NOTE TO READER

This document was published in May 2002. If you need additional information, please contact ODP representatives in JOIDES, JOI, TAMU, or LDEO.

# HYDROGEN SULFIDE DRILLING CONTINGENCY PLAN

## OCEAN DRILLING PROGRAM

May 2002

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# 1 OVERVIEW

## 1.1 Introduction

This document is a guide for the personnel aboard the *JOIDES Resolution* to help them recognize, prepare, and mitigate potentially dangerous $H_2S$ situations during drilling operations.

Not all situations can be foreseen on board the *JOIDES Resolution,* nor can detailed instructions be provided for every situation that might be encountered. The policies and guidelines set forth in this document should be considered as a **minimum** set of requirements for preparing and dealing with $H_2S$ exposure.

In addition, these policies and guidelines can be used to control other heavier-than-air toxic gases, provided that the proper gas detector systems have been installed and calibrated for the specific gas.

## 1.2 Scope

This document super cedes and replaces the two previous Ocean Drilling Program (ODP) $H_2S$ safety documents, Technical Notes 16 and 19. It is intended to supplement existing safety documents of ODP and those of the Ship's Operator.

This document addresses the following issues:

- How to identify, classify, and respond to different levels of $H_2S$ hazards.
- How to prepare to core $H_2S$-bearing formations.
- How to process $H_2S$-bearing cores.
- How to set up the fixed $H_2S$ detection system.
- Required $H_2S$ safety training, drills, and record keeping.
- Responsibilities and duties of personnel in regard to the policies set forth in this document.
- Technical information about $H_2S$ and other gas hazards.
- Copies of wavier forms.

## 1.3 Distribution

An electronic copy of this manual will be kept both on the shore and on the ship ODP website Policy page. An annually updated hard copy of this manual will be kept in both the ODP Operations Manager's (OM) and the ship's Offshore Installation Manager's (OIM) offices.

Both electronic and hard copies **will be available to ALL personnel** aboard the *JOIDES Resolution*.

# 2 $H_2S$ HAZARD CONDITIONS

There are five $H_2S$ hazard conditions, excluding "Normal Operations." This manual provides a minimum set of guidelines for each hazard condition covering the following topics:

1. $H_2S$ Monitoring,
2. Precautions and Special Procedures,
3. $H_2S$ Response, and
4. Special Concerns.

| $H_2S$ condition | Measured from | | Danger to life | Action |
|---|---|---|---|---|
| | Open air (ppm) | Core/Drill string (ppm) | | |
| Normal operations | No $H_2S$ potential at site | | None | None |
| Watch | Potential $H_2S$ at site | | None | Monitor |
| Alert | 1–19 | NA | None | Monitor, use BAs as needed |
| Danger | 20–49 | >20 | Moderate | Stop coring operations |
| Emergency | >50 | NA | Extreme | Evacuate to safe areas |

Throughout this document, the term BA refers to fixed or portable self-contained breathing systems.

The $H_2S$ hazard condition is set by the OIM based on the following information:

- The concentration of $H_2S$ (ppm) in air,
- The type of $H_2S$ source,
- The location of the detector (open air or confined space), and
- The relative distance of the detector from the $H_2S$ source.

## 2.1 Common $H_2S$ Sources

The most common $H_2S$ sources on the *JOIDES Resolution* are the following:

- Gases diffusing from recovered core and samples taken from the core;
- Gases that have accumulated in the core barrel and escape when the core catcher and/or the core liner is removed;
- Gases that are "swabbed" up the drill string when a core, downhole tool, or logging tool is recovered and escape when the drill string is opened at the rig floor;
- Gases that escape from downhole or logging tools when opened in the laboratory after use;
- Gases displaced when the inner core barrel is washed out;
- Decomposition of recovered $H_2S$ clathrates; and

- Well blowout that releases gases up through the drill string or into the surrounding waters.

In all these cases (except for clathrates and blowout situations), the source of $H_2S$ is small in volume or must pass through a small opening first (i.e., the open end of the drill string) before reaching a work area.

## 2.2 $H_2S$ Detectors

On board the *JOIDES Resolution,* three types of $H_2S$ detectors are used: fixed area, portable, and personal detectors.

### 2.2.1 Fixed area detection stations

These stations are mounted around the ship (see Appendix I) where $H_2S$ sources are present or in areas where $H_2S$ may accumulate. Up to two sensors can be attached to each detection station. The stations are mounted in open areas and continuously monitor for $H_2S$ in the work area atmosphere. The detection stations are connected via radio to an alarm control panel mounted on the ship's bridge. In addition, each station can have either an audio or a visual alarm, or both.

All fixed $H_2S$ sensors are set to detect a minimum of 10 ppm. Warning lights and horn units are installed on each detector station. If $H_2S$ is present at 10 ppm, the following will occur:

- A local audible and visual alarm will sound in the hazardous area where $H_2S$ is detected.
- At the same time, an audible and visual alarm will be triggered on the central alarm panel on the bridge.

For detailed operating instructions and specifications, see the manufacturer's operator manual.

### 2.2.2 Portable detectors

The staff on the rig floor and core-receiving platform use handheld portable detectors to spot check for the presence of $H_2S$. In addition, this style of detector can be used to monitor the work atmosphere.

### 2.2.3 Personal detectors

Personal detectors are worn by staff while working directly with potential $H_2S$ sources.

## 2.3 $H_2S$ Hazard Determination

To determine the level of the $H_2S$ hazard, it is important to remember the following facts:

- $H_2S$ concentrations will diminish with distance from the source.
- Moving air will greatly reduce the concentration of $H_2S$ with distance from the source.
- Moving air can direct $H_2S$ away from the sensor.
- $H_2S$ is denser than air and will accumulate in unventilated rooms or in low areas on the ship (e.g., in the elevator well).

The following examples demonstrate why it is important to understand where and how $H_2S$ was detected before assigning a hazard classification.

> Example 1: $H_2S$ has been swabbed up the drill pipe and released onto the drill floor when the pipe was opened to retrieve a core barrel. A fixed detector, mounted 20 ft away and downwind from the open drill pipe, measures an $H_2S$ level of 4 ppm (no alarm).
>
> Example 2: On the core-receiving platform, a Marine Specialist measures 100 ppm of $H_2S$ using a portable detector with the sampling tube inside the cut end of the core liner.
>
> Example 3: The alarm of the $H_2S$ station monitoring the refrigerated core storage has gone off.

In the first example, the $H_2S$ level measured at the detector has been reduced by distance. It is possible that the concentration of $H_2S$ near the open drill string is at a lethal level. In an open-air location, a fixed detector cannot be used as the primary means of $H_2S$ detection. However, the detection of **any** $H_2S$ by a fixed detector in an open-air location could indicate a VERY serious condition near the source. When a fixed detector is activated in an open-air setting, personnel not wearing a BA must leave the work area immediately until the source has been discovered (using a portable detector) and the concentration of $H_2S$ has dropped to a safe level.

In the second example, the $H_2S$ measurement was taken directly at the source in a confined space. Because the staff working on the core-receiving platform are in an open-air environment, a measurement should be taken 12 in away from the core to determine the actual hazard level. If this measurement shows a $H_2S$ level >20 ppm, then BAs are only needed for individuals working directly over the core; other individuals working on the core-receiving platform do not need to wear a BA.

The third example is a serious situation because the detector is monitoring a confined space. Only individuals wearing BAs should enter this area to begin ventilation. **Note, however, that $H_2S$ readings taken in a confined space**

**should not necessarily be used to determine $H_2S$ hazard conditions for the entire ship.**

## 2.4 Responsibilities

### 2.4.1 Offshore Installation Manager (OIM)

The responsibilities of the OIM are as follows:

- Thoroughly understands the $H_2S$ guidelines and policies set forth in this document and ensures that all personnel aboard the *JOIDES Resolution* observe the same.
- Keeps the ODP Operations Manager and Ship's Master and the shipboard supervisors informed of the current $H_2S$ hazard condition.
- Has the authority to modify the policies in this document to fit the safety requirements of the situation.
- Is qualified to conduct the shipboard $H_2S$ safety training.

### 2.4.2 Night Tool Pusher

The responsibilities of the Night Tool Pusher are as follows:

- Assists in carrying out the OIM's responsibilities listed above.
- Is qualified to conduct the shipboard $H_2S$ safety training.

### 2.4.3 ODP Operations Manager (OM)

The responsibilities of the Operations Manager are as follows:

- Assists the OIM in enforcing the policies set forth in this document.
- Keeps shipboard ODP staff informed of the $H_2S$ hazard situation.
- Keeps ODP onshore management informed of $H_2S$ hazard situation.
- Is qualified to conduct the shipboard $H_2S$ safety training.

### 2.4.4 Ship's Master and Officers

The responsibility of the ship's Master and Officers are as follows:

- When an $H_2S$ EMERGENCY (>50 ppm) condition is encountered, the Master or Ship's Officer 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.
- Designates the safe-briefing areas.
- Keeps all personnel advised of the current safe-briefing area.
- Notifies vessels and aircraft in the area of an $H_2S$ emergency.
- Maintains both fixed and portable breathing systems in a safe and working order.
- Maintains a 24-hr watch on the bridge to monitor the $H_2S$ central alarm panel.

### 2.4.5 Laboratory Officer

The responsibilities of the Laboratory Officer are as follows:

- Is qualified to conduct the shipboard $H_2S$ safety training.
- Provides $H_2S$ training to the science party.
- Oversees technical staff in setting up, calibrating, and testing the $H_2S$ detector systems.
- Posts $H_2S$ warning signs.
- Assigns the $H_2S$ Safety Technician's duties.
- Ensures that the scientific party has personal protection equipment (PPE) and knows how to use it.
- Documents all training and maintains training records.
- Assists the OIM in enforcing the policies set forth in this document.

### 2.4.6 Assistant Laboratory Officer

The responsibilities of the Assistant Laboratory Officer are as follows:

- Is qualified to conduct the shipboard $H_2S$ safety training.
- Assists the Laboratory Officer in carrying out his responsibilities as listed above.

### 2.4.7 Ship's Department Supervisors

The responsibilities of the ship's Department Supervisors are as follows:

- Keeps their staff (including the consultant and subcontractors) informed of the current $H_2S$ hazard.
- Provides appropriate PPE and ensure that staff know how to use it.

### 2.4.8 Core Technician

The responsibilities of the Core Technician are as follows:

- Monitors $H_2S$ levels on the rig floor.
- Knows and executes the $H_2S$ monitoring policies set forth in this document.
- Keeps the OIM, OM, and $H_2S$ Safety Technician advised of the $H_2S$ situation in their work area.

### 2.4.9 $H_2S$ Safety Technician

The responsibilities of the $H_2S$ Safety Technician are as follows:

- Monitors $H_2S$ levels on the core-receiving platform and in the Core Laboratory.
- Knows and executes the $H_2S$ monitoring policies set forth in this document.

- Keeps the OIM, OM, Laboratory Officer, and Assistant Laboratory Officer advised of the $H_2S$ situation in their work area.

### 2.4.10 Ship's Physician

The responsibilities of the Ship's Physician are as follows:

- Confirms that personnel working in the hazardous areas do not have punctured eardrums.
- Ensures that the ship is stocked with any special medical supplies that may be needed for treating personnel exposed to $H_2S$.
- Assists with training in resuscitation and $H_2S$ first aid.

### 2.4.11 All Personnel

The responsibilities of all personnel working in the designated hazardous areas (rig floor, core-receiving platform, core laboratory, and reefer) are as follows:

- Are familiar with the procedures outlined in this document.
- Complete an $H_2S$ safety training course.
- Are responsible for their PPE, that it is properly stored and easily accessible.
- Are familiar with the location of all safety equipment in their work area and are able to use it upon notice.
- Stay informed of the current $H_2S$ hazard condition.
- Follow instructions set forth in this document or as provided by their supervisor.

# 3 PREPARATION FOR $H_2S$ OPERATIONS

## 3.1 General

$H_2S$ detection equipment, training materials, and warning signs must be kept on board the *JOIDES Resolution* and in an operational state for every leg, regardless if $H_2S$ is expected or not.

*Responsible positions are enclosed in parenthesis in the following sections.*

## 3.2 Precruise

- All ship personnel must be tested for perforated eardrums as part of their medical exam. Individuals with perforated eardrums will be permitted to work with or in proximity to $H_2S$ cores provided they sign an indemnity wavier (Appendix VII) and do not work in any areas where a BA is required because of $H_2S$.
- Ensure that all $H_2S$ safety equipment that has been returned to the vendor for repair is fixed and sent back to the ship. (Laboratory Officer)
- Ensure that an adequate supply of calibration gases is on board before the ship leaves port. (Laboratory Officer)

## 3.3 Before Arriving on Site Where $H_2S$ is Expected

- Hold $H_2S$ safety training courses for all shipboard personnel and keep records of all who attend. For the science party, this is part of their specific hazard training. The original record of training will be sent to ODP and filed with the Human Resources Office. A copy is kept on board and filed in the Laboratory Officer's office. (For the ship staff: OIM and for the science party: Laboratory Officer)

  Training will cover the following topics:
  - General safety concepts, procedures, and policies of this document;
  - Location and use of air breathing equipment;
  - The hazards of $H_2S$;
  - First aid for $H_2S$ victims;
  - How to operate personal and portable $H_2S$ detectors;
  - Becoming "wind-conscious" (awareness of the direction of the prevailing winds at all times).

- Conduct at least one $H_2S$ evacuation drill. (Ship's Captain)
- Conduct blowout drills until supervisors are satisfied that rig floor personnel can install the drill pipe safety valve while using breathing equipment. (OIM)

- Open the upper air intake and close the lower air intake on the ship's A/C plenum. (Ship's Captain)
- Post $H_2S$ warning signage. (Laboratory Officer)
- Set the core-receiving platform as a NO-SMOKING area. (Laboratory Officer)
- Install wind direction indicators per Appendix II. (Ship's Officers)
- Ensure that both portable and fixed BA systems are in operating order. (Ship's Officers)
- Mount the fixed $H_2S$ detectors and alarms at locations noted in Appendix I. (Laboratory Officer)
- Calibrate and test fixed, portable, and personal $H_2S$ detectors. (Laboratory Officer)
- Distribute portable and personal $H_2S$ to staff as needed and make sure that the staff know how to operate detectors. (Laboratory Officer)
- Designate two $H_2S$ Safety Technicians for 24-hr coverage. (Laboratory Officer)
- Place emergency air escape packs (three each, 5 min of air) inside the elevator. (Laboratory Officer)

# 4 NORMAL OPERATION INSTRUCTIONS

During normal drilling operations, $H_2S$ will typically be first detected by odor (<1 ppm). When $H_2S$ is detected, the OIM should be notified immediately. After consultation with the OM and scientists, the OIM will determine whether or not invoke one of the $H_2S$ hazard conditions.

When invoking an $H_2S$ hazard condition of ALERT or higher, all drilling operations must be suspended until the presite $H_2S$ preparations have been completed, including $H_2S$ safety training, which can be given to each shift before they start work.

In addition, the OIM can permit drilling operations to resume while fixed station detectors are being installed, provided the portable detectors are available for monitoring and $H_2S$ levels do not exceed 20 ppm when measured at the drill string or core.

*At a minimum,* a fixed detector must be installed on the rig floor and on the core-receiving platform.

## 4.1 Unexpected $H_2S$ Release

1. Hold your breath if air breathing equipment is not available.
2. Rapidly evacuate the area containing the $H_2S$ and move upwind if possible.
3. Move up a deck to get upwind of the source.
4. If available, put on a BA.
5. Evacuate anyone who may be affected by the gas to a safe area; administer resuscitation or oxygen as needed or call the Ship Doctor.

| Put on your air breathing equipment before helping anyone overcome by $H_2S$. |
|---|

6. Quickly evacuate to the assigned or announced safe-briefing area to receive instructions from supervisory personnel.
7. Do not panic.

# 5 $H_2S$ OPERATION INSTRUCTIONS

The location, source, and concentration of $H_2S$ when detected are important in determining the potential $H_2S$ hazard condition and resulting actions. The following guidelines address the various locations and activities where $H_2S$ might be encountered.

## 5.1 $H_2S$ Monitoring Responsibilities

### 5.1.1 Bridge

The Ship's Officers will provide 24-hr monitoring of the central $H_2S$ alarm panel while operating on a $H_2S$ site. When an alarm goes off on this panel, it is the responsibility of the Ship's Officer to take the appropriate action.

The following table is provided for guidance ONLY and may be modified by the OIM and the Ship's Master as the situation and experience with the local $H_2S$ environment dictates.

| Alarm Area | Action |
|---|---|
| Core Laboratory | Notify $H_2S$ Safety Technician |
| *Core Receiving Platform | Notify $H_2S$ Safety Technician |
| Core Entry | Notify $H_2S$ Safety Technician |
| *Core Catcher Bench | Notify $H_2S$ Safety Technician |
| Lower 'tween Deck Landing | Notify Laboratory Officer and investigate |
| Hold 'tween Deck Landing | Notify Laboratory Officer and investigate |
| *Fresh Air Intake Plenum | Shut Down intake fans and investigate |
| *Rig Floor | Notify Core Technician |
| Multiple alarms on detectors marked above with "*"<br><br>Possible Blowout! | Sound the alarm using coded bell signals and verbally announce to all personnel via the public address system that an $H_2S$ EMERGENCY exists and to report to a safe-briefing area |

### 5.1.2 Rig Floor

The two Core Technicians are responsible for monitoring $H_2S$ levels on the rig floor during their shift to provide 24-hr coverage. The Core Technician works under the authority of the OIM and the Night Tool Pusher. Note, in the following instructions, references to the OIM include the Night Tool Pusher or other OIM designee.

### 5.1.3 Core Receiving Platform, Core Laboratory, and Core Storage Areas

The $H_2S$ Safety Technicians are two Marine Specialists assigned the responsibility for monitoring $H_2S$ levels on the core-receiving platform and in the Core Laboratory. There is an $H_2S$ Safety Technician assigned to each shift for 24-hr coverage. The $H_2S$ Safety Technicians work under the authority of the Laboratory Officer and Assistant Laboratory Officer.

### 5.1.4 Downhole and Logging Tools

The technicians operating these tools are responsible for monitoring any $H_2S$ that maybe trapped inside the tool.

## 5.2 General Safety Practices

- Use fans to ventilate work areas. Fans can keep the $H_2S$ concentration low enough so that BAs are not required.
- If station-keeping permits, head the ship so that the wind hits the ship just off the port bow, blowing across the core-receiving platform and through the rig floor.
- ALWAYS use the buddy system when working in potentially hazardous areas.
- ALWAYS check your PPE at the beginning of the work shift. NEVER assume that someone has left it for you in working order.
- Do not let materials pile up around fixed $H_2S$ sensors.

## 5.3 Location and Activity: Drill Floor and Opening Drill String

(To retrieve a core barrel or other tools deployed through the drill string.)

### 5.3.1 $H_2S$ Monitoring

The Core Technician is responsible for monitoring $H_2S$ levels on the drill floor with a portable detector.

Where to monitor:

- Drill pipe opening (while opening),
- Upper drill string connection,
- Top of inner core barrel, and
- Bottom of core catcher sub.

### 5.3.2 Precautions and Special Procedures

Use the following table to determine who must wear a BA before opening the drill string and measuring the $H_2S$ levels.

| $H_2S$ hazard condition | BA required before opening drill string | | |
|---|---|---|---|
| | Core technician | Rig floor crew | Driller (in driller's shack) |
| Watch | No | No | No |
| Alert | No | No | No |
| Danger | Yes | Yes | No |
| Emergency | Yes | Yes | Yes |

### 5.3.3 $H_2S$ Response

When $H_2S$ is detected at the drill pipe, the following procedures must be implemented.

**1–19 ppm, measured with a portable detector at the drill pipe:**

1. The Core Technician will notify the OIM, who may change the $H_2S$ hazard condition to "ALERT."

**20–49 ppm, measured with a portable detector at the drill pipe:**

1. The rig floor crew working around the drill pipe must put on BAs.
2. Reconnect the drill pipe and begin circulation.
3. The Core Technician will notify the OIM and OM.
4. After the drill string has been completely flushed, reopen the pipe and check $H_2S$ levels. If still >20 ppm, repeat steps 2 through 4 unless otherwise instructed by OIM.
5. The OIM may change the $H_2S$ hazard condition to "DANGER."

**>50 ppm, measured with a portable detector at the drill pipe or ≥10 ppm at rig floor's fixed station**

1. Rig floor crew, including driller, must put on BAs.
2. Personnel on the core-receiving platform must wear BAs or evacuate the area.
3. Reconnect the drill pipe and begin circulation.
4. The Core Technician will notify the OIM and OM of the situation.
5. Wait for instructions from the OIM.
6. The OIM may change the $H_2S$ hazard condition to "EMERGENCY" and then must notify the ship's Master to sound alarms and evacuate ship's personnel to safe areas.

### 5.3.4 Special Concerns

#### 5.3.4.1 $H_2S$ Blowout

Although unlikely, a set of circumstances could occur that would cause an $H_2S$ blowout to discharge gas up the drill string. The first sign that this situation is occurring would be backflow when the drill string is opened. There are many other reasons for backflow to occur that are not due to a blowout, but while drilling in an environment where $H_2S$ is present you

should do the following if backflow is detected unless otherwise instructed by the OIM:

- Reconnect the drill string as quickly as possible.
- The Core Technician will check atmosphere for $H_2S$.
- The Core Technician will notify the OIM and OM of situation.
- Await instructions from the OIM.

## 5.4 Location and Activity: Drill Floor and Removing Core from Core Barrel

### 5.4.1 $H_2S$ Monitoring

The Core Technician is responsible for monitoring $H_2S$ levels on the drill floor with a portable detector.

Where to monitor:

- Bottom of core catcher sub and
- Bottom of core barrel (after removing core catcher).

### 5.4.2 Precautions and Special Procedures

Use the following table to determine who must wear a BA before the core catcher is removed and the $H_2S$ levels are measured.

| **$H_2S$ hazard condition** | **BA required before removing core catcher** | | |
|---|---|---|---|
| | **Core Technician** | **Rig floor crew** | **Core Handlers** |
| Watch (potential) | No | No | No |
| Alert (1–19 ppm) | No | No | No |
| Danger (20–49 ppm) | Yes | Yes | Yes |
| Emergency (>50 ppm) | Yes | Yes | Yes |

### 5.4.3 $H_2S$ Response

If $H_2S$ is detected from the core barrel, the following procedures must be implemented.

**1–19 ppm, measured with a portable detector at the core barrel:**

1. The Core Technician will notify the $H_2S$ Safety Technician.
2. The Core Technician will notify the OIM and OM. The OIM may change the $H_2S$ hazard condition to "ALERT."

**>20 ppm, measured with a portable detector at the core barrel:**

1. The rig floor crew opening the core barrel and the Core Handlers must put on BAs.
2. The Core Technician will notify the $H_2S$ Safety Technician.

3. The Core Technician will notify the OIM and OM. The OIM may change the $H_2S$ hazard condition to "DANGER."

**≥10 ppm, measured at the rig floor's fixed station:**

1. The rig floor crew, including the Driller, must put on BAs.
2. Personnel on the core-receiving platform must wear BAs or evacuate the area.
3. The Core Technician will locate the source of the $H_2S$ and notify the OIM and OM of the situation.
4. Wait for instructions from the OIM.
5. The OIM may change the $H_2S$ hazard condition to "EMERGENCY" and then must notify the ship's Master to sound alarms and evacuate ship's personnel to safe areas.

## 5.5 Location and Activity: Core Receiving Platform and Core Processing

### 5.5.1 $H_2S$ Monitoring

The $H_2S$ Safety Technician is responsible for monitoring $H_2S$ levels on the core-receiving platform with a portable detector.

Where to monitor:

- At the core (vent holes and cut ends),
- 12 in above the core,
- At the core catcher, and
- Core storage racks (outside the laboratory).

### 5.5.2 Precautions and Special Procedures

Moving core from rig floor to core rack:

- Before the core handlers receive the core from the rig floor, the $H_2S$ level must be measured, as described in the section above. If $H_2S$ levels exceed 20 ppm at the core barrel, core handlers must wear BAs while transferring the core from the rig floor to the core rack.
- Hold the core at waist level when moving it to the core rack. NEVER place the core on your shoulder or allow it anywhere near the face. If the core liner ruptures, the face will have more protection from sharp core liner fragments and direct exposure to $H_2S$.
- When working with very gassy cores, wear face shields and Kevlar aprons, sleeve protectors, and gloves. The $H_2S$ Safety Technician will determine when this special protection is needed.

Curating core on the core rack:

1. After the core has been placed in the core rack, drill 1/8-in diameter holes through the liner to depressurize the core. DO NOT drill the holes

in a straight line, as this can cause a core liner to rupture. Stagger the holes around the circumference and space apart as necessary.
2. As gas is venting, monitor the $H_2S$ level. Check at the vent holes to see if $H_2S$ is present.
3. Check $H_2S$ levels 12 in above the core to determine if core handlers and other personnel working on the core-receiving platform need to wear BAs (See Emergency Response Section).
4. It is best not to cut the core into sections until the core has depressurized, to keep material from being extruded out of the liner.
5. If any part of a core contains $H_2S$, mark the core liner of each section with "$H_2S$." Also, mark all whole-round samples. $H_2S$ warning stickers may be used, as well.

Moving core sections into the Core Entry area of the Core Laboratory:

- Sections of **whole** cores may be brought into Core Entry area provided that
  - The core has depressurized and is no longer actively venting gas (i.e., causing core expansion gaps),
  - Any remaining $H_2S$ diffusing from the core is <20 ppm when measured 12" above the core.
- Sections of core that do not meet the above criteria must remain outside until they do.
- Vent holes and end caps must be sealed with tape if the $H_2S$ level is >10 ppm measured 12" above the core.

### 5.5.3 $H_2S$ Response

When $H_2S$ is detected **12 in above the core liner** during venting, the following procedures must be followed.

**1–19 ppm, measured with a portable detector 12 in above the core:**

1. BAs are not required.
2. The $H_2S$ Safety Technician should continue monitoring until the core has depressurized (as defined above).
3. The $H_2S$ Safety Technician will notify the OIM and OM The OIM may change the $H_2S$ hazard condition to "ALERT."

**≥10 ppm, measured at the core-receiving platform's fixed station:**

1. BAs are required for Core Handlers. *All other individuals on the core-receiving platform MUST leave the area.*
2. The $H_2S$ Safety Technician will identify the source of $H_2S$ and notify the OIM and OM of the situation.
3. Wait for instructions from the OIM.
4. The OIM may change the $H_2S$ hazard condition to "EMERGENCY" and then notify the ship's Master to sound alarms and evacuate ship's personnel to safe areas.

### 5.5.4 Special Concerns

#### 5.5.4.1 $H_2S$ Clathrates

Clathrates (gas hydrates) are crystalline substances composed principally of three-dimensional cages of water in which various gases (e.g., $CH_4$ and $H_2S$) can enter and stabilize the structure. At room temperature and pressure, a clathrate will disassociate, releasing a volume of $H_2S$ gas that can be greater than the original volume of the clathrate.

If a clathrate is recovered from a site where $H_2S$ is expected, the following steps should be taken:

1. Core Handlers must wear BAs.
2. Personnel not handling core must leave the core-receiving platform.
3. Cut out the section of the core containing the clathrate.
4. Quickly measure for $H_2S$ while the clathrate is being removed.
5. Process the clathrate according to the scientist's instructions. Usually this involves placing the clathrate in a pressure container or into liquid $N_2$.
6. If $H_2S$ was detected, place an $H_2S$ warning label on the container.
7. The $H_2S$ Safety Technician will notify OIM the first time a clathrate is recovered at a particular site.

An $H_2S$ clathrate may only be brought into the laboratory if it is in a sealed pressure container. Liquid $N_2$ dewars holding $H_2S$ clathrates must be stored outdoors, away from supply ventilations, sources of ignition, and marked with warning signs.

## 5.6 Location and Activity: Core Lab and Core Processing

### 5.6.1 $H_2S$ Monitoring

The Marine Specialists and the $H_2S$ Safety Technicians are responsible for monitoring $H_2S$ levels in the Core Laboratory with a portable detector.

Where to monitor:

- Core storage racks (inside the laboratory),
- Air in the core splitting room,
- The cut surface of split cores after splitting, and
- The cut surface of split cores while laying out in the core laboratory.

### 5.6.2 Precautions and Special Procedures

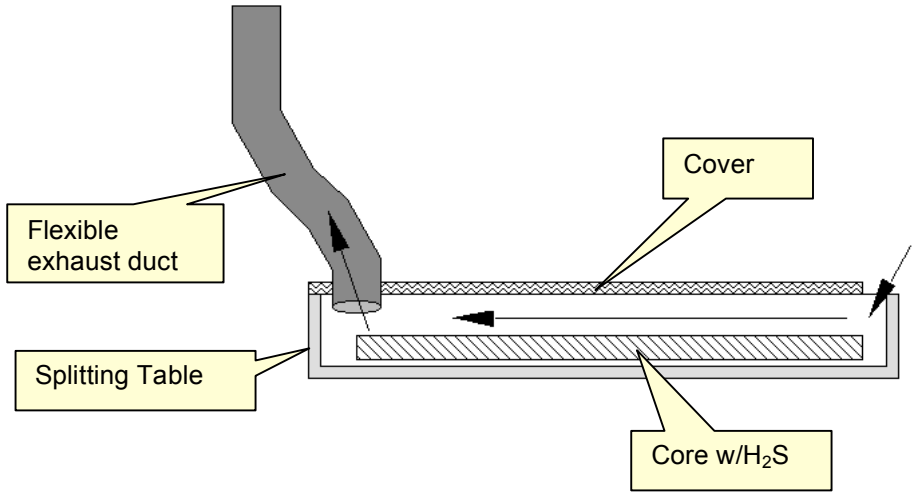
While cores are waiting to be split or measured on the multisensor track (MST), they will continue to warm up and may possibly resume degassing. Should this happen, the Marine Specialists must remeasure the $H_2S$ levels. If the $H_2S$ level is <10 ppm, the core may remain in the laboratory. If it is >10 ppm, the core

should be removed from the laboratory until it can be sealed as mentioned in the previous section.

Warning: Cores that are no longer actively emitting $H_2S$ may release additional $H_2S$ during the core splitting process (especially if the super saw is used). The $H_2S$ levels from split cores are often greater than the levels measured in the whole round!

Prior to splitting cores two BAs must be available and **ready** for use. There must be at least two Marine Specialists in the splitting room when a core is being split. During the splitting process the $H_2S$ levels must be continuously monitored with a hand held detector. If the $H_2S$ level in the splitting room is >20 ppm, then core splitting must stop and the two the Marine Specialists cutting the core must put on their BAs; all others must leave the room.

Cores maybe taken back outside the laboratory to finish degassing or left on the splitting table, covered, and vented using the flexible exhaust duct provided in the splitting room (as shown below).




Core halves may not leave the splitting room until ALL signs of active degassing have stopped and the remaining $H_2S$ concentration from the core is <10 ppm.

Note: Some individuals may be very sensitive to low levels of $H_2S$. The 10-ppm level may have to be set lower for these individuals or a BA provided for them to use.

Tag all D-tubes and core boxes holding cores that have emitted $H_2S$ with $H_2S$ warning labels. Place $H_2S$ warning signs on core refrigerators where these cores are stored.

To keep the air fresh in the Core Laboratory, do the following:

- Fully open the fresh air supply to the Core Laboratory and Top Deck air handlers.
- Open doors and windows, if weather permits.
- Use fans to force additional fresh air into the laboratory.

### 5.6.3 $H_2S$ Response

When $H_2S$ is detected in the Core Laboratory, the following procedure must be followed.

**≥10 ppm at any fixed station in the Core Laboratory:**

1. Evacuate everyone from the immediate area.
2. The $H_2S$ Safety Technician will identify the source of $H_2S$ and notify the Laboratory Officer of the situation.
3. Wait for instructions from the Laboratory Officer.

## 5.7 Location and Activity: Various Locations and Handling Downhole and Logging Tools

### 5.7.1 $H_2S$ Monitoring

Because each tool is unique, it is the responsibility of the technician operating the tool to carefully check for $H_2S$ in sampling chambers or for $H_2S$ trapped inside the tool's housing.

### 5.7.2 Precautions and Special Procedures

If the $H_2S$ hazard condition is "ALERT" (1–19 ppm) or greater, then the tool's sampling chambers should vented outside or in a controlled manner such that there is no chance of $H_2S$ escaping into the work area. The Laboratory Officer will approve such controls prior to tool's operation.

Should the technician suspect the tool's housing has been compromised and may possibly contain fluids or materials with $H_2S$, the technician must open the housing in an open-air location.

If samples collected are transferred to another container, that container must have an $H_2S$ warning tag (see section 5.7.4).

### 5.7.3 $H_2S$ Response

If $H_2S$ is released, evacuate the immediate area until the air can be tested.

### 5.7.4 Presure Core Samplers, Autoclaves, Transfer/Storage/ Logging Containers, and Sampling Manifolds

Downhole tools that return core/gas/liquid under pressure must comply with the following:

- All pressure corers and pressurized transfer/storage/logging containers must have a written operator's manual that has been submitted to and approved by ODP and Trans-Sedco Forex (TSF) management prior to deploying the tool on the *JOIDES Resolution.* The manual must not only instruct the user on safe operation of the tool but also clearly state the types of hazards the tool presents to the operator. In regard to the potential release of $H_2S$, the operator must be informed of all potential locations on the tool where pressure containment could fail (seals, valves, rupture disks, etc.).
- When a pressure sampler is retrieved on the rig floor, all potential locations for containment failure must be surveyed with a handheld detector.
- If the contents of the pressure sampler are transferred to secondary sample chamber or into a manifold/collection system, a handheld detector must be used to monitor the transfer operation.
- When operating in a "WATCH" ($H_2S$ potential) or higher $H_2S$ hazard condition, then it must be assumed that the pressure sampler or transfer/storage/logging container contains $H_2S$ until the trapped gases can be sampled and determined otherwise. The following applies to both pressure samplers and transfer containers:
    - Pressure samplers and transfer/storage/logging containers must be tagged with an $H_2S$ hazard label.
    - Pressure samplers and transfer/storage/logging containers must be surveyed with a handheld detector each time they are relocated to a new storage area.
    - Personnel handling pressure samplers and transfer/storage/logging containers indoors must wear a personal dectector.
    - Areas where the pressure samplers and transfer/storage/logging containers are stored must have $H_2S$ warning signs posted.
    - Pressure samplers and transfer/storage/logging containers must be vented outdoors in a location where personnel downwind are not affected.

# 6 SPECIAL CORING PROCEDURES FOR $H_2S$ SITES

## 6.1 Guidelines

The following guidelines should be used unless otherwise instructed by the OIM.

1. Maintain circulation while a core barrel is dropped or wirelined into and out of the hole.
2. Control wireline speeds to prevent/minimize swabbing of $H_2S$-bearing fluids into the drill string from the well bore.
3. Engage the core barrel with the overshot.
4. Stop the pumps, if necessary, while unseating the core barrel from the outer core barrel assembly (OCB).
5. Pull the core barrel up slowly above the top of the bottom-hole assembly (BHA).
6. Stop the wireline winch once the core barrel is pulled above the top of the BHA.
7. Pump three volumes of fluid (equal to the volume required to fill the inside of the BHA) to clear any $H_2S$-bearing fluid that may have been swabbed into the BHA when the core barrel was unseated.

See Section 5.3, (Location and Activity: Drill Floor and Opening Drill String) for additional safety information.

## 6.2 Drill Pipe Safety Valve (Rig Floor)

A drill pipe safety valve is kept on the rig floor. The valve can be used to prevent excessive backflow of fluid through the drill string. Such backflow could be the result of a hydrocarbon or hydrothermal fluid "kick." Either could possibly carry $H_2S$ to the surface.

Install the valve in the drill string if excessive backflow occurs and the top drive is not readily available (i.e., racked back) for immediate makeup to the drill string.

## 6.3 Baker Float Valve (Rig Floor)

Once the safety 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 drilling fluid to be pumped down the drill string while preventing hot or $H_2S$-contaminated well bore fluids from backflowing up the drill string.

The drill pipe safety valve and Baker float valve assemblies are to be used under special circumstances only only (i.e., when the top drive is not installed or is otherwise inoperable for circulation). Note that if the Baker float valve is installed, no downhole tools can be deployed.

## 6.4 BHA Installed Float Valves (Downhole)

The rotary core barrel (RCB) BHA is equipped with a float (flapper) valve that is compatible with the RCB wireline coring system.

The advanced piston corer/extended core barrel/pressure core sampler (APC/XCB/PCS) BHA can be equipped with a lockable float (flapper) valve (LFV).

Each of these float valves serves to prevent excessive drill cuttings from "u-tubing" or being swabbed up into the BHA during core barrel retrieval. When functional, these flappers seal the throat of the core bit and prevent backflow into the drill string via that path. It should be noted, however, that neither of the BHA float valves seal the bit jets, and therefore they do not completely seal off the lower end of the drill string from the well bore.

The 6-3/4-in drill collar/BHA used with the advanced diamond coring barrel (ADCB) coring system is not compatible with either of the float valves used with the RCB or the APC/XCB/PCS coring systems. It has been suggested, therefore, that use of the ADCB coring system be avoided in formations where $H_2S$ might be present.

# 7 SPECIAL LOGGING PROCEDURES FOR $H_2S$ SITES

The following guidelines should be used unless otherwise instructed by the OIM:

1. Maintain circulation while wireline tools are run into and out of the hole.
2. Control wireline speeds to prevent swabbing $H_2S$ fluids into the drill string from the well bore.
3. Stop the tool above the top of the BHA once sampling or measurements are completed and the wireline tool(s) is/are retrieved inside the BHA.
4. Pump three volumes of fluid (equal to the volume of fluid required to fill the inside of the BHA) to clear any $H_2S$-rich fluid that may have been swabbed into the BHA as the tool was pulled inside it.

See Section 5.7, (Location and Activity: Various Locations and Handling Downhole and Logging Tools) for additional safety information.

Do not use excessive flow rates that may be sufficient to fail cablehead weak points and pump the wireline tools off the wireline (this has happened in the past).

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.

# 8 $H_2S$ EMERGENCY CONDITION

## 8.1 Instructions

When an $H_2S$ EMERGENCY (>50 ppm) condition has been called by the OIM, implement the following procedure:

1. All rig floor personnel will put on BAs and remain on the rig floor unless otherwise instructed by the OIM.
2. All drilling/coring operations will stop and the driller will
   - Make the string back up (if open),
   - Pick up off bottom, and
   - Maintain circulation.
3. The OIM will notify the Ship's Officers and OM of the situation.
4. The Ship's Officers will sound the alarm using coded bell signals and verbally announce to all personnel via the public address system that an $H_2S$ EMERGENCY exists and to report to a safe-briefing area.
5. The Ship's Officers will shut down the ventilation systems.
6. The Ship's Officers will notify any nearby vessels to go upwind and will maintain a radio and visual watch.
7. At the safe briefing the Ship's Officers (or designees) will take roll and account for all ship personnel.
8. The ship's emergency response team, using BAs, will make the maximum effort to determine the source of the $H_2S$ and to suppress the $H_2S$ as quickly as possible.
9. All personnel not assigned to emergency duties or working on the rig floor must report to the upwind safe-briefing area for further instructions.
10. Drilling/coring operations will remain suspended until the source of $H_2S$ has been located and the atmospheric level has fallen to a level <10 ppm.
11. Utilize the buddy system for all personnel remaining in the potential danger area.
12. The hole may be terminated, depending on the source of the $H_2S$ by the OIM.
13. The ODP Operations Manager will notify the appropriate personnel on shore as soon as possible of the situation and the actions taken.

| |
|---|
| Notify the Driller if the exhaust fans in the laboratory stack are turned on to exhaust $H_2S$ because the exhaust fans discharge air above the rig floor. |

## 8.2 Safe-Briefing Area

The primary safe-briefing areas will be the **port and starboard lifeboat stations** located forward on the fo'csle deck.

The port and starboard lifeboat stations are the safe-briefing areas because when the drillship is in dynamic-positioning (DP) mode, the bow of the ship is nearly always oriented into the prevailing wind.

The routes to the safe-briefing area will be determined by the Master and reviewed in safety meetings held with personnel working in each area of the ship. The best route from each location on the ship will be dictated by

- Rig floor activity,
- Weather, and
- Sea conditions.

All personnel not assigned emergency duties who are aft (i.e., back by the helideck) of the rig floor will proceed forward to the safe-briefing stations along the mezzanine or main deck on the windward side of the ship. Personnel must avoid entering areas designated as potential $H_2S$ danger areas as they proceed forward to the safe-briefing areas.

If, for some reason, the stern of the ship is oriented into the wind, the Master will announce to all ship personnel that the safe-briefing area is the helideck.

The location of the designated safe-briefing area is posted by the Master or Mates next to the ship's station bills (where lifeboat assignments are posted) on each deck.

# 9 PERSONNEL RESCUE

Use the following guidelines for personnel rescue when $H_2S$ levels are above 20 ppm; USE A DETECTOR …DON'T ASSUME!

ALWAYS use a portable $H_2S$ detector to monitor $H_2S$ levels in a confined space. Low oxygen levels can be just as lethal as $H_2S$. The Ship's Officers have oxygen meters to determine if a space has enough oxygen. The oxygen meters CANNOT be use to measure $H_2S$ levels. In some cases it will be necessary to use both types of meters.

$H_2S$ levels may be safe at the entrance to a confined area but can change quickly to lethal levels ,depending on the source. Remember that $H_2S$ is denser than air and will settle into low areas.

DO NOT enter a confined space to rescue someone who has passed out without using a BA. YOU WILL ONLY CREATE A SECOND VICTIM!

1. Put on a BA before proceeding to assist anyone affected by the gas.
2. Put on a safety belt with 50 ft of tail line and obtain standby assistance before entering the area if the person is in a high-concentration area.
3. Utilize the buddy system when entering possible contaminated areas.
4. Move victim to fresh air.
5. Administer resuscitation or oxygen as needed.
6. Call the Ship's Doctor.
7. If the person is injured because of exposure to $H_2S$, arrange for evacuation to a shore-based medical facility.

# 10 APPENDICES

## 10.1 Appendix 1: Location of Fixed Area Detectors

Each detector station can support two sensors. The sensors should be mounted 6–12 in above the deck.

| Detector Area | Number and Position of Fixed Sensors |
|---|---|
| Core Processing Area | • Sensor 1: Below the sampling table next to the working half storage rack.<br>• Sensor 2: Below the description table |
| Core-Receiving Platform | • Sensor 1: Mount on handrail at the forward end of the platform next to the outdoor storage rack.<br>• Sensor 2: Mount on the handrail at the midpoint of the platform. |
| Core Entry | • Sensor 1: Mount at the base of the aluminum core rack.<br>• Sensor 2: Mount beneath the splitting table. |
| Core Catcher Bench | • Sensor 1: Mount on the handrail at the aft end of the core-receiving platform.<br>• Sensor 2: Mount beneath core catcher bench. |
| Lower 'tween Deck Landing | • Sensor 1: Mount inside the lower 'tween core refrigerator at the base of the unistrut shelving. |
| Hold Deck Landing | • Sensor 1: Mount inside the hold core refrigerator at the base of the unistrut shelving.<br>• Sensor 2: Mount at the bottom of the stairwell. |
| Fresh Air Intake Plenum | • Sensor 1: Mount inside the fresh air intake plenum where the air enters the A/C on the main deck<br>• Sensor 2: Mounted on the forward end of the core-receiving platform |
| Rig Floor | • Sensor 1: Mount at the base of forward starboard tugger.<br>• Sensor 2: Mount at the base of aft starboard tugger. |

### 10.1.1 Warning Signs

Post warning signs at the entrance(s) to potential $H_2S$ areas during operations at sites where $H_2S$ may be encountered

Use the following text on the warning signs:

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

Warning signs are to be posted in the following areas:

- Rig floor,
- Core receiving platform,
- Core laboratory—in all areas where cores will be processed,
- Core storage reefer—including reefer entrance(s),
- Bottom of core laboratory stairwell—$H_2S$ gas may accumulate in that area, and
- Living quarter exits that are entrances into designated $H_2S$ danger areas—all deck levels.

### 10.1.2 Wind Direction Indicators

Wind socks are to mounted on the following:

- Ship's bow,
- Crane no. 1,
- Crane no. 2s, and
- Crane no. 3.

Bright Color Streamers are located at the following:

- Along the catwalk aft of crane no. 2,
- Under the rig floor on the mezzanine deck, and
- Along the port side of the core-receiving platform.

## 10.2 Appendix II: Origin of $H_2S$

### 10.2.1 Formation and Consumption in Sediments

In most cases where ODP is coring, $H_2S$ forms as a byproduct of the degradation of organic matter. Because sulfate is plentiful in the ocean, sulfate reduction and, hence, hydrogen sulfide production is common in marine sediments.

Specifically, $H_2S$ forms during sulfate reduction via the generalized formula

$$2CH_2O + SO_4^{2-} \longrightarrow H_2S + 2HCO_3^-$$

where,

$CH_2O$ = organic matter,
$SO_4^{2-}$ = sulfate, and
$HCO_3^-$ = bicarbonate or alkalinity.

Despite their common presence in marine sediments, $H_2S$ concentrations do not usually reach very high levels. Relatively low concentrations of $H_2S$ are maintained primarily because either the reactants (organic matter and/or sulfate) may be limited or iron combines with the sulfide to form iron sulfide minerals (e.g., pyrite).

The highest $H_2S$ concentrations encountered during DSDP/ODP operations were located in the carbonate-rich sediments of the south Australian margin (Leg 182; 150,000 ppm in a single core). High sedimentation rates, low iron content, and sulfate-rich pore fluids led to extensive production of $H_2S$.

Typically, diffusion from overlying seawater is the main source of sulfate. However, on some continental margins brines may provide an additional source of sulfate for sulfate reduction and production of $H_2S$.

In areas where overlying seawater is the main source of sulfate, $H_2S$ concentrations will eventually decrease with depth. Even when there is high organic matter content, sulfate eventually becomes depleted with depth. Thus, $H_2S$ may be encountered over several cores, but like sulfate, $H_2S$ should also decline with depth.

### 10.2.2 Environments

Typical environments where $H_2S$ may be present are the following:

- Terrigenous continental margins,
- Carbonate-rich continental margins or carbonate banks,
- Gas hydrate sediments, and
- Hydrothermal systems.

$H_2S$ may be present in terrigenous continental margin environments, especially where coastal upwelling results in sediments with high organic matter content. Typically in this setting, the sedimentary components often provide plenty of available iron, resulting in the removal of $H_2S$ via iron sulfide precipitation.

Slopes of carbonate-rich continental margins or carbonate banks with high sedimentation rates may be a source of $H_2S$. Although carbonate-rich sediments are typically not rich in organic matter, the slopes can be characterized by high sedimentation rates. High accumulation rates bury organic matter, creating an increased potential for organic matter availability for sulfate reduction. Carbonate-rich sediments also have low iron contents, so $H_2S$ is rarely quantitatively precipitated as iron sulfides.

Another potential point source of $H_2S$ on continental margins is gas hydrates (clathrates). Although most natural marine hydrates are dominated by methane, $H_2S$-methane hydrates have been encountered (e.g., Cascadia margin, Legs 146 and 182). Incorporation of $H_2S$ into the hydrate structure shifts the hydrate stability field; hence, $H_2S$-rich hydrates are found at *shallower depths than methane hydrates.*

$H_2S$ may be encountered in hydrothermal systems (e.g., massive sulfide deposits). Consequently, appropriate precautions should be in place when

recovering such fluids or coring sediments whose pore fluids may contain a hydrothermal component.

## 10.3 Appendix III: Properties of $H_2S$

Hydrogen sulfide is

- Colorless,
- Transparent,
- Flammable,
- Smells like "rotten eggs" at very low concentrations, and
- Denser than air and thus may accumulate in low places.

The slightest presence of $H_2S$ in the air is normally detectable by its characteristic "rotten-egg" odor; however, it is dangerous to rely on odor as a means of detecting life-threatening concentrations because the sense of smell is lost rapidly, allowing lethal concentrations to accumulate without warning.

The following table describes the poisonous nature of hydrogen sulfide.

| **Concentration of $H_2S$** | | | EFFECTS |
|---|---|---|---|
| **%** | **ppm** | **g/100 ft$^3$** | |
| 0.001 | 10 | 0.65 | Obvious and unpleasant odor; safe for 8 hr. |
| 0.002 | 20 | 1.3 | Safe for 4 hr exposure. |
| 0.01 | 100 | 6.48 | Kills sense of smell in 3–15 min; may sting eyes and throat. |
| 0.02 | 200 | 12.96 | Kills sense of smell; stings eyes and throat. |
| 0.05 | 500 | 32,96 | Dizziness; breathing ceases in minutes; need prompt artificial respiration. |
| 0.07 | 700 | 45.26 | Unconscious quickly; death will result if not rescued promptly. |
| 0.1 | 1000 | 64.8 | Unconscious immediately, followed by death within minutes. |

## 10.4 Appendix IV: Toxicity of Various Gases

| Common name | Chemical formula | Specific gravity (Air = 1) | Threshold[1] limit (ppm) | Hazardous[2] Limit | Lethal[3] concentration (ppm) |
|---|---|---|---|---|---|
| Hydrogen cyanide | HCN | 0.94 | 10 | 150 ppm/l hr | 300 |
| Hydrogen sulfide | $H_2S$ | 1.18 | 10 | 250 ppm/l hr | 600 |
| Sulfur dioxide | $SO_2$ | 2.21 | 2 | — | 1,000 |
| Chlorine | $Cl_2$ | 2.45 | 1 | 4 ppm/l hr | 1,000 |
| Carbon monoxide | CO | 0.97 | 50 | 400 ppm/l hr | 1,000 |
| Carbon dioxide | $CO_2$ | 1.52 | 5,000 | 5% | 100,000 |
| Methane | $CH_4$ | 0.55 | 90,000 | Combustible >5% in air | — |

[1]*Threshold* - concentration at which it is believed that all workers may repeatedly be exposed, 8 hr/day, every day, without adverse effect.

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

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

## 10.5 Appendix V: Other Hazardous Gases

It is possible that gases other than $H_2S$ may be encountered, but they pose a much lower hazard. In general, the measures taken to protect against $H_2S$ exposure will also be effective against other gases.

### 10.5.1 Carbon Dioxide

Carbon dioxide ($CO_2$) is commonly found dissolved in hydrothermal fluids and could be released from pore water when cores are recovered. $CO_2$ is usually considered inert and is heavier than air (1.5 times), concentrating in low areas of quiet air.

Carbon dioxide gas is toxic in higher concentrations but much less so than $H_2S$ (see toxicity table in Appendix III). The threshold limit of $CO_2$ is 5000 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.

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. If a massive flow of $CO_2$ from the well bore should occur (highly unlikely), the principal danger would be from asphyxiation due to lack of air.

Using a BA will provide adequate oxygen until the emergency can be controlled.

### 10.5.2 Hydrocarbon Gas

Hydrocarbon compounds are known to be present in sediments and potentially in hydrothermal fluids. These hydrocarbons are primarily in the form of methane gas, but some heavier gases and even liquids are possible.

The toxicity of methane is very low (see Appendix V), but it is often a "carrier" of $H_2S$. Because hydrocarbon gas is lighter than air, it does not tend to settle and is easily dispersed. The major threat from natural gas is its extreme flammability and explosivity. Hydrocarbon liquids may be carcinogenic, so common sense should be used in handling them if they are encountered.

The blowout control measures specified in this document can be use to control hydrocarbon gas as well as $H_2S$.

### 10.5.3 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 barium. Small amounts of radon may also be present in the pore water.

The radium emits very small amounts of radon 222 gas through radioactive decay, which also is radioactive. 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. Furthermore, the levels of radioactivity are extremely low—on the nannocurie scale.

ODP has investigated the potential effect of that radiation on health and safety on board the ship. Nevertheless, cores will be monitored for radioactivity if radioactive material is present.

The following precautions are to be taken if radon is encountered:

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

### 10.5.4 Sulfur Dioxide

Sulfur dioxide is produced during the burning of $H_2S$. Sulfur dioxide is

- Colorless,
- Transparent,
- Nonflammable,

- Heavier than air, but will be picked up by a breeze and carried downwind at elevated temperatures, and
- Extremely irritating to the eyes and mucous membranes of the upper respiratory tract.

The following table indicates the toxic nature of the gas.

| **Concentration of $SO_2$** | | **Effects** |
|---|---|---|
| **%** | **ppm** | |
| 0.0002 | 2 | Safe for 8 hr. |
| 0.005 | 3–5 | Pungent odor—normally a person can detect $SO_2$ in this range. |
| 0.0012 | 12 | Throat irritation, coughing, constriction of the chest, tearing, and burning of eyes. |
| 0.015 | 150 | So irritating that it can only be endured for a few minutes. |
| 0.05 | 500 | Causes a sense of suffocation, even with first breath. |

## 10.6 Appendix VI: Facial Hair Waiver

**WAIVER: HYDROGEN SULFIDE EXPOSURE – FACIAL HAIR**

Conditions may develop that require air breathing masks/respirators to be worn by personnel working in 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. Facial hair results in the respirator permitting negative air pressure inside the face piece during inhalation and causing excessive penetration by an air contaminant.

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 seal properly because of interfering facial hair, and I choose not to hold the Ocean Drilling Program–Texas A&M University, Texas A&M Research Foundation, National Science Foundation, or the owners of the *R/V JOIDES Resolution* 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:_____

## 10.7 Appendix VII: Perforated Ear Drum Wavier

**WAIVER: HYDROGEN SULFIDE EXPOSURE - PERFORATED EAR DRUM**

Due to the nature of operations on Leg ____, participants face potential exposure to hydrogen sulfide ($H_2S$) gas. Situations may develop that require air-breathing masks/respirators to be worn by personnel working in 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 University, Texas A&M Research Foundation, National Science Foundation, or the owners of the *R/V JOIDES Resolution* 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: _____

# Amendments