors detect H_2S levels of 1-9 PPM, increase checks to one or more locations on **each core.**

b. If the monitor registers a reading of 10 PPM or more, an H_2S Alert is indicated and the Mate on watch is to be notified.

B. H_2S ALERT - H_2S PRESENT IN CORES AND/OR DRILL STRING IN CONCENTRATIONS OF 10 PPM OR GREATER (PER PORTABLE MONITOR) AND/OR DETECTABLE IN ATMOSPHERE AT LEVELS BELOW 10 PPM AT ANY FIXED DETECTOR.

1. SPECIAL OPERATING PROCEDURES

Drilling/Coring

During coring or drilling operations wherein H_2S gas is present in the cores or drill string in concentrations of 10 ppm or above as measured by portable monitors, the following procedure will be followed:

a. Circulation will be maintained while core barrels are dropped or wirelined into and out of the hole.

b. After a core has been cut, circulation will be maintained while the wireline assembly is being run into the hole for retrieval of the core barrel.

c. After the core barrel has been engaged by the overshot, it may be necessary to stop the pumps momentarily while unseating the core barrel from the outer core barrel assembly. The core barrel should be pulled up slowly above the top of the bottom-hole assembly (BHA). The wireline winch should be stopped at that point and three volumes of fluid (equal to the volume required to fill the inside of the BHA) should be pumped to clear any H_2S-bearing fluid that may have been swabbed into the BHA when the core barrel was unseated.

d. Circulation down the drill string will be maintained while the core barrel is wirelined to the surface. Wireline speeds are to be controlled to prevent/minimize swabbing of H_2S fluids into the drill string from the wellbore.

Logging/Downhole Measurements

As with coring operations, special measures must be taken when downhole measurement, sampling, and logging tools are run in holes where H_2S has been encountered. The procedures below will be followed:

a. Circulation is to be maintained while wireline tools are run into and out of the hole. **Care will be taken to ensure that excessive flow rates, sufficient to fail cablehead weak points and pump the wireline tools off the wireline, are not used. That has happened in the past with logging tools.**

b. After the measurements or sampling have been completed and the wireline tool(s) have been retrieved inside the BHA, the sampling or measuring tool is to be stopped above the top of the BHA. Three volumes of fluid (equal to the volume of fluid required to fill the inside of the BHA) are to be pumped to clear any H_2S fluid that may have been swabbed into the BHA while the tool was pulled inside the BHA.

c. Circulation down the drill string is to be maintained while the wireline tool(s) are retrieved to the surface. Wireline speeds are to be controlled to prevent swabbing H_2S fluids into the drill string from the wellbore.

Core Handling

a. The lower end of each core will be "sniffed" at the rig floor with a portable personal monitor before the core catcher is broken off.

b. If gas is present, take samples (vacutainer) for lab analysis as requested by Science. (See Appendix B for special precautions in dealing with gas shows.)

c. Perforate the core liner as necessary to relieve accumulated free gases.

d. Measure H_2S levels of escaping gas with a portable air monitor.

   If portable personal monitors indicate maximum H_2S concentration below 10 ppm, consult with Captain and ODP and ODL Superintendents as to whether the "H_2S alert" condition should be relaxed.

2. PRECAUTIONARY PROCEDURES FOR PERSONNEL SAFETY

Drilling/Coring

a. All personnel working on the rig floor are to put on air breathing equipment ten stands (≈300m) before each core barrel reaches the surface. That procedure will be followed until H_2S is no longer viewed as a threat in each hole where the gas is encountered. When the drill pipe is initially opened, one of the rig crew will use a personal monitor to check for the presence of H_2S gas in the drill pipe.

Note: The pipe must be confirmed not to contain H_2S before a member of the rig crew is sent up into the derrick to remove the sinker bars from the blocks and to close the WKM valve.

Air breathing equipment should be worn by all personnel working in the area while the core barrel is being pulled from the drill string, laid down, broken out, and removed. Portable personal monitors should be used to monitor for H_2S when the drill string is (1) opened prior to removing the core barrel from the drill string and (2) after the core barrel is laid down and the core catcher is removed. When those detectors indicate a safe atmosphere, the air breathing equipment can be removed.

The following practices must be followed for every core barrel pulled:

a. Due to the difficulty in communicating while air breathing equipment is worn, a chalk board/chalk and note pads will be available during coring operations.

b. Air breathing equipment must be worn by personnel connected with the coring operations during steps in which H_2S could be released into the atmosphere. The most critical times are:

(1) When the drill string is initially opened to remove the core barrel on the rig floor. (If H_2S was swabbed into the drill string as the core barrel was retrieved, a concentration of the gas could possibly exist at the surface below and around the core barrel.) and

(2) When the core barrel is opened. **H_2S may be contained in the core inside the core barrel.**

(3) When the core is cut into sections or split into archive and working halves.

c. All personnel on board not wearing air breathing equipment should stay off the rig floor and the core-receiving platform.

Logging/Downhole Measurements

a. All personnel working on the rig floor are to put on air breathing equipment ten stands (≈300m) before the measuring/sampling tool reaches the surface.

Air breathing equipment should be worn by all personnel in the area while the measuring/sampling tool is being pulled from the drill string, laid down, broken out, and removed. Portable personal monitors should be used to monitor for H_2S around the measuring/sampling tool. When the detectors indicate a safe atmosphere, the air breathing equipment may be removed.

Note: Before a member of the rig crew is sent up into the derrick to remove the measuring/sampling tools from the blocks and to close the WKM valve, the pipe must be confirmed not to contain H_2S.

b. When water-sampling tools and pressure core barrels are run, extreme caution must be used in handling the sample chambers containing the wellbore fluids. **Prior to deployment, each tool is to be carefully inspected to determine if it is suitable for collecting water samples that may contain H_2S. If there is any question as to whether a tool is suitable for use in a H_2S environment, do not run the tool.**

Upon retrieval of a sampler containing fluids from a zone suspected to contain H_2S, the sample chamber is to be marked **"possible presence of H_2S".** The fluid contained within the sample chamber will be assumed to contain H_2S until actual measurements have been made on the fluid that indicate otherwise.

In addition to the possible presence of H_2S in the wellbore, CO_2 and corrosive brine solutions may be present in some areas. The wellbore fluids may have pH levels as low as 2 to 4. Those fluids are highly corrosive. Components that are not designed for operation in H_2S and CO_2 environments are susceptible to sulfide and stress-corrosion cracking. The cracking may occur downhole or at the surface over relatively short periods of time.

If fluids containing corrosives are stored in the sample chamber for even short periods of time, a failure may occur if the chamber is not made of the proper material.

Special precautions and extreme caution are to be observed when storing, as well as when handling, sample chambers with H_2S fluids under pressure.

Core Handling

During an H_2S Alert, it will be assumed that each core can produce hazardous levels of H_2S. Until testing indicates otherwise, personnel on the rig floor are required to wear air breathing apparatus.

a. Only essential personnel will be allowed on the rig floor or on the core receiving platform.

b. Core handlers without protective breathing apparatus must remain upwind from the rig floor and outside the ship's hazardous zone. The hazardous zone is the area within a 50-ft. radius of the well (see the *Sedco/BP 471 Marine Operations Manual* for a more detailed description). The boundary of that zone will be marked on the core receiving platform.

c. Core handlers must wear air breathing apparatus while processing cores on the receiving platform.

d. If the core contains H_2S, the 1.5 meter-long core sections are to be marked to indicate the presence of H_2S.

e. If the core contains H_2S, the liners or "D" tubes are to be marked as such. The liner will be perforated and the core will be stored in an outdoor location. **Note: specific handling procedures for processing cores containing H_2S are contained in Appendix B.**

f. All safety precautions must remain in effect until both:

(1) Accumulated free gases inside the liner have been vented and monitored and

(2) All monitors register H_2S levels less than 10 PPM.

The core lab H_2S safety technician will notify affected personnel when the Captain and Superintendents have determined that precautions are no longer necessary.

C. EMERGENCY CONDITION I - POTENTIAL DANGER TO LIFE - H_2S PRESENT IN ATMOSPHERE AT 10-19 PPM AT ANY FIXED DETECTOR

1. SPECIAL OPERATING PROCEDURES

If, at any time, as much as 10 PPM of H_2S is detected by a **fixed** H_2S sensor, Emergency Condition I exists and the following steps are to be taken:

Drilling/Coring

a. Upon notification by the bridge of a Condition I emergency occurrence on the rig floor, core receiving platform, or core lab, the Driller will make the string back up (if open), pick up off bottom and maintain circulation.

b. Supervisory personnel will make the maximum effort to determine the source of the H_2S and to suppress the H_2S as quickly as possible. **Drilling/coring operations must not proceed until the source of H_2S has been located and the atmospheric level has fallen to a level below 10 PPM. Note: depending upon the source of the H_2S, the hole may be terminated as determined by the ODP and ODL Drilling Superintendents. The hole could also be terminated for high H_2S concentrations in the core lab as well as on the rig floor.**

If concentrations of H_2S in the cores produce Emergency Conditions I, II, or III in the core lab, it is potentially a more dangerous situation than on the rig floor due to the confined space and reduced ventilation.

Logging/Downhole Measurements

a. Upon notification by the bridge of a Condition I emergency occurrence on the rig floor, core receiving platform, or core lab, the Driller will make the string back up (if open), pick up off bottom and maintain circulation. If a wireline is deployed, the winch will be stopped and the packoff will be tightened to permit increased circulation if necessary.

b. The on-duty Safety Technicians will confirm that all H_2S monitoring devices are functioning properly, reading accurately, and will increase gas monitoring activities with portable detection units.

c. Supervisory personnel will make the maximum effort to determine the source of the H_2S and to suppress the H_2S as quickly as possible. **Downhole measurements must not proceed until the source of H_2S has been located and the atmospheric level has fallen to a level below 10 PPM. Note: depending upon the source of the H_2S, the hole may be terminated as determined by the ODP and ODL Drilling Superintendents. The hole could also be terminated for high H_2S concentrations in the core lab as well as on the rig floor.**

If concentrations of H_2S in the cores produce Emergency Conditions I, II, or III in the core lab, it is potentially a more dangerous situation than on the rig floor due to the confined space and reduced ventilation.

No downhole work will be initiated if an Emergency Condition I, II, or III exists on the rig floor, core-receiving platform, or core lab. The Emergency Condition must be brought under control before drill-string or wireline operations proceed.

d. The ODP Operations Superintendent will notify the appropriate personnel on shore as soon as possible of the situation and the actions taken (see Appendix F).

Core Handling

All operations on the rig floor, core-receiving platform, and core lab will be suspended while Emergency Condition I exists.

2. PRECAUTIONARY PROCEDURES FOR PERSONNEL SAFETY

If, at any time, as much as 10 PPM of H_2S is detected by a **fixed** H_2S sensor, the following steps are to be taken:

Drilling/Coring

a. The person detecting the H_2S must immediately notify the Captain or Mate on watch as to the area (rig floor, core receiving platform, core lab, etc.) where the gas was detected. **The Captain or Mate then will decide on the appropriate course of action and if a Condition I emergency status is warranted.** The bridge then will notify the Driller, ODP Operations Superintendent and ODL Drilling Superintendent of the action required.

The following personnel will immediately put on

their air breathing equipment:

(1) All personnel assigned to emergency duties in the area(s) where the Condition I emergency exists (rig floor, core receiving platform, core lab and reefer).

(2) All personnel that are required (for emergency or other vital reasons) to work below and downwind of the source of H_2S.

The H_2S Safety Technician(s) on duty will bring portable H_2S detectors to the area where the H_2S was detected to find the source.

b. The Captain will alert all personnel that a Condition I exists. All personnel not assigned to emergency duties must get their life jacket/survival suits and report to the upwind safe-briefing area for further instructions. The Captain will be prepared to shut down ventilation systems and to close all hatches downwind and below the source of H_2S.

c. The ODL Drilling Superintendent will ensure that all nonessential personnel are out of the potential danger area (rig floor, core receiving platform, and core lab areas). All persons who remain in the potential danger area must utilize the "buddy system" (see Appendix A).

d. The Captain or Mate will ask all personnel to check their safety equipment to confirm that it is working properly and stored in the proper location.

e. Depending upon the location of the Condition I emergency, the fans on the rig floor or in the core lab should be turned on if not already in operation. **Note: If the exhaust fans in the lab stack are turned on to exhaust H_2S, the Driller should be notified because the exhaust fans discharge air above the rig floor.**

Logging/Downhole Measurements

a. The person detecting the H_2S must immediately notify the Captain or Mate on watch as to the area (rig floor, core receiving platform, core lab, etc.) where the gas was detected. **The Captain or Mate then will decide on the appropriate course of action and whether a Condition I emergency status is warranted.** The bridge then will notify the Driller, ODP Operations Superintendent and ODL

Drilling Superintendent of the action required.

The following personnel will immediately put on their air breathing equipment:

(1) All personnel assigned to emergency duties in the area(s) where the Condition I emergency exists (rig floor, core receiving platform, core lab and reefer).

(2) All personnel that are required (for emergency or other vital reasons) to work below and downwind of the source of H_2S.

The H_2S Safety Technician(s) on duty will bring portable H_2S detectors to the area where the H_2S was detected to find the source.

b. The Captain will alert all personnel that a Condition I exists. All personnel not assigned to emergency duties must get their life jackets/survival suits and report to the upwind safe-briefing area for further instructions. The Captain will be prepared to shut down ventilation systems and to close all hatches downwind and below the source of H_2S.

c. The ODL Drilling Superintendent will ensure that all nonessential personnel are out of the potential danger area (rig floor, core receiving platform, and core lab areas). All persons who remain in the potential danger area must utilize the "buddy system" (see Appendix A).

d. The Captain or Mate will ask all personnel to check their safety equipment to confirm that it is working properly and stored in the proper location.

e. Depending upon the location of the Condition I emergency, the fans on the rig floor or in the core lab should be turned on if not already in operation. **Note: If the exhaust fans in the lab stack are turned on to exhaust H_2S, the Driller should be notified because the exhaust fans discharge air above the rig floor.**

Core Handling

Core handling or processing will not be carried out while an Emergency Condition I exists because all personnel not assigned to emergency duties will be assembled in a safe-briefing area.

D. EMERGENCY CONDITION II - MODERATE DANGER TO LIFE - H_2S PRESENT IN ATMOSPHERE AT 20-49 PPM

EMERGENCY CONDITION III - EXTREME DANGER TO LIFE - H_2S PRESENT IN ATMOSPHERE AT 50 PPM OR MORE

1. SPECIAL OPERATING PROCEDURES

Drilling/Coring or Logging/Downhole Measurements

If the H_2S concentration reaches 20 PPM at a **fixed** sensor, Emergency Condition II is indicated and the following steps will be taken:

a. The person detecting the H_2S must immediately notify the Captain/Mate on watch of the area (rig floor, core receiving platform, core lab, etc.) where the gas was detected. **The Captain or Mate will then decide on the appropriate course of action and whether a Condition II or III emergency status is warranted.** The bridge will then notify the Driller, ODP Superintendent and ODL Drilling Superintendent of the action required as directed by the Captain or Mate.

   The following personnel will immediately put on their air breathing equipment:

   (1) All personnel assigned to emergency duties in the area where the Condition II or III emergency exists (rig floor, core receiving platform, core lab, and reefer).

   (2) All personnel required (for emergency or other vital reasons) to work below and downwind of the source of H_2S.

   The H_2S Safety Technician on duty will bring portable H_2S detectors to the area where the H_2S was detected to ascertain the source.

b. Upon notification by the Captain or Mate of Condition II or III emergency, the driller will make the string back up (if open), pick up off bottom and maintain circulation.

c. The Captain or Mate on duty will notify any nearby vessels to go upwind and will maintain a radio and visual watch.

d. Supervising personnel will make a maximum effort to determine the source of the H_2S and to suppress the atmospheric level of the H_2S as quickly as possible. **Drilling/coring operations will not proceed until the**

source of H_2S has been located and the atmospheric level has fallen below 10 PPM. Note: depending upon the source of the H_2S, the hole may be terminated as determined by the ODL Drilling Superintendent. The hole may be terminated for high H_2S concentrations in the core lab as well as on the rig floor.

If concentrations of H_2S in the cores produce Emergency Conditions I, II, or III in the core lab, it is potentially a more dangerous situation than on the rig floor due to the confined space and reduced ventilation (see Appendix B - H_2S Core Handling Procedures).

e. The on-duty Safety Technicians will confirm that all H_2S monitoring devices are functioning properly and reading accurately. They will increase gas monitoring activities with portable detection units.

f. The ODP Operations Superintendent will notify appropriate personnel on shore as soon as possible of the situation and actions taken (see Appendix F).

The ODL Drilling Superintendent, in consultation with the ODP Superintendent, will assess the situation and assign duties to each person to bring the situation under control. When the severity of the situation has been determined, all persons on the vessel will be advised. **As stated above, depending upon the location of the H_2S Condition II or III emergency, the ODL Drilling Superintendent may elect to terminate drilling and coring operations immediately.**

Core Handling

All operations on the rig floor, core-receiving platform, and core lab will be suspended while an Emergency Condition II or III exists.

2. PRECAUTIONARY PROCEDURES FOR PERSONNEL SAFETY

If, at any time, as much as 20 PPM of H_2S is detected by a **fixed** H_2S sensor, the following steps are to be taken:

Drilling/Coring or Logging/Downhole Measurements

a. The Captain will alert all personnel that a Condition II or III exists. All personnel not assigned to emergency duties must get their life jacket/survival suits and report to the upwind safe-briefing area for further instructions. The Captain will have one member of the ship's crew prepared to shut off ventilation systems and close all hatches downwind of the H_2S source.

b. Always put on a portable air breathing unit before proceeding to assist anyone affected by the gas and utilize the "Buddy System" (see Appendix A). If the affected person is stricken in a high- concentration area, put on a safety belt with 50' of tail line and obtain stand-by assistance before entering the area. Always use the "buddy system" when entering possible contaminated areas.

c. The ODL Drilling Superintendent will make sure that all nonessential personnel are out of the potential danger area (rig floor, core receiving platform, and core lab areas). All persons who remain in the potential danger area must utilize the "buddy system".

d. The ODP Operations Superintendent will ask all personnel to check their safety equipment to confirm that it is working properly and stored in the proper location.

If the concentration of H_2S present results in injury to personnel, the designated shorebased medical facility will be contacted. If it is deemed necessary by the ship's doctor to evacuate the person(s), arrangements will be made with the designated helicopter service (see Appendix F). The Captain or Mate on duty will notify air and water craft in the immediate vicinity of the drilling location.

Core Handling

Core handling or processing will not be carried out while an Emergency Condition II or III exists because all personnel not assigned to emergency duties will be assembled in a safe-briefing area.

VI. UNANTICIPATED H_2S OCCURRENCES

The procedures and precautions outlined in the earlier sections of this document pertain to special situations in which the occurrence of H_2S in quantity is considered likely due to the geological setting or previous experience in the area. For several reasons, it is not feasible or desirable to have all those measures in place for routine operations. Nevertheless, it is possible to encounter H_2S (especially in low concentrations) in a variety of environments. Leg 146 demonstrated that higher concentrations also can occur in unexpected settings. **Special caution should be exercised in areas where gas hydrates are anticipated.**

Safe operations can be conducted with properly trained personnel and relatively little equipment so long as H_2S concentrations remain low. A few cores can be recovered and handled safely with higher concentrations, but sustained operations normally would be precluded. **In no case would downhole operations be continued under a condition higher than the equivalent of "H_2S Alert" without full preparations as outlined in Sections I through V.**

A. SAFETY EQUIPMENT

Bulky high-maintenance equipment such as the cascade air system, extra SCBA's, etc. are not carried on board the vessel for standard operations. Some fixed H_2S monitors are carried on board but they normally are not kept installed in working areas or complete with central panel and network components.

The following equipment is to be stored on board the vessel at all times and readily available in the event H_2S is encountered in coring or other downhole operations:

1. H_2S detectors; minimum of four personal electronic monitors and two fixed-type detectors

2. Wind direction indicators

3. H_2S warning signs and signs directing to and designating safe areas

4. Self-contained breathing apparatus (minimum of four units)

5. Ventilation fans for lab and core receiving platform

B. OPERATING PROCEDURES

No special procedures are required in operating areas where hazardous levels of H_2S are not anticipated. Supervisors are responsible to ensure that personnel working with cores and on the drill floor are properly trained. Safety equipment must be maintained in good working order and stored in readily-accessible locations.

C. PROCEDURES UPON THE DETECTION OF H_2S

The most sensitive H_2S detector known is the nose. Thus the first indication of hydrogen sulfide in cores or in the drill string under any conditions probably will be the detection of the characteristic "rotten egg" odor. Normally the odor results from only a small amount of dissolved H_2S in the pore water and "H_2S Alert" procedures are not warranted. The experience of Leg 146 is a reminder that the odor is not to be taken for granted or ignored.

Drilling/Coring or Logging/Downhole Measurements

If the characteristic odor of H_2S is reported at any location on the vessel during downhole operations, the following measures will be taken:

1. Drilling/coring or wireline operations will be suspended until the source of the odor is identified*.

2. A hand-held electronic monitor will be used to "sniff" the H_2S concentration at the drill string, the inner core barrel, or (if processing has begun) the core liner.

3. If no concentration over 10 ppm is detected, operations may continue without declaration of an alert but monitoring should continue as long as the odor persists. If the ODP and ODL Superintendents consider it warranted, operating procedures may be modified to those of "Normal Operations" as described in Section V-A.

4. If a concentration greater than 10 ppm is measured, the Bridge is to be notified immediately and a "H_2S Alert" condition is to be declared. (The Bridge should be notified of the results of the measurements even if concentrations are below the danger level because other personnel probably will report the odor.)

5. Before operations resume, fixed monitors are to be installed and calibrated and all other aspects of the H_2S Alert condition are to be in place (SCBA's, signs, wind

detectors, etc.) A minimum of two operational fixed detectors is required--one on the drill floor and one on the core receiving platform.

6. Operations will continue under H_2S Alert guidelines (see Section **V-B**), but only to the extent permitted by the availability of SCBA's, air bottles, and trained personnel. The limits will be set by the ODP and ODL Superintendents and the Captain in consultation with the Lab Officer and Co-Chief Scientists.

7. If any reading greater than 10 ppm is registered by **any fixed detector**, an Emergency Condition I is indicated and operations will be halted at that site.

*Note that H_2S odor or similar odors may originate from sources other than cores or the drill string. Those include sanitary tanks, drains, tank vents, or open tanks or void spaces.

Core Handling

All core handling operating procedures and precautionary procedures for personnel safety under "H_2S Alert" will be the same as those described in Section **V-B-1 & 2.**

VII. RESPONSIBILITIES AND DUTIES

As stated in Special Provision No. 17 (pg. II-13) of the ODL/TAMRF Subcontract, it is ODL'S "sole and exclusive duty at all times" to determine whether operations can be continued or undertaken, thus the responsibilities outlined below are not intended to circumvent the contract terms but are merely to assist in or prevent an emergency situation. In any event, all final decisions will be ODL'S.

A. ALL PERSONNEL

1. It is the responsibility of **all personnel** working in the designated hazardous areas (rig floor, core walk, core lab and reefer) to familiarize themselves with the procedures outlined in this Contingency Plan.

2. Each individual is responsible for his/her assigned safety equipment and is to see that it is properly stored and easily accessible.

3. Each person assigned to emergency duties in the designated hazardous areas must be familiar with the location of all safety equipment aboard the vessel and be able to use all safety equipment upon notice.

4. All personnel working in the hazardous areas must read and understand the information in the article titled *"GENERAL SAFETY CONSIDERATIONS FOR OPERATING IN AREAS WHERE HYDROGEN SULFIDE MAY BE PRESENT"* contained in Appendix A.

5. Any person detecting H_2S must notify the Captain or Mate as to the area (rig floor, core receiving platform, core lab, etc.) where the gas was detected. The Captain or Mate will notify the Driller, ODP Superintendent, or ODL Drilling Superintendent.

B. ODP OPERATIONS SUPERINTENDENT

1. The ODP Operations Superintendent will be trained and will assist the ODL Drilling Superintendent in enforcing the *"REVISED HYDROGEN SULFIDE DRILLING CONTINGENCY PLAN."*

2. The ODP Operations Superintendent will assist the ODL Drilling Superintendent in seeing that all safety and emergency procedures outlined in the contingency plan are observed by the personnel aboard the drillship.

3. The ODP Operations Superintendent will assist the ODL Drilling Superintendent in seeing that all personnel are trained as specified under Section III, *"STANDARD*

OPERATING PROCEDURES".

4. The ODP Operations Superintendent will ensure that the ODP H_2S Technicians are maintaining all ODP H_2S and high-temperature safety equipment (H_2S detectors, breathing equipment, drill-string safety valve, etc.) on the rig in good operational condition.

C. ODL DRILLING SUPERINTENDENT

1. It is the responsibility of the ODL Drilling Superintendent to thoroughly understand and, along with the assistance of the ODP Operations Superintendent, to see that all safety and emergency procedures outlined in this *"REVISED HYDROGEN SULFIDE DRILLING CONTINGENCY PLAN"* are observed by all personnel aboard the drillship.

2. The ODL Drilling Superintendent shares the responsibility with the assistance of the ODP Operations Superintendent to ensure that all personnel aboard the ship have been trained as specified under Section III, *"STANDARD OPERATING PROCEDURES."*

3. The ODL Drilling Superintendent, with the assistance of the ODP Superintendent, is responsible for seeing that all H_2S and High-Temperature Safety Equipment (H_2S detectors, breathing equipment, drill string safety valve, etc.) on the rig are maintained in good operational condition.

4. The ODL Drilling Superintendent or ODL Rig Superintendent will notify the Captain or Mate on duty of all H_2S emergencies.

D. ODL CAPTAIN

1. When H_2S is encountered, the Captain or Mate on duty is solely responsible for determining what action is required and, as necessary, sounding the general alarm to notify personnel to report to the designated safe-briefing area.

2. The Captain or Mate on duty is solely responsible for designating the safe-briefing area. That area will change depending upon the wind direction. Another safe-assembly area may be designated if the originally-designated briefing areas (2 ea) are found to be unsafe for some reason.

3. The Captain or Mate on duty is responsible for keeping all personnel advised of the current safe-briefing area.

4. The Captain or Mate on duty is responsible for alerting all personnel during a Condition I, II, or III alert.

5. The Captain or Mate on duty is responsible for notifying vessels and aircraft in the area of H_2S emergencies.

6. A ship's officer will always be present on the bridge once an "alert" condition has been reported.

E. ODL DRILLER

1. The driller and his crew must be completely familiar with the personnel safety measures they must implement during a "H_2S Alert" or Condition I, II, or III emergency as outlined under Section V, *"H_2S EMERGENCY PROCEDURES"*.

2. The driller and his crew must be completely familiar with special operating procedures to be carried out while coring and running downhole measurement/sampling and logging tools as outlined in Section V.

F. H_2S SAFETY TECHNICIANS

Designated members of the ODL Deck Department (Mates) and the ODP Lab Officers/Marine Laboratory Specialists will be assigned duties as H_2S Technicians.

1. The H_2S Safety Technicians are responsible for inspecting all continuous monitoring H_2S sensors.

2. The H_2S Technicians are responsible for the calibration of the H_2S monitors and alarm system (fixed and personal type).

3. The H_2S Technicians are responsible for inspecting and maintaining all air breathing equipment. A list showing all items of air breathing equipment and their locations will be checked weekly.

4. The H_2S Technicians are responsible for the familiarization of all personnel on the vessel with the *"REVISED HYDROGEN SULFIDE DRILLING CONTINGENCY PLAN"* as directed by the ODL and/or ODP Superintendents.

5. The H_2S Technicians are responsible for the familiarization of all new personnel arriving on the vessel with the *"REVISED HYDROGEN SULFIDE DRILLING CONTINGENCY PLAN"* and the current condition under which the vessel is operating.

6. The H_2S Technicians are responsible for assisting the ODL Drilling Superintendent and ODP Operations Superintendent

as needed during H_2S drills, H_2S Alerts, and Emergency Conditions I, II and III.

7. The H_2S Technicians will confirm that all personnel working in the designated hazardous areas have completed all required safety training courses.

8. The H_2S Technicians will confirm that the H_2S warning signs are posted in the locations as specified in Section II (C) *"H_2S WARNING SIGNS"*.

G. ODL PHYSICIAN

As is normal procedure, the Physician will confirm that each leg participant has completed the required physical. In addition to the standard requirements, personnel working in the hazardous areas must be examined to confirm that they do not have punctured ear drums. **Even if a person is wearing breathing equipment, H_2S can enter the body through a punctured ear drum.**

The Physician will be responsible for ensuring that the ship is stocked with any special medical supplies that may be needed for treating personnel exposed to H_2S. The Physician also will assist with training in resuscitation and H_2S first aid procedures.

VIII. PROCEDURE FOR INFORMING PERSONNEL OF THE H_2S CONTINGENCY PLAN

Prior to commencing operations, the H_2S Technicians will have confirmed that all personnel working in the designated hazardous areas (rig floor, core receiving platform, core lab and reefer) have read their copies of the *"REVISED HYDROGEN SULFIDE DRILLING CONTINGENCY PLAN"*. Each person will be required to sign a log that he/she has read and understands the plan. If, during the leg, additional personnel come onto the vessel, it is the H_2S Technicians' responsibility to ensure that the new personnel are given and have read their copies of the Contingency Plan.

IX. APPENDICES

APPENDIX A

GENERAL SAFETY CONSIDERATIONS FOR OPERATING IN AREAS WHERE HYDROGEN SULFIDE MAY BE PRESENT

This document is intended to familiarize personnel with conditions that can exist when drilling/coring operations are conducted in areas where H_2S gas may be present.

All personnel should become familiar with all safety equipment on the vessel, its use, and its location. The windsocks and wind streamers are provided to show which direction the wind is blowing so that the "safe-briefing area" can be defined easily. Personnel should become "wind-conscious" and observe the wind direction indicators. All persons aboard *Sedco/BP 471* will receive instructions on the use of safety equipment and on what to do during a H_2S emergency. The designated hazardous areas (rig floor, core-receiving platform, core lab and core reefer(s)) will be monitored by fixed continuous H_2S detectors. Portable personal monitors also will be placed in all designated hazardous areas.

The following conditions will be in effect during drilling and coring operations at sites where H_2S is anticipated to be encountered. **Once H_2S has been encountered in an area, the Captain or Mate will decide whether Condition I, II, or III is warranted.**

A. NORMAL OPERATIONS - PRESENCE OF H_2S NOT CONFIRMED OR H_2S PRESENT IN CORES OR DRILL STRING (LESS THAN 10 PPM)

1. WARNING SIGNS - Warning signs will be posted and maintained at all times in all designated hazardous areas as defined in Section II C of the *HYDROGEN SULFIDE--HIGH TEMPERATURE CONTINGENCY PLAN*.

2. ALARM - None

3. CHARACTERIZED BY - Drilling and coring operations being conducted at sites that may contain hydrogen sulfide. That condition will be in effect continuously at all sites unless it is necessary to go to H_2S Alert condition or Condition I, II or III.

4. GENERAL ACTION

   a. Be alert for a changing condition.

   b. Routinely monitor core barrels and drill string for H_2S with hand-held monitor.

c. Keep all safety equipment available and sensors functioning properly.

d. Perform all drills for familiarization and proficiency.

B. H_2S ALERT - H_2S PRESENT IN CORES OR DRILL STRING (10 PPM OR GREATER) OR IN ATMOSPHERE (LESS THAN 10 PPM)

1. WARNING SIGNS - Warning signs will be posted and maintained at all times in all designated hazardous areas as defined in Section II C of the *REVISED HYDROGEN SULFIDE CONTINGENCY PLAN*.

2. ALARM - P.A. announcement will be made that a H_2S Alert situation exists and that general actions for the alert condition are to be instituted.

3. CHARACTERIZED BY: - Drilling and coring operations continuing with small amounts of H_2S detectable in the drill string and/or in core samples. That condition will be in effect continuously from the time H_2S is first detected until it is no longer considered a hazard or it is necessary to go to Condition I, II, or III.

4. GENERAL ACTION

   a. Be alert for a changing condition.

   b. Routinely monitor core barrels and drill string for H_2S with hand-held monitors.

   c. Check all safety equipment for proper location and functioning. Keep it available.

   d. Follow the instructions of the Supervisor(s).

   e. Personnel monitoring cores and drill string on the rig floor and personnel working on the core receiving platform will wear self-contained breathing equipment.

C. CONDITION I - POTENTIAL DANGER TO LIFE - H_2S PRESENT IN ATMOSPHERE AT 10-19 PPM

1. WARNING SIGNS - Warning signs will be posted and maintained at all times in all designated hazardous areas as defined in Section II C of the *REVISED HYDROGEN SULFIDE CONTINGENCY PLAN*.

2. ALARM - In the hazardous area (rig floor/core receiving platform, core lab and reefer(s)) where H_2S is detected at a fixed sensor in concentrations of 10 ppm or greater, a flashing strobe light will come on. In designated areas (rig floor, core lab, and reefer(s)) a siren will also sound. The alarms (flashing light and siren) will be local only for the area where H_2S is detected. At the same time, an alarm will be triggered on the central alarm panel. The alarm signal will continue as long as the H_2S concentration is 10 ppm or greater in the area or until deactivated by the H_2S Technicians, ODP Operations Superintendent, or ODL Drilling Superintendent.

3. CHARACTERIZED BY: - Drilling and coring operations halted until the source of H_2S is located and suppressed. That condition will be in effect continuously from the time the H_2S concentration reaches 10 ppm unless it is necessary to go to Condition II or III.

4. GENERAL ACTION

   a. Follow the procedures outlined under Section V, *H_2S EMERGENCY PROCEDURES*. All personnel not assigned to emergency duty will report to the **safe-briefing area.** Notification of appropriate personnel on shore will be made.

   b. There will be **no smoking** outside of living quarters. Welding or open fires are not allowed in the hazardous areas at any time without hot work permits.

   c. Check all safety equipment for proper location and functioning. Keep it available.

   d. Follow the instructions of the Supervisor(s).

   e. All personnel working in the hazardous area will wear self-contained breathing equipment. All personnel will restrict their movements as directed by the ODL Drilling Superintendent and the ODP Operation Superintendent.

D. CONDITION II - MODERATE DANGER TO LIFE - H_2S PRESENT IN ATMOSPHERE AT 20-49 PPM

1. WARNING SIGNS - Warning signs will be posted and maintained at all times in all designated hazardous areas as defined in Section II C of the *REVISED HYDROGEN*

SULFIDE CONTINGENCY PLAN.

2. ALARM - In the hazardous area (rig floor/core-receiving platform, core lab and reefer(s)) where H_2S is detected at a fixed sensor in concentrations of 10 ppm or greater a red flashing light will appear. In designated areas (rig floor, core lab, and reefer(s)) a siren will also sound. The alarms (flashing light and siren) will be local for only the area where H_2S is detected. At the same time an alarm will be triggered on the central alarm panel. The alarm signal will continue until as long as the H_2S concentration present is 10 ppm or greater in the area or until deactivated by the H_2S Technicians, ODP Operations Superintendent, or ODL Drilling Superintendent.

3. CHARACTERIZED BY: - Drilling and coring operations halted until the source of H_2S has been located and the atmospheric level of H_2S has been suppressed. This condition will be in effect continuously from the time the H_2S reaches 20 ppm until it falls below that level or it is necessary to go to Condition III.

4. GENERAL ACTION

   a. Follow the procedures outlined under Section V, "*H_2S EMERGENCY PROCEDURES*". All personnel not assigned to emergency duty will report to the **safe-briefing area.** Notification of appropriate personnel on shore will be made.

   b. There will be **no smoking** outside of living quarters. Welding or open fires are not allowed in the hazardous areas at any time without hot work permits.

   c. Check all safety equipment for proper location and functioning. Keep it available.

   d. Follow the instructions of the Supervisor(s).

   e. All personnel working in the hazardous area will wear self-contained breathing equipment. All personnel will restrict movements as directed by the ODL and ODP Superintendents.

E. CONDITION III - EXTREME DANGER TO LIFE - H_2S PRESENT IN ATMOSPHERE AT 50 PPM OR GREATER

1. WARNING SIGN - Follow the procedures outlined under Section V, *H_2S EMERGENCY PROCEDURES*. All personnel not

assigned to emergency duty will report to the safe-briefing area.

2. ALARM - In the hazardous area (rig floor/core-receiving platform, core lab and reefer(s)) where H_2S is detected in concentrations of 10 ppm or greater, a red flashing light will appear. In designated areas (rig floor, core lab, and reefer(s)), a siren also will sound. The alarms (flashing light and siren) will be local for only the area where H_2S is detected. At the same time an alarm will be triggered on the central alarm panel. The central panel alarm will continue until deactivated by personnel on the vessel's bridge.

3. CHARACTERIZED BY - Drilling and coring operations halted until the source of H_2S has been located and the atmospheric level of H_2S has been suppressed. This condition will be in effect continuously from the time the H_2S reaches 50 ppm or greater until it falls below that level.

4. GENERAL ACTION

   a. Follow the procedures outlined under Section V, *"H_2S EMERGENCY PROCEDURES"*. All personnel not assigned emergency duties will report to the **safe-briefing area**. Radio communications will be used to alert known air and water craft in the immediate vicinity. Notification of appropriate personnel on shore will be made.

   b. All personnel not specifically assigned to correct or control the emergency will stay in the **safe-briefing area** until the situation is brought under control. If the situation becomes life-threatening to personnel in the safe-briefing areas, at the ODL Captain's discretion, non-essential personnel are to be evacuated from the ship in the lifeboats as necessary. A suggested list of essential personnel to be left on board will be prepared by ODL.

   c. There will be **no smoking** outside of living quarters. Welding or open fires are not allowed in the hazardous areas at any time without hot work permits.

   d. Check all safety equipment for proper location and functioning. Keep it available.

   e. Follow the instructions of the Supervisor(s).

f. All personnel working in the hazardous area will wear self-contained breathing equipment. All personnel will restrict movements as directed by the ODL Drilling Superintendent and ODP Operations Superintendent.

F. GENERAL INFORMATION ON H_2S SAFETY

1. During an emergency, persons should utilize the "buddy system" to prevent anyone from entering an H_2S area alone. If you are wearing a mask, do not remove it until you are absolutely certain the air is safe to breathe. A personal H_2S monitor can be used to check the area. If a sudden gas release occurs without warning, you should:

   a. Hold your breath and rapidly evacuate the area containing the H_2S. Move up-wind if possible. Climb up the derrick, move up a deck, or climb atop the lab stack.

   b. Put on air breathing equipment.

   c. Help anyone who may be affected by the gas. **NOTE: Put on your air breathing equipment before helping anyone overcome by H_2S.** Then get him/her to a safe area and administer resuscitation or oxygen as needed.

   d. Evacuate quickly to the **safe-briefing area** to receive instructions from supervisory personnel.

   e. Do not panic.

2. All personnel, including the Captain and Mates, working in the designated hazardous areas will become familiar with the *REVISED HYDROGEN SULFIDE CONTINGENCY PLAN*. Particular attention should be paid to the following topics:

   a. H_2S emergency procedures
   b. Responsibilities and duties
   c. Safety equipment list and location

3. Personnel wearing eyeglasses and contact lenses must take special precautions when wearing air breathing equipment. The ear pieces on the eyeglasses will interfere with the seal on the face mask of both the self-contained breathing apparatus and the cascade breathing system. Lens holders will be available for mounting eyeglasses inside the face masks with the ear pieces removed.

   Injuries have been sustained by personnel wearing contact lenses using air breathing equipment. The positive

pressure in the face mask can push the lens up inside the cavity of the eye. The flow of dry air also dries the eye out behind the lens. Therefore, contact lenses should not be worn with the breathing equipment face masks. Instead, a pair of conventional glasses should be worn inside the face mask using the lens holder as described above.

The tables in Appendix C list various poisonous gases and the concentrations at which they become dangerous.

G. MEDEVAC

If the operating area is within helicopter range of medical facilities, arrangements will be made for helicopter evacuation on short notice. Communications with the helicopter dispatcher will be tested after the drillship arrives on site. Applicable call signs, frequencies, and/or phone numbers will be posted in the ship's radio room. For areas outside helicopter range, standard operating policy regarding medical emergencies will be followed.

APPENDIX B

LABORATORY PROCEDURES FOR CORES CONTAINING H_2S

Gas Shows

As soon as the core is laid out on the receiving platform, it must be inspected for gas shows (ie. foamy sediment, bubbles and expansion voids). If gas is evident:

1) During an H_2S alert*, the core lab H_2S Safety Technician insures that:

   a) Non-essential personnel are not on the core receiving platform and remain indoors until the "all clear" is given.

   b) Core handlers are using personal air breathing apparatus.

2) Take gas samples (vacutainer) for lab analysis. (Be sure that all samples needed for scientific purposes are collected before the liner is vented.)

3) Perforate the core liner as necessary to relieve accumulated free gases.

4) Measure H_2S levels of escaping gas with a portable air monitor. If portable personal monitors detect H_2S levels of 10 ppm or greater:

   a) Immediately notify the Mate on watch of the situation.

   b) Check fixed air monitors. If H_2S levels are greater than 10 ppm, notify the Mate on watch, then relocate the core to a "safe area" for degassing. (See definition of a safe area at the end of this appendix.)

The core lab H_2S Safety Technician will give the "all clear" when both of the following conditions exist:

1) There are no gas shows **or** all accumulated free gases inside the liner have vented.

2) Portable monitors indicate H_2S levels less than 10 ppm.

*The H_2S Safety Technician may elect to institute these precautions when an H_2S Alert has not been declared, *e.g.* when the occurrence of H_2S is anticipated or when there is a strong H_2S odor.

H_2S/LAB Test:

The H_2S/LAB test will determine the amount of H_2S in the core.

1) The chem lab specialists will have calibrated the gas chromatographs/ChemStation ahead of time with H_2S gas standards of different concentrations. A sample from the vacutainer should immediately be injected on the gas chromatograph to determine the concentration of the H_2S gas.

2) An H_2S analysis can be performed on the Interstitial Water sample (IW). The IW is taken immediately after accumulated free gases inside the liner have been vented. Pore waters are squeezed from the sediment in the chem lab and the concentration of H_2S is determined by standard laboratory methods.

The H_2S Safety Technician and shipboard geochemists will decide where and how many samples to take. If gas shows are not present, samples can be taken without special precautions. Otherwise, the precautions used for gas shows must be continued until accumulated free gases in the liner have vented and both portable and fixed monitors indicate H_2S levels less than 10 ppm.

The H_2S/LAB test results are compared to two threshold levels for H_2S in the interstitial waters. Those levels are designated as the Lab Threshold (LT) and Storage Threshold (ST). The determination of the LT and ST values are discussed in this appendix.

Cores that have H_2S levels above the LT:

1) **<u>Cannot</u> be taken inside the lab spaces.**

2) **Are to have H_2S warning stickers affixed to liners.**

3) **Must be degassed until their H_2S levels are below the LT.**

4) **Must be repeat-tested until H_2S levels are below the LT.**

Most core degassing can be accomplished by perforating the core liner. Cores with very high levels of H_2S can be split in half to expose more surface area. A portable core splitter will be provided to split cores outside the core lab. Cores that have H_2S levels above the ST and below the LT are to have H_2S warning stickers affixed to liners. Cores with H_2S levels below the ST can be processed and stored as usual.

Inside the Core Lab

There are no specific H_2S tests performed inside the core lab. Harmful cores are identified by the H_2S/LAB test and prevented from entering the lab. Personnel should remain alert, however, to the possible buildup of H_2S inside the core lab. It is important that the following tasks/precautions be performed:

1) Monitor H_2S levels near the core rack in the Core Entry Lab.

2) Monitor H_2S levels in the Core Splitting room whenever a core is split (especially those cores marked with H_2S warning stickers).

3) Make sure that cores with H_2S levels above the ST have H_2S warning stickers affixed to both archive and working half liners, D-tubes and core boxes.

4) Do not split a new core until the previous core is stored in its D-tube.

5) Ensure that the lab stack's air conditioning and exhaust systems are balanced and functioning properly.

6) In the event that the lab levels of H_2S detected at any sensor exceed 10 ppm: All personnel are to be evacuated and the H_2S Safety Technicians will remove all unsealed cores from the core lab. The fans will be used to vent the lab and personnel will not reenter the lab until H_2S levels are below 10 ppm.

Storage

As previously mentioned, cores with H_2S levels above the ST are stored outside the lab stack. Cores with H_2S levels below the ST can be stored in the ship's core storage area. All personnel that need to enter those spaces should be cautious and must always:

1) Check the fixed H_2S detector for hazardous H_2S levels.

2) Work with a partner. **Never enter alone!**

3) Carry a portable personal H_2S monitor on his/her person while inside the storage area.

CORE LAB H_2S SAFETY TECHNICIAN JOB DESCRIPTION

The core lab H_2S Safety Technician is a member of the H_2S Safety Squad (see Section VII). During an H_2S Alert condition, he/she must

be present on the core receiving platform as each core is recovered and will be responsible for the following tasks:

1) Enforcing H_2S safety policy on the core-receiving platform and in the core lab.

2) Ensuring that all H_2S testing is completed and conducted in a safe manner.

3) Recording the results of all tests for each core.

4) Ensuring that cores that contained H_2S have H_2S warning stickers affixed to their liners, D-tubes and core boxes, for both archive and working halves.

5) Ensuring that personnel handling hazardous cores are using their personal air breathing apparatus correctly.

6) Ensuring that safety equipment is in good condition and functioning properly.

7) Ensuring that monitoring equipment is calibrated and functioning properly.

8) Being responsible for notifying the ODL/ODP Superintendents when H_2S alarm conditions exist or when H_2S levels measured by the H_2S/LAB test are above the LT.

9) Testing the pH of each core for acidic fluids. If acidic fluids are found, ensure that core handling personnel are wearing protective clothing.

10) Posting warning signs and limiting access to hazardous areas.

DETERMINATION OF THE LAB & STORAGE THRESHOLD VALUES

Definitions

LAB THRESHOLD: The Lab Threshold (LT) is defined as the concentration of H_2S for a given amount of **split** core (both archive and working halves) that will produce a concentration of 10 ppm of H_2S in the air volume of the Core Splitting room after one hour of exposure.

STORAGE THRESHOLD: The Storage Threshold (ST) is defined as the LT for 950 cm of core recovery. (With 100% recovery, 950 cm is the length of core recovered in one core barrel.)

Equations:

Equation 1 is used to calculate the amount of H_2S produced by molecular diffusion for a given concentration, core surface area and time.

(1) $J(\mu g/cm^2\ sec) * A(cm^2) * T(sec) = M(\mu g)$

where: **J** is the mass flux per unit area with time

A is the area of the split core's surface

T is time of exposure

M is the mass of H_2S

The concentration of H_2S in the air volume is given by:

(2) $CL(\mu g/g) = M(\mu g)/[V(cm^3) * \rho air(g/cm^3)\ ]$

or

$M\ (\mu g) = CL(\mu g/g) * \rho air(g/cm^3) * V(cm^3)$

where: **CL** is the concentration of H_2S in the lab air space

ρair is the density of air

M is the mass of H_2S

V is the volume of air

Combine equations 1 and 2:

$J(\mu g/cm^2\ sec) * A(cm^2) * T(sec) = CL(\mu g/g) * \rho air(g/cm^3) * V(cm^3)$

Expand the mass flux term **J**:

The value J is determined by Fick's first law (Crank, 1975):

$J = D\ \partial CC/\partial X$

where: **D** is the diffusion constant

CC is the concentration of H_2S in the core. This value is determined by the H_2S/LAB test. Because the concentration of H_2S in the air is assumed zero, then $\partial CC = CC$

X is the diffusion path. We'll assume that all

gases released from the core are homogeneously mixed in the lab air space. Therefore the term $\partial X = X$

Substitute for the **J** term:

(3) $[D(cm^2/sec) * CC(\mu g/cm^3) / X(cm)] * A(cm^2) * T(sec) = CL(\mu g/g) * \rho air(g/cm^3) * V(cm^3)$

Determination of the LT and ST values:

To determine the LT and ST limits we must solve for **CC**. That is done by rearranging equation 3 as follows:

(4) $CC(\mu g/cm^3) = [CL(\mu g/g) * \rho air(g/cm^3) * V(cm^3) * X(cm)] / [D(cm^2/sec) A(cm^2) * T(sec)]$

Before solving equation 4, values for the above terms must be defined:

CL: 10 $\mu g/g$ the maximum level of H_2S allowed in the Core Splitting room by definition.

ρair: density of air 1.204 $x10^{-3}$ g/cm^3

V: volume of the air space above Core Splitting table: 250 cm x 100 cm x 100 cm = 2.5 x 10^6 cm^3

X: diffusion path from the center of the split core to its surface = 1.6 cm

D: diffusion constant = 10 x 10^{-6} cm^2/sec. H_2S in solution will be mainly in the species HS- which has an activity coefficient similar to the Cl- ion. The diffusion constant for Cl- in a typical fine grained marine sediments ranges from 10 to 20 * 10^{-6} cm^2/sec. The effects of tortuosity, temperature, chemical reaction and inter-ion effects are not considered.

A: area of the split core's surface for both archive and working halves = **R**(cm) * 6.6 cm, where **R** is the core recovery. Because there are two halves, that value is multiplied by **2**. Also because the surface is rough, term **A** must be multiplied by a roughness factor of 5 (estimate).

T: 1 hour of exposure = 3.6 x 10^3 sec (average time to process a core after splitting)

Substitute the values for equation 4:

(4) $CC(\mu g/cm^3)=[10\ \mu g/g * 1.204 \times 10^{-3}\ g/cm^3 * 2.5 \times 10^6\ cm^3 * 1.6\ cm]/[1.0 \times 10^{-5}\ cm^2/sec * [R\ (cm) * 6.6\ cm * 2 * 5] * 3.6 \times 10^3\ sec]$

Simplify the equation to produce the formula for the Lab threshold value as a function of core recovery. That function is graphed below.

(5) For LT: **CC**(μg/cm^3) = **2 x 10^4** (μg/cm^2)/ **R** (cm)

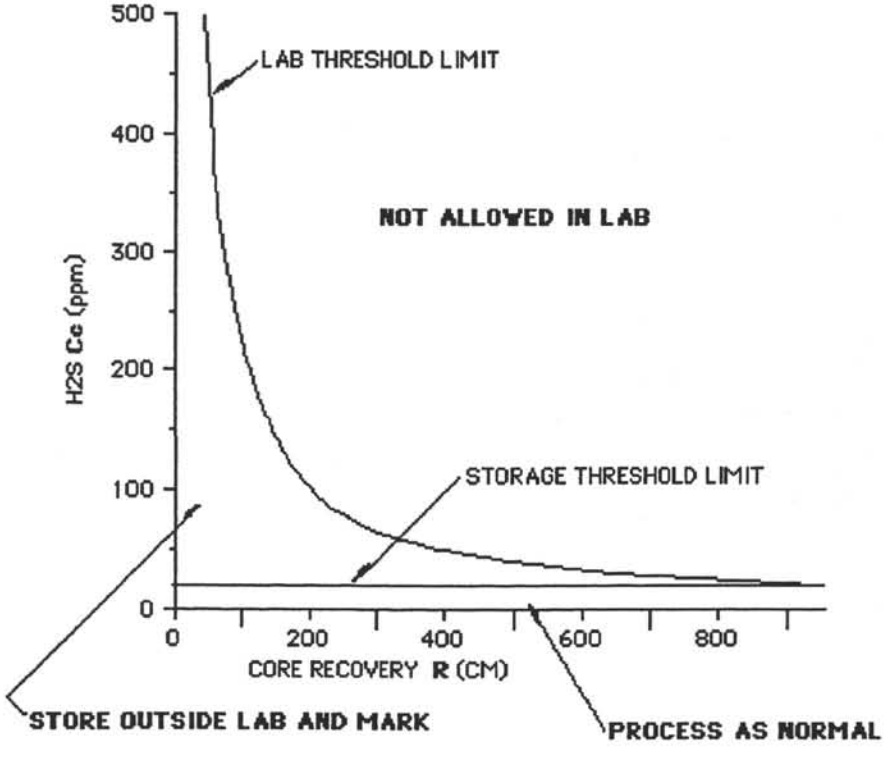
To determine the ST value set **R** to 950 cm and solve equation 5.

(5) **CC**(μg/cm^3) = **2 x 10^4** (μg/cm^2)/ **950** (cm)= 21.3 or **20 ppm** in the interstitial waters

Threshold Graph:

By plotting the ppm of H_2S vs. core recovery on the following graph, the H_2S hazard potential for each core can be determined.

Note: The graph is based on the assumptions of: roughness factor of 5; diffusion constant of 10^{-5}; exposure of 1 hour, and an LT of 10 ppm. The graph is for illustration purposes only!



A Word of Caution:

As you have probably noticed, the values used in the above equations for the diffusion constant, roughness factor, etc., are "guesstimates". As we gain more experience handling H_2S cores we revise these estimates. It is important that the core-lab safety procedures outlined in section 2.3 be followed to maintain a safe working environment inside the core lab.

SAFE AREA

The "safe area" is an exterior location on the ship where cores can degas without creating a downwind hazard for other personnel. Because weather will influence the location of that area, its selection will be made by the ship's personnel and approved by the ODL/ODP Superintendents. Any changes in ship's heading while cores are degassing must be approved by the ODL/ODP Superintendents. Also, any changes in the wind direction must be reported to the ODL/ODP Superintendents and corrective action taken immediately.

APPENDIX C

TOXICITY OF VARIOUS GASES

Common Name	Chemical Formula	Specific Gravity (Air=1)	Threshold[1] Limit	Hazardous[2] Limit	Lethal[3] Concentration
Hydrogen Cyanide	HCN	0.94	10 ppm	150 ppm/1 hr	300 ppm
Hydrogen Sulfide	H_2S	1.18	10 ppm	250 ppm/1 hr	600 ppm
Sulfur Dioxide	SO_2	2.21	2 ppm	---	1000 ppm
Chlorine	Cl_2	2.45	1 ppm	4 ppm/1 hr	1000 ppm
Carbon Monoxide	CO	0.97	50 ppm	400 ppm/1 hr	1000 ppm
Carbon Dioxide	CO_2	1.52	5000 ppm	5%	10%
Methane	CH_4	0.55	90000 ppm	Combustible Above 5% in air	---

[1]*Threshold* - concentration at which it is believed that all workers may repeatedly be exposed, day after day, without adverse effect.

[2]*Hazardous* - concentration that may cause death.

[3]*Lethal* - concentration that will cause death with short-term exposure.

PROPERTIES OF GASES

The produced gas will probably be a mixture of carbon dioxide, hydrogen sulfide, and methane.

A. *Carbon Dioxide*

1. Carbon dioxide (CO_2) is usually considered inert and is commonly used to extinguish fires. It is heavier than air (1.5 times) and CO_2 will concentrate in low areas of quiet air. Air containing 5% CO_2 will cause disorientation in a few minutes. Continued exposure to CO_2 after being affected will cause convulsions, coma, and respiratory failure.

2. The threshold limit of CO_2 is 5,000 ppm. Short-term exposure to 50,000 ppm (5%) is reasonable. This gas is colorless and odorless and can be tolerated in relatively high concentration.

B. *Hydrogen Sulfide*

1. Hydrogen sulfide itself is a colorless, transparent gas and is **flammable.** It is heavier than air and thus may accumulate in low places.

2. Although the slightest presence of H_2S in the air is normally detectable by its characteristic "rotten-egg" odor, it is dangerous to rely on odor as a means of detecting excessive concentrations because the sense of smell is lost rapidly, allowing lethal concentrations to accumulate without warning. The following table indicates the poisonous nature of hydrogen sulfide, which is more toxic than carbon monoxide.

CONCENTRATION			EFFECTS
$\%H_2S$	PPM	GR/100 SCF	
0.001	10	0.65	Obvious and unpleasant odor. Safe for 8 hours.
0.002	20	1.30	Safe for 4 hours exposure.
0.01	100	6.48	Kills smell in 3 to 15 minutes; may sting eyes and throat.
0.02	200	12.96	Kills smell shortly; stings eyes and throat.
0.05	500	32.96	Dizziness; breathing ceases in a few minutes; needs prompt artificial respiration.
0.07	700	45.36	Unconscious quickly; death will result if not rescued promptly.
0.1	1000	64.80	Unconscious at once; followed by death within minutes.

C. *Sulfur Dioxide*

1. Sulfur dioxide is a colorless, transparent gas and is non-flammable.

2. Sulfur dioxide (SO_2) is produced during the burning of H_2S. Although SO_2 is heavier than air, it will be picked up by a breeze and carried downwind at elevated temperatures. As sulfur dioxide is extremely irritating to the eyes and mucous membranes of the upper respiratory tract, it has exceptionally good warning powers in that respect. The following table indicates the toxic nature of the gas.

CONCENTRATION		**EFFECTS**
$\%SO_2$	PPM	
.0002	2	Safe for 8 hours.
.0005	3 to 5	Pungent odor - normally a person can detect SO_2 in this range.
.0012	12	Throat irritation, coughing, constriction of the chest, tearing and smarting or burning of eyes.
.015	150	So irritating that it can only be endured for a few minutes.
.05	500	Causes a sense of suffocation, even with first breath.

APPENDIX D

OTHER GAS HAZARDS

The information below has been distributed in memo form to shipboard participants to achieve compliance with the requirement of Section III. A. 4.

The following information is provided in keeping with the requirement of the ODP *"REVISED HYDROGEN SULFIDE DRILLING CONTINGENCY PLAN"* to notify all on-board personnel of potential hazards from CO_2, radon, and hydrocarbon gases. Though it is possible that any or all of those gases may be encountered, they pose much less of a hazard than does H_2S. In general, the measures we take to protect ourselves from H_2S also will be effective against the other gases.

Carbon dioxide (CO_2); CO_2 commonly is found dissolved in hydrothermal fluids and could be released from pore water when cores are recovered. The gas is toxic in higher concentrations, but much less so than H_2S (see Appendix C of the Contingency Plan). CO_2 is considerably heavier than either air or H_2S and will displace air from low places. If a massive flow of CO_2 from the wellbore should occur (highly unlikely), the principal danger would be from asphyxiation due to lack of air. Again, donning the breathing apparatus would provide adequate oxygen until the emergency could be controlled.

Hydrocarbon gases; Hydrocarbon compounds are known to be present in the sediments and probably in the hydrothermal fluids of our drill sites. Those are primarily in the form of methane gas, but some heavier gases and even liquids are expected because of the high-temperature environment. The quantities will be small, however, and the JOIDES Safety Panel has taken the unusual step of approving penetration even when liquids are encountered. The toxicity of methane is very low (see Appendix C), but it is often a "carrier" of H_2S. It is lighter than air so it does not tend to settle and is easily dispersed. The major threat from natural gas is its extreme flammability and explosivity. The blowout control measures specified by the Contingency plan are for the control of hydrocarbon gas as well as H_2S. Hydrocarbon liquids may be carcinogenic, so common sense should be used in handling them if they are encountered.

Radon; The barite precipitated in seafloor rocks and sediments by hydrothermal activity has been found to contain measurable amounts of radioactive radium 226, which is chemically similar to barite. The radium emits very small

amounts of radon 222 gas, which also is radioactive, through radioactive decay. Small amounts of radon may also be present in the pore water. ODP has investigated the potential effect of that radiation on health and safety on board the ship. The radiation is in the form of alpha particles, which have extremely limited ability to penetrate tissue. Thus the principal danger comes from inhaling or ingesting the radioactive material. Further, the levels of radioactivity are extremely low--on the nannocurie scale. Nevertheless, cores will be monitored for radioactivity if radioactive material is found to be present. In addition, the following precautions should be taken:

Use extra ventilation around cores (as with H_2S) before packing and when D-tubes are opened.

Use dust masks and adequate water spray when splitting cores.

Seal D-tubes to contain gas and/or ventilate storage areas.

Avoid eating and drinking in the immediate area of the cores.

Wash hands thoroughly after handling barite-rich cores or samples.

APPENDIX E

MUD CHEMICALS PROCEDURES FOR H_2S CONTAMINATION

The option of treating the circulating fluid with chemicals has been considered at some length. Because *Sedco/BP 471* is not equipped with a recirculating mud system, any treatment chemical would be circulated through the hole quickly and lost. Thus no chemical change in the borehole fluid could be sustained during drilling/coring operations while circulation is maintained. Continuous treatment of the seawater drilling fluid is not considered to be either necessary or practical. For special circumstances (stuck pipe, unusual logging or sampling operations, etc.) where there is an influx of H_2S-bearing fluid and the drill string must remain in the hole without circulation, there will be a provision for filling the hole with fluid containing chemical scavengers. Depending upon the situation, the fluid will be fresh-water-based bentonite mud, seawater-based sepiolite mud, or seawater. The fluid will be mixed with a concentration of 5 lb/bbl of ironite sponge and 5 lb/bbl hydrated lime for scavenging H_2S and CO_2, respectively.

APPENDIX F

EMERGENCY TELEPHONE CONTACT NUMBERS*

- The following personnel should be notified in the event of an H_2S Emergency Condition I, II, or III **or** in the event of uncontrollable backflow or steam flash:

R. M. Grout	ODP	Office:	(409) 845-2144
		Home:	(409) 693-6410
or			
M.A. Storms	ODP	Office:	(409) 845-2101
		Home:	(409) 696-8035
F.B. Williford	ODL	Office:	(409) 696-7955
		Home:	(214) 335-9530
or			
C. Nehring	ODL	Office:	(409) 696-7955
		Home:	(409) 693-1720

- In addition, it may be necessary to notify appropriate authorities of the coastal state in whose waters ODP is operating at the time. Necessary telephone numbers will be acquired before the leg begins. If the drilling leg is located close to shore, medical facilities and helicopter services will be identified prior to the leg. However, because of the global extent of ODP operations, such facilities are not available for most legs.

THE FOLLOWING CONTACTS WERE USED ON LEG 146 IN CANADIAN WATERS; THEY ARE OUT OF DATE AND ARE INCLUDED ONLY AS AN EXAMPLE.

I. **Emergency Condition I or II** (10-49 ppm in atmosphere)

National Energy Board	Office:	(613) 991-2017
F. Lepine	Home:	(613) 224-8302
	Fax:	(613) 993-9897
or		
G. Yungblut	Office:	(613) 993-3760
	Home:	(613) 722-9286
or		
P. Ragusa	Office:	(613) 991-2021
	Home:	(613) 830-9350

II. **Emergency Condition III** (50 ppm or greater in atmosphere)

Canadian Coast Guard — Via Radio: 2182 KHz
Victoria, B.C. - Search & Rescue — VH F16

Telephone: (604) 363-2333
(800) 742-1313

- The following hospital is the primary treatment center for any injuries:

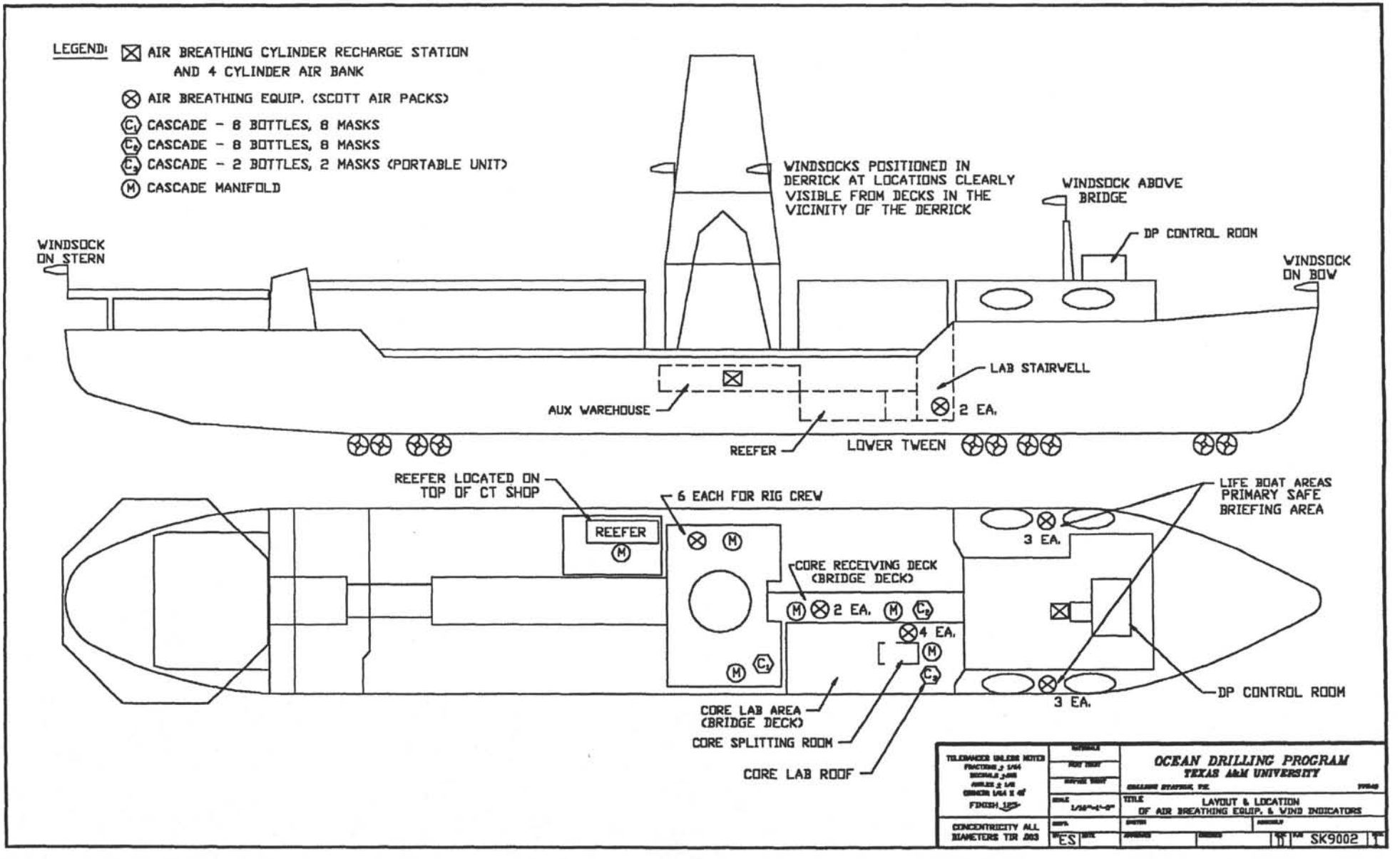
Victoria General Hospital
Victoria, B.C.
Telephone: (604) 727-4181
24 hrs/day

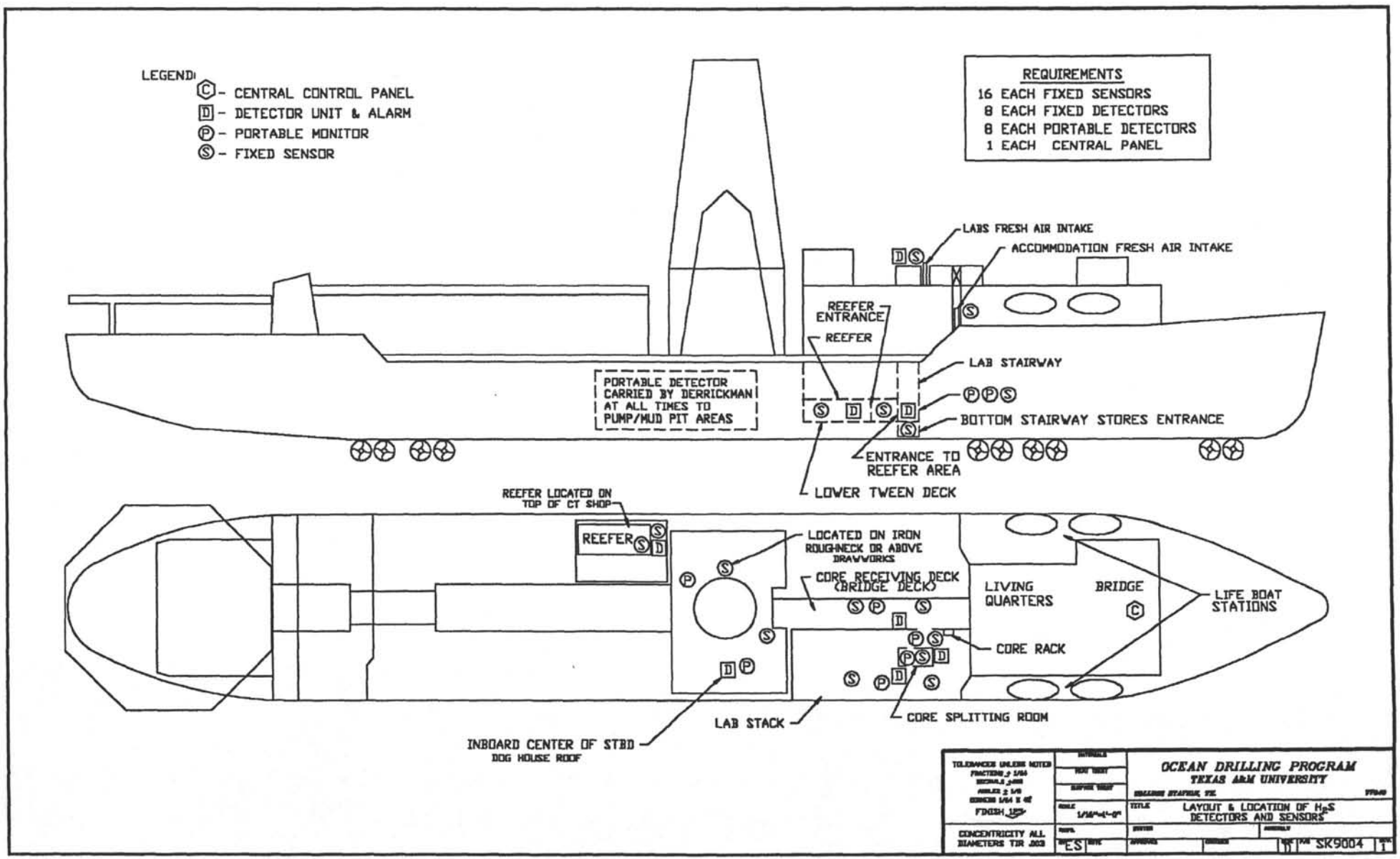
- The following helicopter service will be used for Medevac/emergency transport:

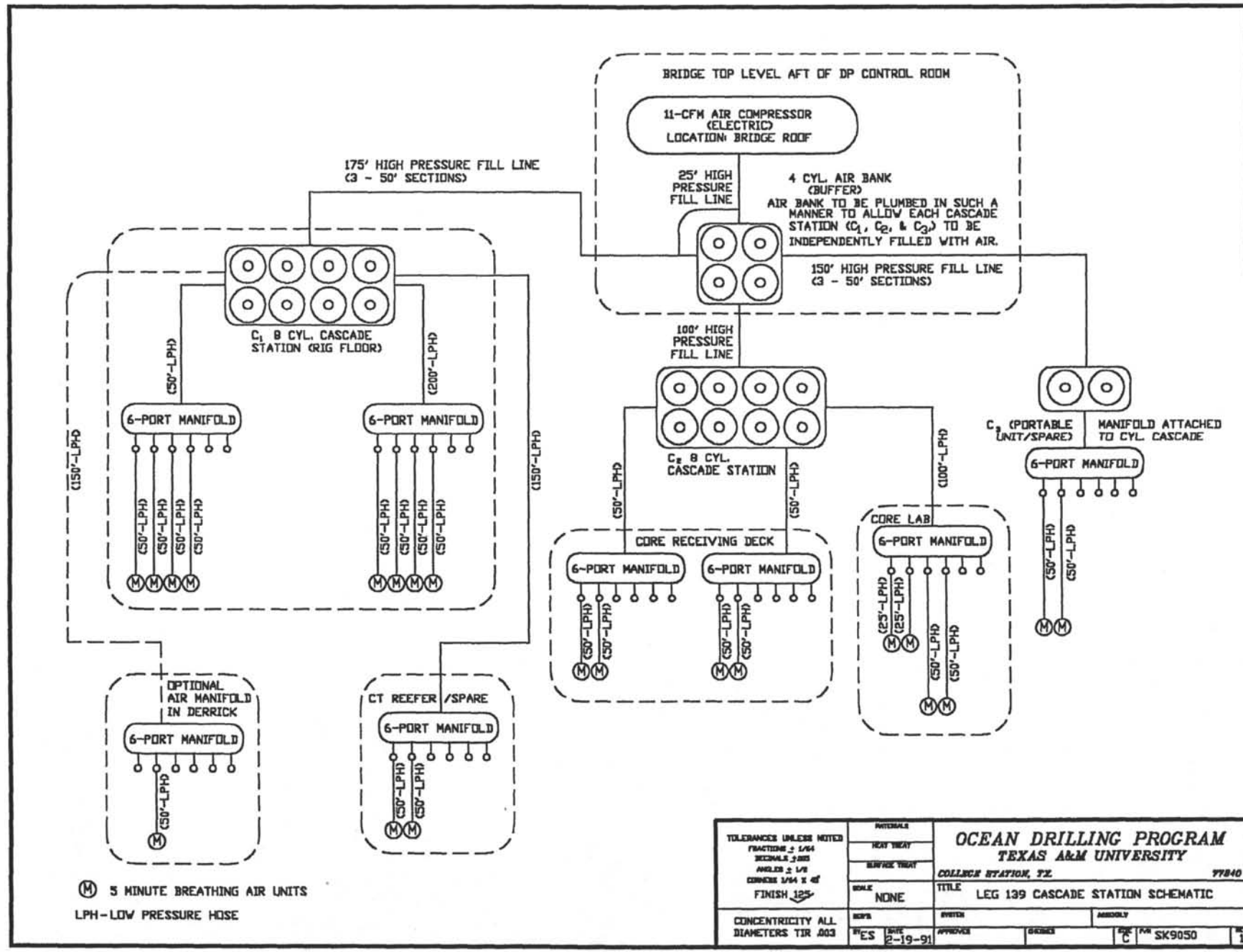
Pacific Rim Helicopter
Vancouver International Airport
ATTN: G. Kearney
Telephone: (604) 276-0015
24 hrs/day

APPENDIX G

DRAWINGS


LEGEND:
AIR BREATHING CYLINDER RECHARGE STATION AND 4 CYLINDER AIR BANK
AIR BREATHING EQUIP. (SCOTT AIR PACKS)
C1 CASCADE - 8 BOTTLES, 8 MASKS
C2 CASCADE - 8 BOTTLES, 8 MASKS
C3 CASCADE - 2 BOTTLES, 2 MASKS (PORTABLE UNIT)
M CASCADE MANIFOLD
WINDSOCKS POSITIONED IN DERRICK AT LOCATIONS CLEARLY VISIBLE FROM DECKS IN THE VICINITY OF THE DERRICK
WINDSOCK ABOVE BRIDGE
DP CONTROL ROOM
WINDSOCK ON STERN
WINDSOCK ON BOW
LAB STAIRWELL
AUX WAREHOUSE
2 EA.
REEFER
LOWER TWEEN
REEFER LOCATED ON TOP OF CT SHOP
6 EACH FOR RIG CREW
LIFE BOAT AREAS PRIMARY SAFE BRIEFING AREA
REEFER
CORE RECEIVING DECK (BRIDGE DECK)
3 EA.
2 EA.
4 EA.
3 EA.
DP CONTROL ROOM
CORE LAB AREA (BRIDGE DECK)
CORE SPLITTING ROOM
CORE LAB ROOF
OCEAN DRILLING PROGRAM
TEXAS A&M UNIVERSITY
COLLEGE STATION, TX.
TITLE
LAYOUT & LOCATION OF AIR BREATHING EQUIP. & WIND INDICATORS
SK9002


LEGEND:
C - CENTRAL CONTROL PANEL
D - DETECTOR UNIT & ALARM
P - PORTABLE MONITOR
S - FIXED SENSOR
REQUIREMENTS
16 EACH FIXED SENSORS
8 EACH FIXED DETECTORS
8 EACH PORTABLE DETECTORS
1 EACH CENTRAL PANEL
LABS FRESH AIR INTAKE
ACCOMMODATION FRESH AIR INTAKE
REEFER ENTRANCE
REEFER
LAB STAIRWAY
PORTABLE DETECTOR CARRIED BY DERRICKMAN AT ALL TIMES TO PUMP/MUD PIT AREAS
BOTTOM STAIRWAY STORES ENTRANCE
ENTRANCE TO REEFER AREA
LOWER TWEEN DECK
REEFER LOCATED ON TOP OF CT SHOP
REEFER
LOCATED ON IRON ROUGHNECK OR ABOVE DRAWWORKS
CORE RECEIVING DECK (BRIDGE DECK)
LIVING QUARTERS
BRIDGE
LIFE BOAT STATIONS
CORE RACK
CORE SPLITTING ROOM
LAB STACK
INBOARD CENTER OF STBD DOG HOUSE ROOF
OCEAN DRILLING PROGRAM
TEXAS A&M UNIVERSITY
LAYOUT & LOCATION OF H2S DETECTORS AND SENSORS
SK9004


BRIDGE TOP LEVEL AFT OF DP CONTROL ROOM
11-CFM AIR COMPRESSOR (ELECTRIC) LOCATION: BRIDGE ROOF
25' HIGH PRESSURE FILL LINE
4 CYL. AIR BANK (BUFFER)
AIR BANK TO BE PLUMBED IN SUCH A MANNER TO ALLOW EACH CASCADE STATION (C_1, C_2, & C_3) TO BE INDEPENDENTLY FILLED WITH AIR.
150' HIGH PRESSURE FILL LINE (3 - 50' SECTIONS)
175' HIGH PRESSURE FILL LINE (3 - 50' SECTIONS)
100' HIGH PRESSURE FILL LINE
C_1 8 CYL. CASCADE STATION (RIG FLOOR)
C_2 8 CYL. CASCADE STATION
C_3 (PORTABLE UNIT/SPARE)
MANIFOLD ATTACHED TO CYL. CASCADE
6-PORT MANIFOLD
(50'-LPH)
(200'-LPH)
(150'-LPH)
(100'-LPH)
CORE RECEIVING DECK
CORE LAB
(25'-LPH)
OPTIONAL AIR MANIFOLD IN DERRICK
CT REEFER /SPARE
(M) 5 MINUTE BREATHING AIR UNITS
LPH - LOW PRESSURE HOSE
TOLERANCES UNLESS NOTED
FRACTIONS ± 1/64
DECIMALS ±.005
ANGLES ± 1/2
CORNERS 1/64 X 45°
FINISH 125
MATERIALS
HEAT TREAT
SURFACE TREAT
SCALE NONE
CONCENTRICITY ALL DIAMETERS TIR .003
DRN'S ES
DATE 2-19-91
OCEAN DRILLING PROGRAM
TEXAS A&M UNIVERSITY
COLLEGE STATION, TX. 77840
TITLE LEG 139 CASCADE STATION SCHEMATIC
SYSTEM
ASSEMBLY
APPROVED
CHECKED
SIZE C
FSN SK9050
REV. 1

APPENDIX H

EXAMPLE OF WAIVER FOR SAFETY CONDITIONS

Air breathing equipment

Conditions may develop which require air breathing masks/respirators to be worn by personnel working in the designated hazardous areas. A proper seal between the surface of a respirator face piece and the wearer's skin is imperative. Facial hair, such as beards, sideburns, moustaches, and even a few days' growth of stubble will prevent a good seal. That results in the respirator permitting negative air pressure inside the face piece during inhalation and causing excessive penetration by an air contaminant.

Personnel wearing eyeglasses and contact lenses must take special precautions when wearing breathing equipment. The ear pieces on the eyeglasses will interfere with the seal on the face mask of both the self-contained breathing apparatus and the cascade breathing system. Lens holders will be provided to mount eyeglasses inside the face masks with the ear pieces removed.

Injuries have been sustained by personnel wearing contact lenses using air breathing equipment. The positive pressure in the face mask can push the lens up inside the cavity of the eye. The positive air pressure also dries the eye out behind the eye. Therefore, contact lenses should not be worn with the breathing equipment face masks. Instead, a pair of conventional glasses should be worn inside the face mask using the lens holder as described above.

Personnel working in hazardous area(s)

Persons assigned tasks in the hazardous area(s) that require the use of breathing equipment during situations should not have stubble, beards, sideburns, or moustaches.

Scientists working in the lab stack

Those scientists that (1) have work activities confined to the inside of the lab and (2) are not assigned emergency duties may elect not to shave facial hair. If the individual elects not to shave facial hair, he must sign the statement provided below.

> My signature below (with witness) indicates that I have been informed of the dangers associated with using a breathing apparatus that might not suitably seal because of interfering facial hair and I choose not to hold the Ocean Drilling Program responsible for any accidents, illness, or medical problems that might occur if it becomes necessary for me to use a breathing apparatus during an H_2S emergency.

Signature_____Date_____

Witness_____Date_____
(H_2S Technician)

WAIVER

Hydrogen sulfide exposure - perforated ear drum

Due to the nature of operations on Leg ..., participants face potential exposure to hydrogen sulfide (H_2S). Situations may develop which require air breathing masks/respirators to be worn by personnel working in the designated hazardous areas. Since the protective breathing apparatus does not cover the ears, H_2S may enter the body through a perforated or punctured eardrum.

If an individual suspects or has been diagnosed to have a punctured/perforated eardrum but elects to participate on ODP Leg ..., he or she must sign the statement provided below.

My signature below (with witness) indicates that I have been informed of the dangers associated with hydrogen sulfide (H_2S) exposure when a perforated or punctured eardrum condition exists. I choose not to hold the Ocean Drilling Program-Texas A&M Research Foundation responsible for any accidents, illness, or medical problems that might occur as a result of H_2S exposure via a punctured or perforated eardrum.

Signature _____ Date _____

Witness _____ Date _____
(H_2S Technician)

PLEASE READ THE FOLLOWING STATEMENT CAREFULLY BEFORE SIGNING NEXT TO YOUR NAME, PRINTED BELOW.

LEG ... HYDROGEN SULFIDE TRAINING ACKNOWLEDGEMENT

My signature below (with witness) indicates that I have been informed of the potential for and risks associated with Hydrogen Sulfide (H_2S) exposure as a result of operations on ODP Leg .... Specifically, I received the following training: (1) attended an informational meeting discussing safety procedures, (2) viewed and understand the audiovisual material on Hydrogen Sulfide, and (3) received, read, and understand a) the "Occupational Health Guidelines for Hydrogen Sulfide" (gold color handout), and b) the "Hydrogen Sulfide-High Temperature Drilling Contingency Plan" (ODP Technical Note No. 16).

_____ _____

Participant name (print) Participant signature

_____

Date

Witness Signature: _____ Date: _____

APPENDIX I

PARTICIPANT MEDICAL EVALUATION REQUIREMENTS

Notification must be provided to the ODP Administrator and ODP Personnel Supervisor at least three months in advance of port call, or sooner if possible during the planning stages of any leg when the possibility of encountering Hydrogen Sulfide is known in advance. All participants and ODP employees must be notified of the potential for encountering H_2S and must receive a special medical evaluation for perforated eardrums (a tympanogram) as part of the pre-cruise physical exam requirements.

The following statement will appear in the physical exam package sent to all participants. Any participants with current physical exams on file will be required to complete a tympanogram to participate on an H_2S leg.

Participants on Ocean Drilling Program Leg ___ have the potential for hydrogen sulfide (H_2S) exposure due to the nature of operations. Specifically, H_2S could come up the drill string and vent onto the drill floor or reside within the recovered ocean floor sediment core material.

The Ocean Drilling Program will be employing strict safety procedures to prevent injury in the event of H_2S exposure. All participants will receive training on safety procedures and the use of self-contained breathing equipment as part of the safety program. However, participants following all safety precautions may still be vulnerable to the effects of H_2S exposure if it enters the body through a perforated eardrum.

Participant:

Please report any ear-related problems you have experienced to your examining physician. The physician should carefully examine your eardrum for a possible perforation. A tympanogram test must be performed and the results returned to ODP with the physical exam package when completed. A perforated eardrum will not affect your opportunity to participate on Leg ____. If you experience congestion, a head cold, or any difficulty with your ears during your flight(s) enroute to port, we request that, upon arrival at the ship, you be re-examined for a perforated eardrum by the ship's physician. You will be asked to sign a waiver of liability if a perforated eardrum condition is discovered and you wish to participate on Leg ____.

Physician:

Please report any indication of a perforated eardrum or ear problems for this participant. A tympanogram test must be performed and the results returned to ODP with the physical exam package when completed.

The ODL ship's physician must be notified if any participant's evaluation reveals an eardrum perforation prior to the start of an H_2S leg. In addition, any participants experiencing sinus problems, earaches, hearing difficulties, or similar problems must report to the ship's physician for evaluation. Appendix H includes an example of the waiver of liability which must be signed by participants diagnosed with eardrum perforation who are participating on an H_2S leg.

LEG ... PARTICIPANT LIST

PARTICIPANT NAME	AUTHORIZED ACCESS, LEG ... AREA(S)

APPENDIX J

EXPERIENCES OF LEGS 139 & 146

Leg 139

All provisions of this manual were followed in the preparation for and operations of ODP Leg 139. The operating area was the Middle Valley portion of the Juan de Fuca Ridge--a sedimented active spreading center where drilling objectives included penetrating zones of hydrothermal activity and sampling high-temperature fluids known to contain hydrogen sulfide. Though the safety hazards were recognized to be less than in oilfield or on-land geothermal drilling under similar circumstances, the rigid safeguards were adopted because of ODP's limited experience in such circumstances and because compliance with the Canadian Government's rigid safety code was a condition of our permission to drill in Canadian waters.

Preparations included the installation of all monitoring and safety equipment (either purchased or leased) described in this manual, the training of ODL and ODP personnel as H_2S safety instructors, their subsequent training of the entire shipboard complement, establishment of emergency shore contacts, a regimen of H_2S drills for all personnel from the beginning of the voyage, stocking of special additives for mud and cement, stocking high-temperature core liners and other coring/drilling components, etc.

Hydrogen Sulfide

In general, the anticipated H_2S-laden pore fluids were not encountered and the objective of drilling into a hydrothermal fluid reservoir was not realized. The exception was at Site 858, which was located only meters from active seafloor vents that were known to be producing hot, H_2S-bearing water. Two holes cored at Site 858 apparently penetrated the conduit to the vents at about 20 meters below the seafloor (mbsf). The cores from that interval in both holes contained sufficient hydrogen sulfide to trigger an H_2S Alert condition in both cases. A gas sample from the conduit interval of the core contained several hundred parts per million (ppm) H_2S, while gas samples from other parts of the same core failed to detect hydrogen sulfide.

Because the gas occurrences were sufficient only to generate alerts, it was not necessary to halt operations. Nevertheless, the opportunity was taken in both cases to hold an H_2S drill, for which operations were halted and personnel were sent to the safe areas. During the period of the alert, core handlers were required to wear air breathing apparatus. While that was a great inconvenience and slowed progress considerably, it was determined that the core-handling and laboratory work could continue under an H_2S alert

condition if necessary.

Participating scientists indicated that the pore fluids contained less dissolved H_2S than anticipated because the pH was higher (around 8) than in other sedimented hydrothermal areas such as the Guaymas Basin. It also was noted that we would have had to deal with H_2S-rich fluids had we succeeded in reaching the source of the water that was venting at the seafloor, as its chemistry was radically different from that of the overlying sediments.

Downgraded drill pipe was used in the lower portion of the drill string to avoid exposing premium drill pipe to H_2S-laden fluids and the risk of hydrogen embrittlement. That probably was an unnecessary step because experience has been that pore pressures at depth normally are less than the hydrostatic head of cold seawater in the hole. Also the near-constant pump circulation would keep the hydrogen concentration very low through dilution. Note that the coring hardware and BHA were exposed to H_2S-bearing fluid in the borehole at Site 858, but that there were no metal failures or indications of embrittlement.

Leg 146

In contrast with Leg 139, hydrogen sulfide was **not** expected to occur at hazardous levels in the sediments or fluids of Leg 146. The situation had been evaluated in response to queries by the drilling subcontractor and the results of extensive sampling and investigation were reviewed. H_2S had been detected at levels of a few ppm in fluids venting on the Oregon Margin and investigators considered that to be the maximum potential concentration that could be encountered in cored sediments. Consequently none of the special training and equipment precautions of Leg 139 were in place for Leg 146.

No H_2S was detected until the first ("mudline") core of the final Oregon Margin site (892) was brought on deck. A strong odor alerted personnel to check levels of atmospheric H_2S near the core. The portable personal monitor gave an off-scale reading in excess of 100 ppm. A "modified H_2S Alert" situation was declared and precautions were taken before the core was processed on the core walk and the next core (already cut and waiting in the drill pipe) was brought on deck.

While an emergency meeting of operational principals was in progress, gas-chromatograph data confirmed anomalously high concentrations of H_2S in the gas samples collected from the first core. Concentrations in the thousands of ppm were indicated and apparently were associated with hydrocarbon gas hydrates noted to be present in the cores in considerable quantity.

Monitoring equipment on board was limited to two electronic

personal monitors and some conventional Draeger detectors. In addition, the supply of self-contained breathing apparatus (SCBA) and air bottles was limited to that routinely carried in case of fire or other emergency. However, three senior ODP personnel had been trained in H_2S safety in preparation for Leg 139 and ODL rig personnel were versed in H_2S safety as a result of their ongoing training program. It was agreed that the operation could proceed safely on a core-by-core basis, but that sustained continuous coring was not feasible due to limitations of equipment, air, and trained personnel.

Only the uppermost two cores of Hole 892A were rich in H_2S, though monitoring precautions remained in place during core recovery until total depth was reached at 176 mbsf. Because of the great scientific value of the cores from the hydrated zone, all or part of the hydrated section was cored on three additional occasions before the site was abandoned. Additional training for technical and scientific personnel was accomplished before the second penetration of the zone.

Three or four core-handling personnel suffered temporary effects of H_2S exposure (dizziness, headache, nausea) as a result of their initial encounter with the first core. No further physical effects occurred after safety measures were instituted and no serious or lingering symptoms were reported.

As a precautionary measure, the lowermost 12 joints of drill pipe (which had been exposed to H_2S) were removed from the drill string and returned to ODP. The BHA was magnetically inspected and no cracks were found.

There were indications of a considerable amount of H_2S in the water column above the seafloor, possibly as a result of disturbance by the drilling operation. (An atmospheric level of 8 ppm was measured emanating from the case of the underwater TV camera after its recovery.) Because of the shallow water depth (674 m) and accessible location (50 n.m. off Newport, OR) of the site, a warning has been issued to the scientific community regarding the hazard associated with attempting to sample the hydrated seafloor sediment.

General Comments

Though a quantity of "ironite sponge" H_2S scavenger was stocked on Leg 139, the situations in which its use would be needed or effective are highly unlikely to occur, even if H_2S should be encountered in cores or pore fluids. The need for scavenger should be scrutinized closely for future voyages.

The H_2S safety and instructor training received by the H_2S technicians and other key personnel at **PITTS** in Edmonton was of

high quality. The training subsequently provided to shipboard personnel was considered more than adequate. Nevertheless, we were fortunate in that the Canadian National Energy Board relaxed its requirement that all personnel be H_2S-certified. That would have required considerable additional expenditures on individual training materials, equipment for demonstration that is not applicable to our situation, and additional hours of instruction. The experience of Leg 146 demonstrated the value of maintaining a cadre of key ODP personnel trained and certified in H_2S safety. It is recommended that such a training program become standard policy. Good training is available in Texas and it should not be necessary to send anyone out of the area unless it is a condition of permission to drill as it was in Canada.

The most critical "hands-on" training for shipboard personnel is the donning and use of air breathing apparatus. It is important that each person be required to complete the routine at least two or three times. **Once is not enough.**

Because of the Leg 146 experience, additional electronic personal monitors will be carried aboard the vessel on future legs. A minimum of two fixed monitors will be stored on the ship in case an unexpected H_2S situation develops. As explained in Section VI, that would provide minimal protection for safe **but limited** operations.