HEALTH, SAFETY & ENVIRONMENT DEPARTMENT

HYDROGEN SULPHIDE (H_2S) SAFETY STANDARD

1. PURPOSE

The purpose of this Standard is to mitigate the risk of exposure to personnel from hydrogen sulphide (H_2S) through safe work practices, engineering controls and emergency response.

2. SCOPE

2.1 In Scope

-> This Standard applies to Refinery, Sitra, Wharf and Marketing areas where there may be a risk of exposure to Hydrogen Sulphide.

Note: The hazards of Hydrogen Sulphide with respect to confined space entry is addressed in the Confined Space Entry Standard Reference: 5ii)

3. DEFINITIONS

3.1 H_2S Designated Area

An H_2S Designated Area is a Refinery Unit or Off-site Area which in the owner department's opinion may expose personnel to hazardous concentrations of hydrogen sulphide. This may be because the area contains H_2S Regulated Streams but this is not the only criteria.

-> H_2S Designated Areas within Bapco include:

- Crude Distillations Units
- Vacuum Distillation Units
- FCC Complex
- LSFO Complex
- LSDP Complex
- Oily Water Separators
- Waste Water Treatment Plant
- Other Refinery Units

Full details of H_2S Designated Areas can be found in Appendix 3

Note: H_2S may be present in non- "Designated" areas and can be encountered during a wide range of activities. The risks associated with specific work shall be addressed under the Permit to Work System. An area containing a "Regulated Stream" does not automatically make it a "Designated Area".

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3.2 Occupational Exposure Limits (OEL)

OEL is the generally acceptable level of personal exposure to a substance over a specified period of time.

3.3 H2S Regulated Streams

H2S Regulated streams are gas and liquid streams ***containing*** greater than 0.5% (5000 ppm) H2S by volume.

Note: There may be exemptions from regulated streams such as flare lines which have no flanges or valves. Similarly, some streams may pose an H2S hazard even though they have not been defined as regulated.

3.4 Short Term Exposure Limit (STEL)

STEL is a time-weighted average (TWA) exposure that should not be exceeded for any 15-minute period; allowed four times a day, with at least 60 minutes between exposures.

3.5 Immediate Danger to Life and Health (IDLH)

IDLH is any exposure that poses an immediate threat to life, or which is likely to result in acute or immediate severe health effects.

3.6 Bump Testing (Before Use Maintenance Procedure)

A bump test is "a qualitative function check in which a challenge gas is passed over the sensor(s) at a concentration and exposure time sufficient to activate all alarm settings." i.e. the bump test is the process that verifies "the performance of the gas detector and ensures that sensors are responding to their target gas." For example, an H2S sensor is exposed to H2S gas to verify its ***responsiveness***.

3.7 Calibration

A gas monitor calibration is a quantitative check to determine if a sensor can accurately read the known concentration of a calibration gas. If it can't, the calibration electronically adjusts the gas monitor to correct the difference between the sensor and calibration gas.

The International Safety Equipment Association (ISEA) issued the following position statement on instrument calibration: "A bump test or full calibration of direct-reading portable gas monitors should be made before each day's use in accordance with manufacturer's instructions, using an appropriate test gas." If the instrument fails a bump test, it must be adjusted through a full calibration before it is used.

3.8 Visitor

* For the purpose of this Standard, a "Visitor ***include Contractors in scope of visitor***" is anyone entering an H_2S Designated Area who is not part of the workforce normally associated with that area or not from within the H_2S Designated Area Department/Section.

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3.9 The Buddy System

This is where two people, (buddies), operate together as a single unit so that they are able to monitor and help each other during dangerous activities.,

3.10 Owner Department Responder

* A member of the owner department, such as the Area Outside Operator, ***who is*** trained to respond to H_2S situations and, qualified and certified in the use of SCBA.

3.11 * ***Docking Station:***

A Docking Station in the context of this standard is the actual station or cradle in/on which the personal H2S Monitor (or other gas tester) rests (or is docked) to perform a function.

4. RESPONSIBILITIES

4.1 Manager Health, Safety & Environment Department shall:

Be responsible for the issue, review and updates to this Standard and its general administration. He shall also ensure that this procedure is audited on a periodic basis for compliance and coordinate the appropriate training described in 6.6 and documenting the training accordingly.

4.2 H2S Designated Area Owner Department Managers shall:

a) Ensure that departmental employees involved in work or exposed to hazards associated with Hydrogen Sulphide attend required training as per clause 6.6.
b) Ensure the requirements of this Standard are implemented in the areas under departmental control.
c) Ensure availability of PPE and both fixed and portable gas detection / monitoring equipment in the areas under departmental control in compliance with this Standard.

4.3 Managers and Supervisors (Other Departments) shall:

a) Ensure that departmental employees involved in work or exposed to hazards associated with Hydrogen Sulphide attend required training as per clause 6.6
b) Ensure the requirements of this Standard are implemented in the areas under departmental control.
c) Ensure availability of PPE and portable gas detection / monitoring equipment as applicable in compliance with this Standard.

4.4 Employees shall:

a) Comply with all aspects of this Standard as applicable.
b) Ensure that they attend the required training stipulated in clause 6.6.

4.5 Visitor's shall:

Not enter any H_2S Designated Area unless they have either undergone the required training stipulated in clause 6.6 OR are accompanied by someone who has undergone the required training i.e. the Buddy System.

4.6 Plant Engineering Department (PED) – Instrument Engineer:

-> Following the established CPDEP process, in conjunction with the Owner Department and Analyser Instrument Group (AIG) representatives, the PED Instrument Engineer shall be responsible for the selection and approval of all H_2S monitors / analysers and definition of calibration requirements and frequency in accordance with manufacturer's recommendations.

4.7 Analyser Instrument Group (AIG) - Plant Maintenance Department:

In coordination with the Owner Department, AIG shall be responsible for conducting the calibration of all monitors / analysers as per the recommended schedule.

5. -> *REFERENCES*

i) OSHA Standard 29CFR 1910.1000 Table Z-2.
ii) OEMS/SAFE/SWP/CONF/1 Confined Space Entry Standard
iii) Caltex Principles D4 Hydrogen Sulphide 1993
iv) Caltex GPS-S7 Hazard Detection Systems and Alarm Signalling Systems.
v) OEMS/FE/EMERG/EMER/4 BAPCO NEW CRISIS AND EMERGENCY RESPONSE PLAN
vi) American National Standard – ANSI/ASSE Z390.1-2006 Accepted Practice for Hydrogen Sulphide Training Programs
vii) REFIN/OPDGEN/000/EMER/1OPD Standard EMERGENCY DRILL - H_2S LEAK RESPONSE
viii) OEMS/FE/FIRE/FIRE/2 Maintenance and Calibration of Portable Gas Testing Equipment
ix) REFIN/TS/000/GENE/3 BAHRAIN REFINERY TERMINOLOGY FOR PROCESS UNITS AND FEED AND PRODUCT STREAMS

6. PROCEDURE

Hydrogen Sulphide (H_2S) gas occurs as a by-product of crude oil and the refining process. H_2S also occurs naturally by decaying organic matter such as sewage.

6.1 H_2S Designated Areas (Access Control)

6.1.1 Sign Posting

-> Appropriate sign posting shall be displayed at all the entrances to H_2S Designated Areas in both Arabic and English.

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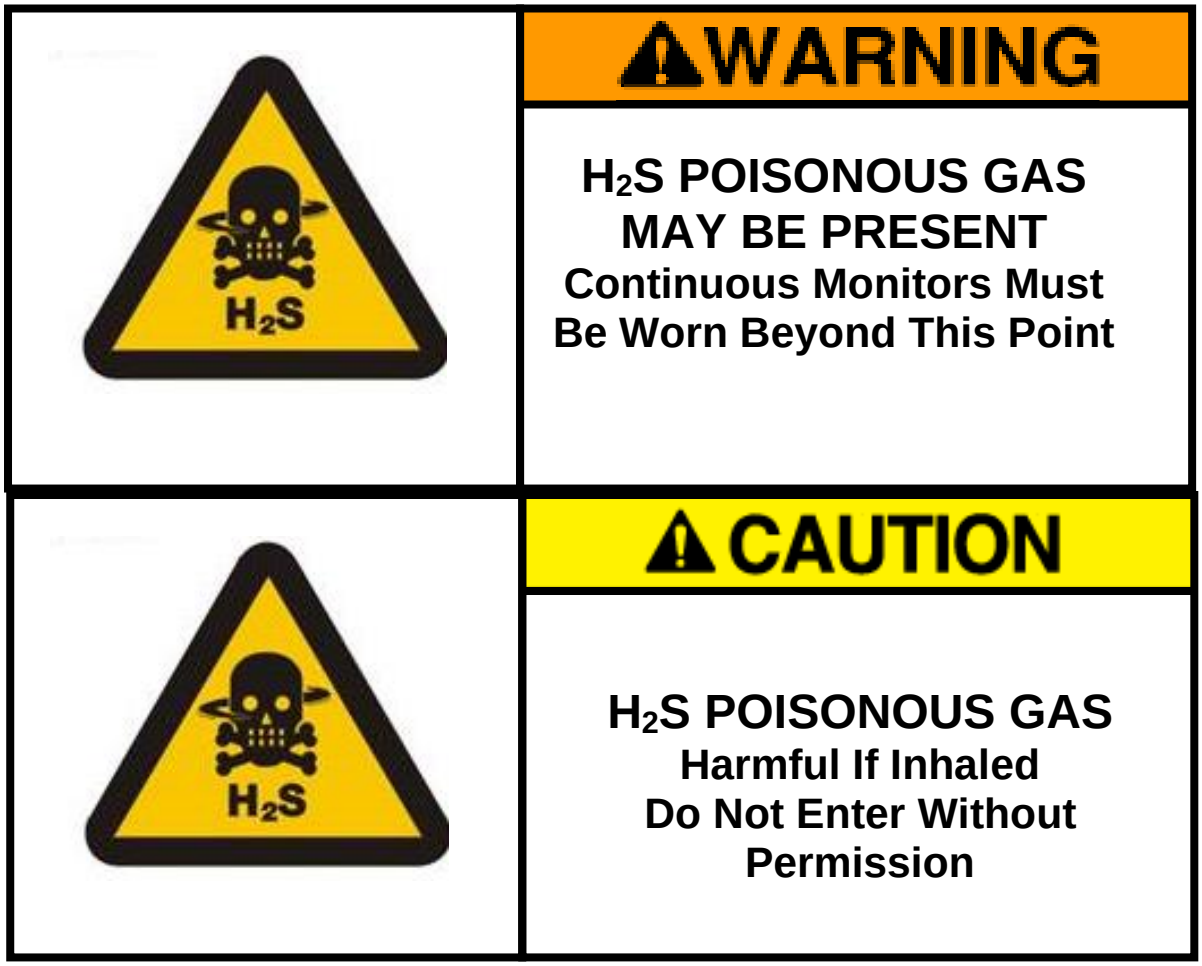

6.1.2 Labelling

All H_2S regulated streams shall be stenciled with black lettering on a yellow background **"HYDROGEN SULPHIDE"** at no more than 15 meter intervals and/or in other strategic and appropriate locations. These are in addition to the normal stream identification stenciling. The stenciling shall be kept / maintained in good condition.

6.1.3 Wind Socks

Wind socks shall be strategically located and maintained in all H_2S Designated Areas.

6.1.4 -> Entry to H2S Designated Areas

- Before entering an H_2S Designated Area, (as with any Refinery Unit) permission must first be obtained from the Control Room or Work Station.
- The visitors Company Badge will be exchanged for an H_2S Badge. This may only be done if the visitor has attended an approved H_2S course as described in Clause 6.6 **OR** is escorted at all times by someone who meets the criteria of Clause 6.6.

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- All personnel entering an H_2S Designated Area shall wear an H_2S Personal Monitor except for visitors who are being escorted (buddied) by a trained individual who is wearing one.
- In the case where a visitor is trained to the requirements of Clause 6.6, but does not have his own Personal H2S Monitor; limited numbers of spares may be available with the Owner Dept. **BUT,** it is not the Owner Departments responsibility to have adequate spares for all visitors.
- All personnel entering an H_2S Designated Area shall also ***c***arry a personal escape mask. A number of spares shall be available at designated Control Rooms/Workstations.

Where a Permit To Work is required, the Issuing or Approving Authority shall indicate on the Permit whether the work is being conducted in an H_2S Designated Area and accordingly shall ensure that personal H2S Monitors and escape masks are used by personnel entering the area.

Note: **Under certain circumstances such as pre-shutdown activities where there are many people working in a relatively small area, the requirement for individual personal monitors/alarms may be replaced by the use of strategically positioned portable monitor /alarms. Any such deviation shall be at the discretion of the Owner Department Manager.**

6.2 Warning Systems

There are various H_2S warning alarm systems that are used in various locations and for various applications in Bapco and these are discussed below:

6.2.1 Fixed Monitor/Alarms

These are generally installed in all H_2S Designated Areas. Their sensors are typically located 18" above the ground and have an elevated visual beacon and audible alarms which are both actuated when the sensor detects H_2S at or above the alarm set point.

6.2.2 Portable Monitor/Alarms

Portable gas monitor/alarms are used when tasks are being conducted where there is a potential for the presence or release of H_2S and no fixed monitor/alarms are installed in that area.

6.2.3 Hand Held Multi Gas Testers

These are typically used by Bapco's Operations departments (OPD, OS&E, P&U) to test on-site conditions before permit issuance.

6.2.4 Personal Monitor/Alarms

***** Personal monitor/alarms are small light weight devices worn by an individual preferably on the top pocket or clipped near the collar, i.e. near the nose and mouth (breathing zone).

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If it is clipped on the top pocket, care must be taken not to obscure the sensor from the source of gas.

Personal H_2S monitors must be worn by every person in all H_2S Designated Areas as well as for certain maintenance activities outside of H_2S Designated Areas where there is a potential exposure to H_2S (this may be determined within the risk assessments).

Note: Specific rules for use of personal H_2S monitors:
Personal H_2S monitors must be inspected for defects and bump tested in accordance with manufacturer's recommendations to ensure proper function.

Note: Monitors with two sensor technology (i.e. where two sensors detect the same gas and provide simultaneous readings to the monitor) have been proven to be more reliable than single sensor devices. Under these circumstances and provided the manufacturer has supported such a decision, the requirement for BUMP testing can be waived provided monthly calibration is conducted.

6.2.5 Calibration

All H_2S detectors must be calibrated in accordance with the manufacturer's instructions. Bapco's calibration regime is as per the table below. Calibration expiry dates are fixed to units (except for fixed monitor/alarms or devices that are calibrated in a Docking Station):

*

Current Calibration Regime			
Equipment Description	Alarm set point (High)	(High-High)	Frequency
Fixed Detectors (Drager)	15ppm (old refinery units)	-	13 weeks
Fixed Detectors (Drager)	10ppm (new refinery units)	-	13 weeks
Multi-gas ***portable***	6 ppm H_2S O_2 19.5% Low alarm 10%LEL	15 ppm H_2S O_2 22% high alarm 20% LEL	4 weeks ***and daily Bump Test***
Personal (BW)	10 ppm	-	daily Bump Test
Personal (IS Tango)	10ppm		4 weeks ***and weekly Docking***
Transportable (Dalek) Crowcon/Multiguard	10 ppm	_	4 weeks

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6.3 Respiratory Protective Equipment (RPE)

There are three types of RPE available in Bapco for use with H_2S:

a) Self Contained Breathing Apparatus (SCBA) which is strategically located in H_2S Designated Areas. These can only be used by qualified and trained employees for the use of rescue operations and investigation of H_2S sources.
b) 10-minute Escape sets which are strategically located in H_2S Designated Areas. These can only be used by qualified and trained employees for the use of escape.
c) Escape Device (Mask) (mouth piece / nose clip) which have a concentration limit and designed for escape purposes only. These should be carried by all personnel entering H_2S Designated Areas and donned immediately upon hearing an H_2S alarm.

6.4 Action in Case of an H_2S Alarm within the Refinery

6.4.1 Alarm/Evacuation /Monitoring

If a personal or fixed H_2S monitor should alarm, or an H_2S leak is detected within the refinery, the following action shall be taken:

a) Employee and Contractor / Visitor H_2S Evacuation Response:

1. Don personal escape mask and evacuate the potential H_2S exposure area in either the upwind or crosswind direction, and proceed to the nearest designated muster area.

2. *Visitors / ***Contractors*** and non-response personnel may NOT return to the potential H_2S exposure area until after the H_2S source has been removed and the site declared safe for re-entry by the Owner Department on-site Commander.

b) Operators' Response

The Control Operator shall monitor the alarm point locations and concentrations from the control panel where applicable and maintain direct contact with all Owner Dept on-site personnel.
The Area Outside Operator or other Owner Dept responder shall don SCBA and assess the situation. The responder(s) shall work with a stand-by man or in a buddy system and:

1. Ensure the area is evacuated of all non-essential personnel.
2. Check area for casualties and move them to a safe area (fresh air) if possible.
3. If necessary, instruct the Control Operator to call the emergency number 5555 for emergency assistance such as the ambulance or traffic control etc.
4. Direct emergency responders to safe areas.
5. Identify and Isolate the source of H_2S leak where possible.
6. Indicate to the Control Room Operator if and when the area can be reoccupied.

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Note: If the alarm situation/leak persists for an extended period of time, additional SCBA shall be made available at the owners request by HS&E Department.

Note: Personnel with long beards and/or prescription glasses must not enter the H_2S exposure area for investigation purposes. They should leave the exposed area after donning a 10-minute Escape set or Personal Escape Mask and inform their Supervisor.

Note: If there is a release that may potentially reach public areas (outside the refinery), the Company Crisis and Emergency Response Procedure (CERP) shall be initiated.

6.4.2 Drills

Owner Departments shall conduct regular H_2S "Alarm Drills" for evacuation and response purposes.

As a minimum the Owner Department shall conduct emergency drills on quarterly intervals in each H_2S Designated Area / Section /Complex.

The results and findings of these drills shall be communicated to the Section Superintendent and Department Manager and recorded in their emergency drill record. Employees, Contractors and Visitors who fail to respond to the drills in an appropriate manner shall be investigated and corrective actions developed. The investigation and corrective actions shall form part of the emergency drill record. Any disciplinarily action resulting from non-compliance, shall be considered on a case-by-case basis by the individual Manager's.

6.5 Breaking Containment of an H_2S Regulated Stream

The minimum requirements for "breaking containment of an H_2S Regulated Stream" are as follows:

1. System must be depressured to a safe location (either to flare, incinerator or back into the process)
2. System must be "gas freed" by steaming or inert gas displacement to a safe location
3. Where possible, systems should be chemically decontaminated using "Zyme-flow" or equivalent process. Note if chemical decontamination is carried out, gas freeing requirement will be greatly reduced or eliminated.
4. Where possible, systems must be "wetted" with either clean water or steam to prevent ignition of pyrophoric material when exposed to oxygen.
5. The area surrounding the break of containment site must be adequately barricaded to prevent unauthorized entry.
6. * Flanges shall ONLY be broken under a "Hot Work" ***certificate*** which MUST stipulate the use of self-contained breathing apparatus.
7. * An ***Owner*** Department ***representative*** shall be standing by at a safe distance and in radio contact with control room.
8. * A portable H2S monitor shall be placed downwind of the work ***site***.

9. * A rescue plan shall be developed for each ***plausible*** scenario.
10. Once opened, systems must be carefully monitored for temperature rise which would indicate burning of pyrophoric material.

6.6 Training

6.6.1 Initial Training

Employees and Contractors required to work in or enter any areas that may contain hydrogen sulphide (H_2S) shall be provided with training prior to initial assignment. Training shall be developed and conducted by personnel who are qualified either by specific training or through educational or work-related background. At a minimum, training should include:

a) Physical and health hazards of hydrogen sulphide,
b) Symptoms of exposure to H_2S,
c) Specific locations where personal H_2S monitors and respiratory protective equipment are required, locations of fixed H_2S monitor/alarms, and emergency response.
d) Use of respiratory protective equipment,
e) Methods to detect the presence or release of hydrogen sulphide (e.g., monitor/alarms, monitoring equipment),
f) Emergency and medical procedures as outlined in facility contingency plan,
g) Special precautions to minimize exposure,
h) Cardio-Pulmonary Resuscitation (CPR) and First Aid awareness.
i) How to report an H_2S leak.

Personnel working in an H_2S environment shall carry their current H_2S training certification card, as proof of having received the correct training, on their person at all times.

Note: This training only provides an introduction to respiratory protective equipment and CPR/First Aid and does not replace specialized certified training.

6.6.2 Refresher Training

Refresher training shall be conducted every three years. This will be significantly shorter than initial training but will include all the elements of the initial training and may be computer based. Refresher training must be documented and records retained as per Company requirements.

6.7 Emergency Response Planning

Plans, procedures and scenarios shall be incorporated within the Company Crisis and Emergency Response Procedure (CERP) for catastrophic releases of H_2S which may impact the community at large.

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6.8 Occupational Exposure Monitoring

Occupational Exposure Limits (OEL)		
	8-Hour TWA (PPM)	15-min STEL (PPM)
Bahrain	10	15
Bapco adopted value	10	15
UK (Europe)	5	10
U.S. (ACGIH)	1	5

Note:*-> Extensive personal Occupational Exposure monitoring *has been conducted* for both Operations and Maintenance personnel. No routine task exposures for either the 8-hour TWA or 15-min STEL's were identified. Therefore, routine exposure monitoring will be of no further benefit and the risk of H_2S exposures continues to be loss of containment as a result of leaks, sampling activities etc.

6.9 Disposal Considerations

6.9.1 Calibration and Bump Station Gas Cylinders

a. Gas Cylinders owned by the Company shall be depressurized and sent to the procurement salvage yard when empty.
b. Where a full supply and service agreement has been made for the provision of Personal H_2S Monitors and docking stations, the Service Provider shall be responsible for the collection and disposal of the gas cylinders, used within this Contract.

6.9.2 Personal H_2S Monitors

a. Personal H_2S Monitors owned by the Company shall be collected by all end user departments and stored until HSE Department – Environmental Section has implemented a process for recycling these devices.
b. Where a full supply and service agreement has been made for the provision of Personal H_2S Monitors and docking stations the Service Provider shall be responsible for the collection and disposal of the broken or expired Personal Monitors used within this Contract.

7. APPENDICES

ii) Appendix 1 – Health Effects of H_2S

iii) Appendix 2 – Properties & Hazards of H_2S

iv) -> Appendix 3 – H_2S Designated Areas

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8. SUPERSEDED DOCUMENTS

***** ***HYDROGEN SULPHIDE (H2S) SAFETY Standard OEMS/OCCHY/000/PHYCO/14, Issue 2.1, dated 8th February, 2016.***

Changes/Additions are shown in Bold/Italics and with an asterisk (*)
-> Denotes Deletion

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Appendix 1

Health Effects of H_2S

The following table provides general health effects of H_2S at various concentrations. Physiological effects may vary and are dependent upon the sensitivity & medical condition of an individual, exposure concentration, and length of exposure.

Table 1 – Health Effects of Hydrogen Sulphide

H_2S Concentration	Signs & Symptoms
0.0012 – 0.13 ppm	Odour threshold, smell of rotten eggs (highly variable)
1 – 10 ppm	Moderately offensive odor, possibly with nausea, or headaches with prolonged exposure.
15-50 ppm	Nose, throat and lung irritation, digestive upset and loss of appetite, sense of smell starts to become "fatigued", odour cannot be relied upon as warning for exposure.
100 - 200 ppm	Severe nose, throat and lung irritation, ability to smell odour completely disappears. IDLH (Immediately Dangerous to Life and Health) – maximum concentration that a healthy worker can be exposed to for up to 30-minutes & not suffer debilitating or irreversible health effects.
200 – 300 ppm	Marked eye inflammation and respiratory tract irritation after one hour of exposure.
500 ppm	Loss of consciousness and possibly death in 30-minutes to 1-hour.
700 – 1000 ppm	Rapid loss of consciousness, cessation of respiration and death.
>1000 ppm	Unconsciousness in seconds, death in few minutes unless victim is removed from exposure.
LEL = 4.3% by volume of air (43,000 ppm) & **UEL** = 45.5% by volume of air (455,000 ppm)	

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Appendix 2

Properties & Hazards of H_2S

Hydrogen Sulphide is a colourless, flammable, toxic and corrosive gas that can occur naturally in crude oil, natural gas and produced water. Synonyms: dihydrogen monosulphide, dihydrogen sulphide, hydrogen sulfuric acid, sewer gas, stink damp, sulfurated hydrogen, sulfur hydrogen; CAS #: 7783-06-4;

It has a distinctive odour of rotten eggs in low concentrations and may accumulate in low-lying areas due to it being heavier than air (vapor density 1.18). It also may be present in airspace above liquids in tanks, sewers and pits. A release may occur when equipment is opened, drained or when sludge is agitated and proper precautions (i.e. permitting/air monitoring, breathing air) shall be addressed prior to performing work.

Prolonged exposure to a low concentration can decrease the sense of smell and may irritate the eyes, nose, throat and respiratory tract. Also, the ability to smell H_2S disappears at higher concentrations; therefore the sense of smell should never be depended upon to detect any level of H_2S. Exposure to high concentrations (i.e. $\geq$ 100 ppm) of H_2S can paralyze the olfactory nerves, resulting in a loss of the sense of smell, which could result in asphyxiation and death.

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-> ***Appendix 3***

H_2S Designated Areas

Standard Abbreviation	Unit Name	Dept
Crude Distillation Units		
1CDU	No.1 Crude Distillation Unit	OPD-N
2CDU	No.2 Crude Distillation Unit	OPD-N
3CDU	No.3 Crude Distillation Unit	OPD-N
4ACDU	No.4A Crude Distillation Unit	OPD-S
5CDU	No.5 Crude Distillation Unit	OPD-N
Vacuum Distillation Units		
1VDU	No.1 Vacuum Distillation Unit	OPD-N
5VDU	No.5 Vacuum Distillation Unit	OPD-S
6VDU	No.6 Vacuum Distillation Unit	OPD-N
FCC Complex	Fluid Catalytic Cracking Complex	OPD-N
FCCU	Fluid Catalytic Cracking Unit	OPD-N
GCU	Gas Concentration Unit	OPD-N
OGTU	Olefinic Gas Treating Unit	OPD-N
NRC	Naphtha Rerun Complex	OPD-N
	Wet Gas Compressor	OPD-N
LSFO Complex	Low Sulphur Fuel Oil Complex	OPD-N
#1H2 Plant	No.1 Hydrogen Plant	OPD-N
2HDU	No.2 Hydrodesulphurisation Unit	OPD-N
3SRU	No.3 Sulphur Recovery Unit	OPD-N

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4SRU	No.4 Sulphur Recovery Unit	OPD-N
2TGTU	No.2 Tail Gas Treating Unit	OPD-N
3SWS	No.3 Sour Water Stripper	OPD-N
4SWS	No.4 Sour Water Stripper	OPD-N
OGTU	Olefinic Gas Treating Unit	OPD-N
PSA	Pressure Swing Adsorption	OPD-N
LSDP Complex	Low Sulphur Diesel Production Complex	OPD-S
1HCU	No.1 Hydrocracking Unit	OPD-S
2HCU	No.2 Hydrogen Unit	OPD-S
LBOU	Lube Based Oil Unit	OPD-S
1ARU	No.1 Amine Regeneration Unit	OPD-S
1SRU	No.1 Sulphur Recovery Unit	OPD-S
2SRU	No.2 Sulphur Recovery Unit	OPD-S
1TGTU	No.1 Tail Gas Treating Unit	OPD-S
BAGRU	Bulk Acid Gas Removal Unit	OPD-S
1SWS	No.1 Sour Water Stripper	OPD-S
2SWS	No.2 Sour Water Stripper	OPD-S
Other Units		
CGRU	Crude Gas Recovery Unit	OPD-N
1VBU	No.1 Visbreaker Unit	OPD-N
Unifiner	Unifiner (Naphtha Hydrotreater)	OPD-S
KGSP	Khuff Gas Sweetening Plant	OPD-N
SHF	Sulphur Handling Facility	OPD-N
WWTP	Waste Water Treatment Plant Biological Treatment Area / Unit Feed Pit	P&U
No.3 OS	No. 3/4/5 Oil Separator (Badges at HLPH)	P&U