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## CONFINED SPACE SAFE PRACTICE



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### **Guidelines for safe entry of Confined Spaces**

# Confined Spaces Safe Practice

## 1 Definitions

### 1.1 Confined Space

*Confined space* means a space that has any of the following characteristics:

- limited openings for entry and exit;
- unfavourable natural ventilation;
- not designed for continuous worker occupancy.

It includes, but is not limited to, boilers, pressure vessels, cargo holds, cargo tanks, ballast tanks, double bottoms, double hull spaces, fuel oil, lube oil, sewage-tanks, pump-rooms, compressor rooms, cofferdams, void spaces, duct keels, inter-barrier spaces and engine crankcases.

### 1.2 Competent person

*Competent person* means a person with sufficient theoretical knowledge and practical experience to make an informal assessment of the likelihood of a dangerous atmosphere being present or subsequently arising in the space.

### 1.3 Responsible person

*Responsible person* means a person authorised to permit entry to a confined space and having sufficient knowledge of the procedure to be followed.

### 1.4 Marine Chemist

A *Marine Chemist* is a person who possesses a current Marine Chemist Certificate issued by the National Fire Protection Association (NFPA 306: Control of Gas Hazards on Vessel Sections) or equivalent.

## 2 General Hazards

Work in confined and enclosed space has a greater likelihood of causing fatalities, severe injuries and illness than any other type of shipyard work or onboard ships.

The key hazards associated with confined spaces are:

- serious risk of fire or explosion;
- loss of consciousness from asphyxiation arising from gas, fumes, vapour or lack of oxygen;
- drowning arising from increased water level;
- loss of consciousness arising from an increase in body temperature;
- asphyxiation/suffocation arising from free flowing solid (engulfment) or the inability to reach a breathable atmosphere due to entrapment.

Surveyors will routinely enter confined spaces that are difficult to access due to small and/or narrow openings. There may be physical constraints within the space which need to be considered, and the space itself may be cramped permitting only restricted mobility.

Given the usual enclosed and darkened nature of a confined space this activity ideally should not be carried out by personnel suffering from phobias (e.g. claustrophobia) or who are susceptible to panic or anxiety attacks.

For further details regarding hazards in confined spaces see Annex, section 2, Confined Space Hazards.

## 3 Confined space – Safe entry policy

### 3.1 General

When requested to enter a confined space:

Only enter a confined space when a permit to enter has been issued and if you consider it is safe to do so, and then only remain in the inside for as long as it is necessary to carry out the work.

It is the full responsibility of the owner of the confined space (i.e. ship, shipyard) to make and ensure that the confined space is safe to enter.

- The surveyor has the right to refuse to enter an unsafe and/or unknown space.
- If he/she is not confident that a space is safe, he/she should report his concerns and not enter until all safety requirements are met.

The surveyor shall not enter a space that requires use of a respirator.

The surveyor may wear a respirator or escape pack if required by an Owner's policy and only if sufficiently trained in the use of such equipment, BUT the space MUST be safe first.

**Note:**

- ***Do not enter a space first or alone!***
- ***If in doubt - do not enter - no survey is worth risking life or health for.***

### 3.2 Entering confined spaces adjacent to loaded tanks

It is important to be aware that confined spaces may be, or have been, subject to leakage from the adjacent space. The risk is that such leakage often remains undetected because the space is not subject to regular gas measurements and ventilation.

Confined spaces adjacent to loaded tanks may be entered provided the procedure for entry as given in item 4 below is completed.

Spaces adjacent to cargo tanks, like cofferdams and double bottom tanks, may contain accumulated residues from previous cargoes and information about these cargoes is needed to determine proper test methods for the atmosphere in the adjacent spaces.

If a tank is loaded with cargoes having a toxic vapour hazard identified by an entry T in column K of the IBC Code Ch.17, or with a toxic symbol in the Data Sheet, no survey is to be carried out in a confined space adjacent to that tank.

Be aware that toxicants produced by work (like coating, sandblasting and hydro blasting) in the area of a confined space can enter and accumulate in the confined space.

### 3.3 Entering confined spaces adjacent to inerted tanks

When other tanks in an inert condition are either adjacent or interconnected (e.g. pipeline) to the space to be entered, personnel should be alert to the possibility of inert gas leaking into that space through, for example, bulkhead fractures or defective valves. The risk of this occurring can be minimized by maintaining a small but positive pressure in the space to be entered relative to the inert gas pressure. At all times the procedures on the vessel are to be followed.

## 4 Confined space - Safe entry procedure

### 4.1 General

Prior to entry into an enclosed space or tank the following procedure should be applied:

- a) A Safety meeting should be held prior to the survey to discuss all aspects of safety measures including at least all items below.
- b) Entry Permit should be obtained for the space to be entered. See item 5 below.
- c) Identify the hazards and assess the risks.
- d) In order to be able to identify the hazards in the space to be surveyed and assess the risks, the following information should be available:
  - Latest content of the spaces to be surveyed should be identified and the content in spaces adjacent to them.
  - For Gas Carriers: a data sheet for the last cargo should be presented.
  - For Chemical Tankers: a data sheet for the previous three cargoes should be presented.

It is the Owner's responsibility to provide this information.

- e) Evaluate ventilation of the space:
  - Check that the tank or enclosed space is empty, cleaned and ventilated.

The Owner is obliged to document that this is carried out. See also item 7.1 below.
- f) Evaluate need for isolation of the space. See item 7.2. below.
- g) Ensure that a standby and/or rescue team is in place. See item 7.3 below.
- h) Check and evaluate gas measurements taken. For testing and limit values see item 6 below:
  - as a minimum, oxygen measurements should be carried out before entry into the enclosed space. When found necessary the measurements should be taken under the supervision of the surveyor.
  - in addition a set of additional control measures should be evaluated depending on what kind of tank is to be surveyed. See Annex, Checklist for Entry into Confined Spaces.

The surveyor should always use his personal gas measuring equipment during the survey.
- i) Evaluate need for precaution against extreme temperature. See Annex, section 6.1, Temperature extremes.
- j) Evaluate the lighting arrangement. See Annex, section 8.2, Lighting.
- k) Evaluate if special clothing and/or equipment are required.

A checklist with the items above is recommended to be used for evaluation if the space is safe to enter.

If extensive work is to be carried out within a large space, such as a cargo tank, it is recommended that a full assessment of the tank atmosphere is undertaken after the initial tests have been satisfactorily carried out and recorded. The tank atmosphere should be checked frequently during this entry, with particular attention being placed on testing the work location(s) and places that are inaccessible for testing from the deck. On satisfactory completion of this additional atmosphere test, the results should be recorded as required by the appropriate safety procedure in the Safety Management System.

## 4.2 Entering confined spaces adjacent to loaded tanks on double hull tankers – additional requirements

The compartmentalized structure in double hull and double bottom tanks makes them more difficult to gas free than conventional tanks and particular care should be taken to monitor the tank atmosphere.

Although entry into double hull or double bottom tanks with adjacent tanks loaded should be kept to a minimum, tank entry will on occasion be required for such purpose as tank inspections.

In relation to the entry procedure above, the following additional recommendations should be strictly enforced.

Once the tank atmosphere meets the entry criteria at each sampling point, actual entry by personnel should be undertaken in two stages.

### First stage

The first stage should be for the purpose of atmosphere verification and a general safety review. The personnel making the entry should be equipped with:

- an emergency escape breathing set,
- personal gas detector capable of monitoring at least hydrocarbon and oxygen,
- portable radio,
- emergency light source,
- a retrieval harness,
- an alternative means of attracting attention, e.g. a whistle.

### Second stage

Only after the first stage has verified that the atmosphere throughout the tanks is safe for the intended task should entry for other purpose be permitted.

## 5 Permit-to-work and permit-to-enter

The ISM code requires the Company to establish safe practices in ship operation and a safe working environment. This is commonly provided for by a permit-to-work system that is drawn up to provide a formal written safety control system. MOU and FPSO units not covered by ISM code have a similar permit-to-work system.

A permit-to-work will:

- set out the work to be done, the location and the precautions to be taken;
- predetermine safe methods of work;
- provide a clear record that all foreseeable risks have been considered;
- define the precautions to be taken and their sequence;
- provide written authority for the confined space to be entered and the work to start and the time when the work must cease.

Entry into a confined space should only be allowed when a separate permit-to-enter has been issued. This permit should only be issued after tests have taken place to ensure that the atmosphere is safe to breathe.

### **Note:**

***Use of non-explosion proof equipment like cameras, torches, chipping hammers, may be allowed provided that it is stated in the Entry permit issued and the space is safe for hot work or safe for workers and LEL is measured to 0%.***

## 6 Testing of the atmosphere

### 6.1 General

Initial testing should be carried out by a certified “Marine Chemist” or a “Competent person” or similar accredited person who will issue a certificate stating whether the space is ‘safe for man’ and/or work, and if any special conditions are to be observed.

On a vessel this may be the Chief Officer, or other competent person onboard. If in doubt of the officer’s qualification, documentation is required to be shown. In no case should the class surveyor be considered to be a “Competent Person” - even if he is equipped with his own personal testing equipment.

Ventilation should be stopped about 10 minutes before tests are made and not restarted until the tests are completed.

The testing should be carried out in the following sequence

- Oxygen-deficient or -enriched atmospheres
- Flammable atmospheres
- Toxic atmospheres when considered necessary

To evaluate the measurements taken, the following limit values should be used.

### 6.2 Testing for oxygen

Any atmosphere with less than 20.8% ( $\pm 0.2\%$ ) oxygen by volume should *not* be entered. Oxygen measurements should be carried out by, or under supervision of, the surveyor immediately before entry into the confined space.

### 6.3 Testing for flammable atmosphere

A space with an atmosphere with more than 1% of the “Lower Flammable Limit” (LFL) or “Lower Explosive Limit” (LEL), on a combustible gas indicator should not be entered.

The Flammability indicator shows the percent within a safety range of 0-10% of the Lower Explosive Limit (LEL) and, ideally, should read 0%.

Combustible gas detectors have normally two measuring ranges 0-100% LEL and 0-10% LEL.

### 6.4 Testing for toxic atmospheres

Toxins are measured in parts per million (PPM). Under no circumstances should the surveyor enter a confined space

exceeding the limits specified below. Different testing bodies throughout the world may, however, have different acceptance limits.

Gas	Limit 8 Hour work shift [ppm]	Limit 15 min working [ppm]
Benzene (C <sub>6</sub> H <sub>6</sub> )	1	5
Hydrogen Sulphide (H <sub>2</sub> S)	5	20
Carbon Dioxide (CO <sub>2</sub> )	5000	10000
Carbon Monoxide (CO)	20	50
Nitrogen Dioxide (NO <sub>2</sub> )	1	3
Nitrogen Monoxide (NO)	25	50
Sulphur Dioxide (SO <sub>2</sub> )	2	5

For vessels with inert gas systems, trace amounts of various toxic gases may increase the hazard of exposure for personnel. Normally, a steady 21% by volume of oxygen reading will be sufficient to dilute these gases to below their "Threshold Limit Value" (TLV).

**Note:**

***Never trust one's own senses to determine if the air in a confined space is safe! Many toxic gases and vapours can neither be seen nor smelled, nor can the level of oxygen present be determined.***

Be aware that some chemicals have a lower TLV value than odour value. Gases from these substances will not be traceable by smell before they are dangerous to health.

## 6.5 Testing instruments

For further details, see Annex, section 8, Personal Protection Equipment (PPE), and section 3.2, Testing Instruments.

**Note:**

- ***When Draeger tube or equal is used for detecting toxic gases the sampling gas should have sufficient time to pass through the sampling hose.***
- ***If manual hand rubber pump is used, approx. 4 squeezes are needed for each metre of the sampling hose.***
- ***If battery driven pumps are used, approx. 10 sec. for each metre of sampling hose should be sufficient.***

## 7 Preparation for Entering Confined Spaces

### 7.1 Ventilation

Ventilation should be continuous where possible because in many confined spaces the hazardous atmosphere will form again when the flow of air is stopped. All openings are to be opened for ventilation including emergency exit.

De-ballasting a tank does not guarantee a safe atmosphere. Testing of the atmosphere is still required.

The inert gas fans should not be used to provide fresh air ventilation because contaminants from the inert gas lines could be introduced into the tanks.

For further details, see Annex, section 4, Ventilation.

## 7.2 Isolation of Space

The surveyor should evaluate the need for isolation of the confined space from service before entering the space.

The surveyor should not enter or remain in any ballast or cargo tank if ballast is transferred into or out of any tank, if not agreed beforehand.

For further details regarding isolation of spaces from service, see Annex, section 5, Isolation of space.

## 7.3 Standby / rescue

### *Standby*

A standby person should be assigned to remain on the outside of the confined space and be in constant contact (visual or two-way voice communication e.g. walkie-talkie) with the survey team inside. Routines for communication intervals with the survey team should be established.

The standby person:

- should not have any other duties than to serve as standby and know who should be notified in case of emergency;
- should never leave his post even after help has arrived and is a key communication link to others onboard;
- should be able to communicate sufficiently in a relevant common language.

Communication between watch personnel (Bridge, Cargo Control Room or Engine Control Room) and standby person should be established.

### *Rescue*

Rescuers must be trained in and follow established emergency procedures and use appropriate equipment and techniques (such as lifelines, respiratory protection, standby persons).

Emergency and evacuation procedures should be agreed and understood by all parties involved in a potential rescue operation. Steps for safe rescue should be included in all confined space entry procedures. Rescue should be well planned and evidence should be made available that indicates drills have been frequently conducted on emergency procedures.

### ***Note:***

***Unplanned rescue, such as when someone instinctively rushes in to help a downed co-worker, can easily result in a double fatality or even multiple fatalities if there is more than one would-be rescuer.***

***Over 50% of the workers in confined spaces die while attempting to rescue other workers.***

***An unplanned rescue could be the last!***

## 8 Personal Protection Equipment (PPE)

PPE is traditionally regarded as the last line of protection with the emphasis being placed on avoidance and appropriate managerial control methods. However, the potentially hazardous nature and isolated position of those entering a confined space means that, for the surveyor, PPE may be the first line of protection.

Each confined space will present different hazards and degrees of risk to health and safety, the final provision of PPE should therefore be based on an assessment of risk.

As a general rule the following guidance is offered.

Basic surveyor PPE should include:

- Body protection (hard wearing overalls with suitable pockets for notebook, etc);
- Foot protection (steel toecaps (200 joules), steel midsoles, good grip, oil resistant);
- Head protection (hard hat with chinstraps);



- Hand protection (hard wearing gloves);
- Eye protection (protective glasses, goggles);
- Ear protection (ear defenders or ear plugs – worn subject to communication system);
- Gas meter - multi-gas meter for measuring of HC, H<sub>2</sub>S, CO, O<sub>2</sub> is recommended;
- Lighting (hand held with lanyard and appropriate beam width).

## Reference List

ISGOTT International Safety Guide for Oil Tankers and Terminals, fifth edition.

Tanker Safety Guide Chemicals, third edition

Tanker Safety Guide Liquid Gas, second edition 1995

OCIMF - Health, Safety and Environment at New-building and Repair Shipyards and During Factory acceptance testing (01 July 2003)

IACS Recommendation No. 39 - Safe use of Rafts or Boats for Survey

## Annex to Recommendation 72

### Guidelines for Safe entry of Confined Spaces

#### 1 General

If a Survey is required to be carried out in a:

- boiler or pressure vessel,
- cargo tank,
- ballast tank,
- double hull space,
- fuel oil tank,
- lube oil tank,
- cargo hold,
- void space, or
- similar type of enclosure,

the work will take place in a confined space.

#### *How to Identify a Confined Space?*

A confined space is a space that has any one of the following characteristics:

- limited openings for entry and exit;
- unfavourable natural ventilation;
- not designed for continuous worker occupancy.

#### *Limited openings for entry and exit:*

Confined space openings are limited primarily by size or location. Openings are usually small in size, perhaps as small as 450 mm (18 inches) in diameter, and are difficult to move through easily. Small openings may make it very difficult to get needed equipment in or out of the spaces, especially life-saving equipment when rescue is needed. However, in some cases openings may be very large, for example open-topped spaces such as ships' holds. Access to open-topped spaces may require the use of ladders, hoists, or other devices, and escape from such areas may be very difficult in emergency situations.

#### *Unfavourable natural ventilation:*

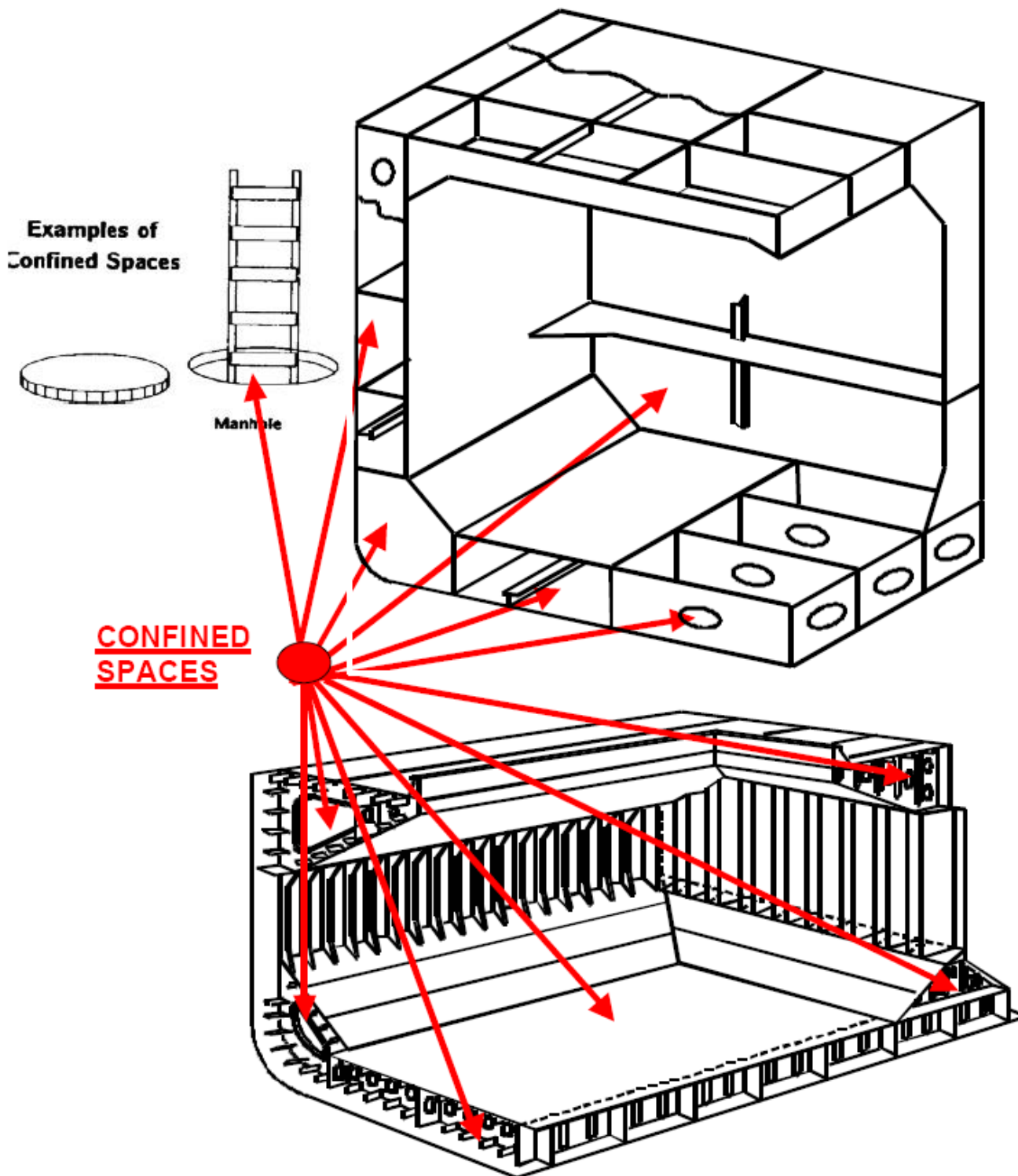
Because air may not move in and out of confined spaces freely due to the design, the atmosphere inside a confined space can be very different from the atmosphere outside. Deadly gases may be trapped inside, particularly if the space is used to store or process chemicals or organic substances which may decompose. There may not be enough oxygen inside the confined space to support life, or the air could be so oxygen-rich that it is likely to increase the chance of fire or explosion if a source of ignition is present.

#### *Not designed for continuous worker occupancy:*

Most confined spaces are not designed for workers to enter and work in them on a routine basis. They are designed to store a product, enclose materials and processes, or transport products or substances. Therefore, occasional worker entry for survey, inspection, maintenance, repair, cleanup, or similar tasks is often difficult and dangerous due to chemical or physical hazards within the space.

A confined space found in the workplace may have a combination of these three characteristics, which can complicate working in and around these spaces as well as rescue operations during emergencies.

**If a survey requires entry to one or more work spaces with the characteristics listed above, read the following information – some day it may save life.**



## 2 Confined Space Hazards

### 2.1 Hazardous atmospheres from the containment in the tank

The atmosphere in a confined space may be extremely hazardous because of the lack of natural air movement. This characteristic of confined spaces can result in:

- oxygen-deficient atmosphere,
- flammable atmospheres, and/or
- toxic atmospheres.

## 2.1.1 Oxygen-deficient atmosphere

### General

The health effects and consequences because of lack of oxygen in a confined space are listed in the table below. These effects will take place without any warning such as odour or physical symptoms.

Health effects from lack of oxygen	
O <sub>2</sub> level	Effects
22 %	Oxygen enriched atmosphere
20.8%	Normal level – Safe for Entry ( $\pm 0.2\%$ )
19.5%	Oxygen deficient atmosphere
16%	Impaired judgement and breathing
14%	Rapid fatigue and faulty judgement
11%	Difficult breathing and death in a few minutes

Lack of oxygen leads very quickly to unconsciousness and death. Lack of oxygen may be a problem in all kinds of confined spaces, it is therefore considered as the most dangerous factor when considering dangers in a confined space.

The oxygen level in a confined space can decrease because of work being done, such as welding, cutting, or brazing; or, it can be decreased by certain chemical reactions like: rusting, paint drying or through bacterial action (fermentation).

In tanks and/or voids of complicated geometry with high possibility of "pockets of atmosphere" with low O<sub>2</sub>-content, and where rescue operations may be difficult, the use of a portable oxygen meter with audible alarm is strongly recommended.

### *Inert gas, N<sub>2</sub> and exhaust*

Inert gas is a non-reactive gas used to prevent possible explosive atmosphere from different cargo vapours.

On Oil Tankers the most common inert gas is the exhaust from oil fired boilers, main- or auxiliary engines. On Chemical Tankers the most common inert gas is nitrogen.

Pure nitrogen is not poisonous itself, but it causes displacement of the natural breathing environment.

Exhaust contains hundreds of chemical compositions. Main components are: carbon monoxide, oxygen, nitrogen, water vapour, sulphur dioxide, nitrogen oxides and hydrocarbons. The exhaust as described above may cause reduced lung capacity and increased respiratory in addition to irritating mucous membrane in eye, nose and throat.

Total dilution of oxygen by another gas, such as carbon dioxide, will result in unconsciousness, followed by death.

### *Bulk Cargoes*

A number of bulk cargoes may cause low level of oxygen in the cargo hold. This is mainly with cargoes like vegetables, grain, timber, forestry products, iron metals, metal sulphide concentrates and coal.

Some bulk cargoes may oxidize which may result in reduced level of oxygen, poisonous gases, or self ignition. Other bulk cargoes may produce poisonous gases without oxidation, especially when they are wet.

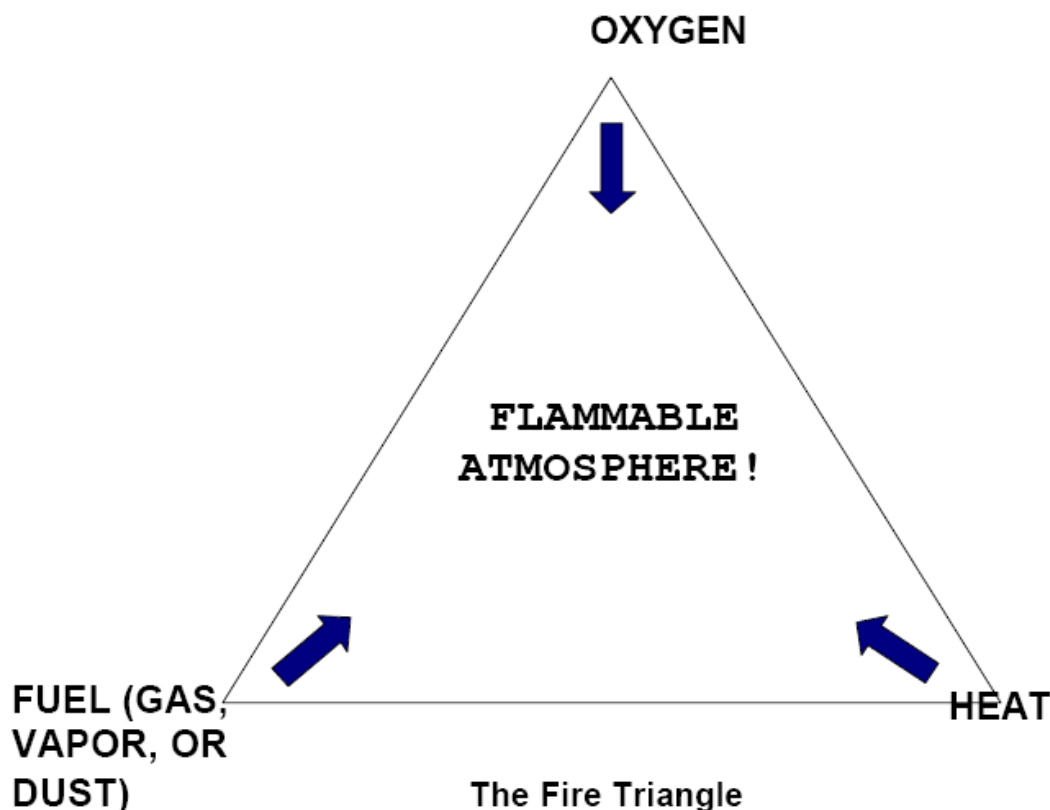
## 2.1.2 Flammable atmospheres

Two things make an atmosphere flammable:

- the oxygen in air, and
- a flammable gas, vapour, chemical reaction or dust in a proper mixture.

Different gases have different flammable ranges. If a source of ignition (e.g. a sparking or electrical tool, static electricity, sand blasting) is introduced into a space containing a flammable atmosphere, an explosion will result. An oxygen-enriched atmosphere (above 22%) will cause flammable materials, such as clothing and hair, to burn violently when ignited. Therefore, *never use pure oxygen to ventilate a confined space*. Ventilate with normal air.

Some bulk cargoes may produce health toxic dust which also will represent an explosive hazard, especially during cargo handling and cleaning.



### 2.1.3 Toxic atmosphere

Unless a certified Marine Chemist or a competent person has certified a space as safe, assume that any substance (liquids, vapours, gases, mists, solid materials and dust) in a confined space can be hazardous. Toxic substances may range from fast acting poisons to long term cancer causing carcinogens. Toxic substances can come from the following:

- the product stored in the space;
- the work being performed in a confined space;
- areas adjacent to the confined space.

Some bulk cargoes will act corrosive on skin, eye and mucous membrane.

### Products stored in the space:

#### Chemical products

In cargo tanks for chemicals it is possible to find all types of chemicals. It is very important that the customer provides a Data Sheet for the product that has been stored in the tank and follows the instructions for safety measures according to this.

Health effects as a result of exposure from chemicals in general may cause immediate headache, nausea, fainting and possible death. Long-term exposure to benzene can result in serious blood disorders such as allergy, anaemia and leukaemia.

Chemicals can be absorbed into the structure and/or tank coatings and give off toxic gases at a later stage. When removed or when cleaning out the residue of a stored product, toxic gases can be given off.

It is very important to follow the marking and recommendations as given in the Data Sheet to reduce immediate damage as well as the risk for long term damage.

#### Petroleum products

Most petroleum products are distilled from crude oil which is a product with very high complexity regarding composition of different substances. The composition of crude oil and the products distilled from crude may vary depending on what part of the world the production of crude took place.

Petroleum products may be absorbed into the body by inhalation, absorbed through skin or ingested. Effects to health will depend on how high exposure and for how long. Immediate effects of high exposure can include headaches, tiredness, nausea and dizziness. Unconsciousness may occur if exposure is very high. Long-term exposure can result in serious blood disorders such as anaemia and leukaemia.

Be aware that several of the fuels on the market have different additives to prevent e.g. bacteria growth in diesel. These additives may be highly toxic. When the additives are above a certain percentage they are supposed to be included in the Data Sheet. If the amount of additives is very small it does not need to be a part of the Data Sheet.

Be aware that several of the fuel producers are very reluctant to reveal what kind of additives they are using in fuels, because this is considered to be business sensitive. Extra care should then be taken with respect to cleaning and measuring for the correct toxic product in diesel and fuel oil tanks.

When testing for toxins in a confined space that has contained petroleum products, it may be very difficult to decide what toxic gas to measure for. In general, testing for the most dangerous toxic product in the composition should be carried out.

If not otherwise stated on the Data Sheet, benzene is the most toxic part in petroleum products and measuring for this product should be done. If the readings for benzene are within the limits, all the other natural parts of the petroleum product should be within the acceptance limits.

### **Hydrogen sulphide, H<sub>2</sub>S**

Hydrogen sulphide is highly toxic and also flammable and is created by the decay of organic matter that is found in sewers and sewage treatment plants. H<sub>2</sub>S may also be found in crude oil tanks, ballast tanks, void spaces and other tanks that have been empty and decomposition of organic material has taken place.

Hydrogen sulphide is heavier than air and has no colour but does have a strong “rotten egg” odour at low concentrations.

Hydrogen sulphide can affect when inhaled and when passed through the skin. Contact can irritate the eyes. Long-term exposure to low levels can cause pain and redness of the eyes with blurred vision. Breathing hydrogen sulphide can irritate the nose, throat and irritate the lungs causing coughing and/or shortness of breath.

Higher exposures can cause a build-up of fluid in the lungs (pulmonary oedema), a medical emergency with severe shortness of breath. Exposure can cause nausea, dizziness, confusion, headache and trouble with sleeping. Very high levels can cause immediate death.

Hydrogen Sulphide is a HIGHLY FLAMMABLE GAS and a DANGEROUS FIRE HAZARD.

At high concentrations H<sub>2</sub>S paralyses neurons inside the nose and the odour cannot be smelled, hence smelling should not be used as an indicator that the tank is free from hydrogen sulphide.

Example: Removal of sludge or mud from a tank-decomposed material can give off deadly hydrogen sulphide gas and/or methane gas.

### **Benzene**

Benzene is a highly flammable liquid which occurs naturally in crude oil, natural gas and some ground waters. It is also manufactured from crude oil and is present in crude oil vapours.

Benzene evaporates easily, and most people can just detect its distinctive smell at concentrations between 2.5 and 5 ppm in air. Exposure to benzene may occur in oil refineries, chemical and petrochemical plants including offshore installations. Benzene can be absorbed into the body by inhalation, absorbed through skin or ingested.

Benzene can affect human beings when inhaled and when passed through the skin. It can irritate the eyes and skin with drying and scaling of the skin. Exposure can irritate the nose and throat. Benzene can cause symptoms of dizziness, light-headedness, headache and vomiting. Convulsions and coma, or sudden death from irregular heart beat, may follow high exposure. Repeated exposure can cause damage to the blood cells (aplastic anaemia).

### **Methane**

Methane is an odourless, colourless gas, or liquid under pressure. It is used as a fuel and in the manufacture of organic chemicals, acetylene, hydrogen cyanide, and hydrogen.

Methane is a HIGHLY FLAMMABLE GAS and a DANGEROUS FIRE and EXPLOSION HAZARD.

In addition to being an explosion hazard, very high levels of methane can cause suffocation from lack of oxygen. Skin contact with liquid methane can cause frostbite.

### **Solvents**

Many solvents, such as kerosene, gasoline, paint strippers, degreasers, are not only flammable, but if inhaled at high concentrations can cause central nervous system (CNS) effects. CNS effects can include dizziness, drowsiness, lack of concentration, confusion, headaches, coma and death.

Solvents should never be used as cleaners for the purpose of removing paint or similar from hands. If liquid solvents are in contact with skin, they are absorbed through the skin 10 times more efficiently compared to high content solvent gas absorbed into the body through breathing.

### **LSA's**

Naturally occurring radioactive materials have been known to be present in varying concentrations in hydrocarbon reservoirs in a number of areas of the world. It is now recognised that these materials can give rise to radioactive scales (and sludge),

which are usually referred to as Low Specific Activity (LSA) scale.

The scales tend to be barium sulphate and strontium sulphate, which co-precipitate with naturally occurring radium leached out of the reservoir rock; such scales emit alpha, beta and gamma radiation and this, together with the physical properties of the LSA scale, can give rise to problems if such scales or sludge have to be removed, handled or disposed.

Levels of radioactivity can vary from just above background radiation to those requiring restricted areas and classified workers.

### Others

*Fibre*: Synthetic mineral fibre is a common description for fibrous inorganic products mainly represented from rock, clay, slag and/or glass. These fibres can be classified as follows:

- fibre glass (glass wool/ fibreglass);
- mineral wool (rock wool/ slag-wool);
- ceramic fibre.

Long term exposure in high concentrations may increase risk of lung cancer. This is observed among workers fabricating such products. Surveyors will normally not be exposed to concentration levels or time periods which are considered to be of high risk. However, low concentrations may lead to skin- and respiratory irritation.

### Leakage of refrigerating system

*Ammonia*. Ammonia is used as refrigerant, distributed within cooling system for fish-factory vessel and hold area. Normal pressure is approximately 20 bars. Ammonia does have a characteristic odour, even for low concentration levels. The health effect and consequences of ammonia are listed in the table below:

Concentration: (ppm)	Health effect:
20-50	Characteristic odour
40-100	Eye and respiratory irritation
400-700	Serious eye and respiratory irritation – possible irreparable damage
1700	Convulsive coughing, bronchial spasm, deadly after ½ h exposure
5000-10000	Deadly

*CO<sub>2</sub>*: CO<sub>2</sub> is natural occurrence in exhaled air, however high concentrations can be hazardous. CO<sub>2</sub> is odourless and is heavier than normal air. Concentrations may occur in the lower part of the tanks, close to the bottom. Low concentrations – below 5% are not considered as hazardous. Concentrations above 5% may lead to increased breath intensity and death. Also long term exposure may lead to unconsciousness and death.

*Propane/ butane*: Because of huge fire hazard related to these two products, they will normally not be found onboard vessels except from vessels carrying high risk fire hazardous products i.e. gas carriers. Inhalation of high concentrations may lead to heart arrhythmia (heart rate interruption), and feel suffocating.

*Group 1 refrigerant*. These refrigerants are non-poisonous and non-fire hazardous. The most common name for these products is Freon. Group 1 refrigerants consist of a number of chlorofluorocarbon combinations. Distribution onboard vessels are mainly within cooling system for fish factory- and hold area.

CFC = chlorofluorocarbon (i.e. R-11, R-12). These refrigerants are no longer allowed onboard new-buildings, but still exist onboard existing vessels.

HCFC = hydro-chlorofluorocarbon (i.e. R-22). These refrigerants may still be found onboard, but a phase out program has started.

HFC = hydro-fluoro-carbon (i.e. R-134a, R-404a, R410a, R-507). These refrigerants are presently used for most new refrigerating plant installations.

Exposure to Group 1 refrigerant may cause eye- and/ or skin irritation. High concentrations may cause dizziness, spasm and may affect the central nervous system and lead to heart rate interruption. Be aware of the fact that refrigerants will displace O<sub>2</sub>. Refrigerant gases are odourless.

### Ammonia in fish holds:

Note the hazards of ammonia in fish holds where nets are stored when in a period of refit or from fish, and/or by fish products in fishing vessel bilge wells.

**Hydrogen emission from anodes and/or accumulators:**

Hydrogen gas (H<sub>2</sub>) is produced from an electrolytic reaction from zincous-/carbon and alkaline accumulators. A mix of hydrogen gas (H<sub>2</sub>) and oxygen (O<sub>2</sub>) may form a highly explosive mixture. Hydrogen gas (H<sub>2</sub>) is a light gas which displaces oxygen (O<sub>2</sub>). Oxygen measuring equipment is recommended to be used when entering accumulator room and other enclosures where accumulators are kept.

**2.2 Work being performed in a confined space**

Examples of such include welding, cutting, brazing, painting, scraping, sand blasting and degreasing. Toxic atmospheres are generated in various processes. For example, cleaning solvents are used in many industries for cleaning/degreasing. The vapours from these solvents are very toxic in a confined space. It is also important to be aware that hot work carried out consumes oxygen.

**Welding**

Hot work on all surfaces with coating will create several gases which may be very toxic. This gas may come from hot work being carried out in a tank adjacent to the space being surveyed.

**Coating**

Special attention should be paid when spray coating is carried out in the area of the survey. Spray coating where small size particles are mixed with air will lead to high toxic exposure if inhaled.

**Grinding**

Grinding may cause miscellaneous compositions of dust. Absorption of metal dust into the body through inhalation is dependent on the physical and chemical properties and the size of the particles. Dust like this may cause metal fume fever and bronchitis.

**Sandblasting**

The dangers connected to sandblasting very much depend on the object's substance and the size and containment of grit. Several grits used for sandblasting contain carcinogenic substances like quartz, nickel, lead and lead compound.

During sandblasting the containment of carcinogenic chemicals may increase depending on the surface of the sandblasted area.

**Hydro blasting**

Hydro blasting may create aerosols. Aerosols are dispersion of solid or liquid particles in air which are small enough to stay in the air for a long period of time. Aerosols may transport reactive chemicals deep into the lungs in a way that causes very high exposure.

Aerosols may be produced from dust, dirt and cleaning chemicals in the process of high-pressure cleaning of miscellaneous surfaces.

**NDT operations**

Chemicals from NDT operations may also be dangerous. Most ultrasonic thickness measuring equipment is not intrinsically safe.

**3 Testing****3.1 General**

It is important to understand that some gases or vapours are heavier than air and will settle to the bottom of a confined space. Also, some gases are lighter than air and will be found around the top of the confined space.

Therefore, it is necessary to test all areas (top, middle and bottom) of a confined space with properly calibrated testing instruments to determine what gases are present. Atmospheres may be different in individual bays of the same tank. If testing reveals oxygen-deficiency, or the presence of toxic gases or vapours, the space must be ventilated and re-tested before entering.

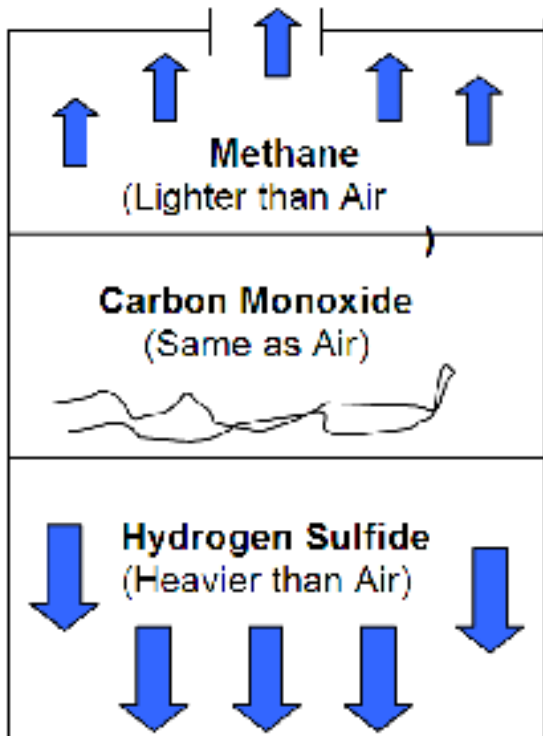
If in doubt whether the gas to be measured is lighter or heavier than air, consider the properties for the possible gas in question and compare it with the molecule weight of air.

Weight of air: 28.8 mol

Methane, CH<sub>4</sub> is lighter than air.

All gases from liquids under normal conditions are heavier than air (except ammonia).





No tank is to be entered until the tank atmosphere has been thoroughly tested with approved and calibrated instruments. Following tests are to confirm that all areas of the tank, bottom in particular, are safe for entry, i.e.:

- oxygen-deficient atmosphere,
- flammable atmospheres, and/or
- toxic atmospheres.

It is important to start the measurement of the tank atmosphere by measuring the HC (Hydrocarbon) content in % by volume and that the combustible gas detector is not used before the atmosphere content is less than Lower Explosive Limit (LEL). If measurement is started at a higher level the catalytic metal filament in the combustible gas detector may be destroyed. Combination instruments are available with a measuring range 0-100% by volume and 0-100% LEL.

### 3.2 Testing instruments

Testing instruments for oxygen and flammability read in percent. The oxygen meter should indicate 20.8% oxygen in the space being tested. The flammability indicator shows the percent within a safety range of 0-10% of the Lower Explosive Limit (LEL) and, ideally, should read 0%.

Testing instruments are available in several different forms, hand powered by squeezing a rubber bulb or bellows, and battery powered giving the indication either on an analogue gauge or digital read-out.

Be aware that in cases where Draeger tube or equal is used for detecting toxic gases the sampling gas should have sufficient time to pass through the sampling hose. It is important to follow the instructions for use given by the manufacturer of the instrument.

As a rule, if a manual hand rubber pump is used, approximately 4 squeezes are needed for each metre of the sampling hose. If battery driven pumps are used, approximately 10 seconds for each metre of sampling hose should be sufficient.

## 4 Ventilation

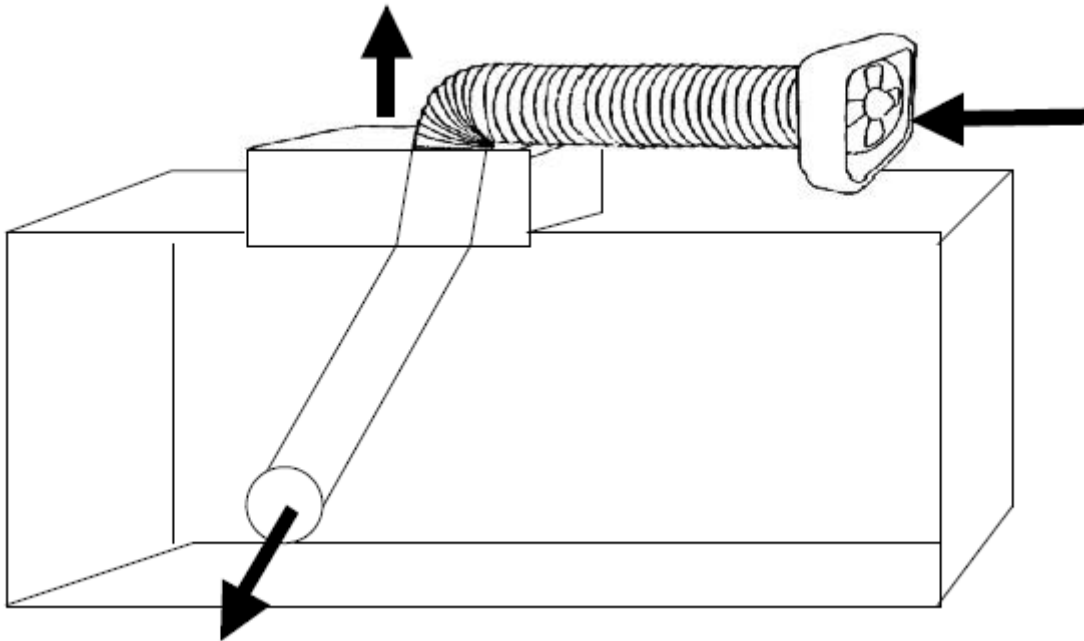
Ventilation by a blower, eductor or fan may be necessary to remove harmful gases and vapours from a confined space. There are several methods for ventilating a confined space. The method and equipment chosen are dependent upon the size of the confined space openings, the gases to be diluted (e.g. are they flammable?), and the source of make-up air.

Under certain conditions where flammable gases or vapours have displaced the oxygen level, but are too rich to burn, forced air ventilation may dilute them until they are within the explosive range. Also, if inert gases (e.g. carbon dioxide, nitrogen) are used in the confined space, the space should be well ventilated and re-tested before a surveyor may enter.

A common method of ventilation requires a large hose, one end attached to a fan and the other lowered into a manhole or opening. For example, a manhole would have the ventilating hose run to the bottom (see figure) to dilute or displace all harmful gases and vapours.

The air intake should be placed in an area that will draw in fresh air only.

Schematic principles for ventilation:



Ventilation should be continuous where possible, because in many confined spaces the hazardous atmosphere will form again when the flow of air is stopped.

All openings are to be opened for ventilation and emergency exit.

## 5 Isolation of space

Isolation of a confined space is a process where the space is removed from service by one or more of the following.

*Locking out:*

Electrical sources, preferably at disconnect switches remote from the equipment.

*Blanking and bleeding, securing valves:*

Cargo, ballast, IGS, pneumatic and hydraulic lines. The inert gas branch should be blanked off. The appropriate blanking is to be checked at each tank if entry is required while inerting, or gas freeing of other tanks is taking place, or if any other tanks are inerted or contain hydrocarbons. An alternative to pipe blanking would be to remove a section of the branch line.

*Disconnecting:*

Mechanical linkages on shaft-driven equipment where possible.

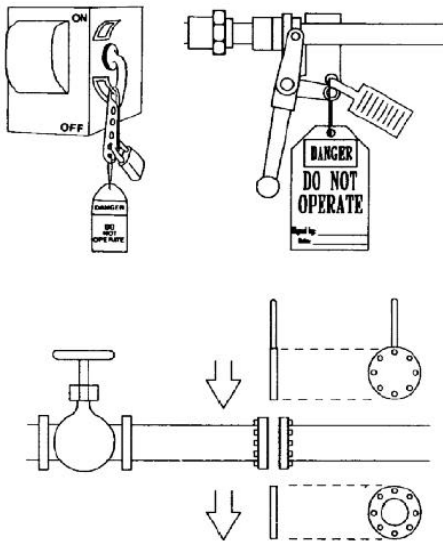
*Securing:*

Mechanical moving parts within confined spaces with latches, chains, chocks, blocks, or other devices.

*Notice boards*

Appropriate notices, which clearly specify which space and prevailing requirements agreed upon for confined space entry, should be displayed in prominent locations such as bridge, cargo control room, and/or engine control room.

Blanking, locking and securing of equipment:



## 6 General and physical hazards

### 6.1 Temperature extremes

Extremely hot or cold temperature can present problem for the surveyor.

*Cold temperature.* At very cold temperatures, the most serious concern is the risk of hypothermia or dangerously low body temperature. Another serious effect of cold exposure is frostbite or freezing of the exposed extremities such as fingers, toes, nose and ear lobes. Hypothermia could be fatal in absence of immediate medical attention.

Warning signs of hypothermia can include complaints of nausea, fatigue, dizziness, irritability or euphoria. Surveyors can also experience pain in their extremities (for example hands, feet, ears) and severe shivering. Surveyors should be moved to a heated shelter and seek medical advice when appropriate.

*Heat.* A person working in a very hot environment loses water and salt through sweat. This loss should be compensated by water and salt intake. Fluid intake should equal fluid loss. On average, about one litre of water each hour may be required to replace the fluid loss. *Plenty of drinking water* should be available on the job site and persons should be encouraged to drink water every 15 to 20 minutes even if they do not feel thirsty. Drinks specially designed to replace body fluids and electrolytes may be taken. Alcoholic drinks should NEVER be taken as alcohol dehydrates the body.

An acclimatized surveyor loses relatively little salt in their sweat and therefore the salt in the normal diet is usually sufficient to maintain the electrolyte balance in the body fluids. For un-acclimatized surveyors who may sweat continuously and repeatedly, additional salt in the food may be used. Salt tablets are not recommended because the salt does not enter the body system as fast as water or other fluids. Too much salt can cause higher body temperatures, increased thirst and nausea. Persons on salt-restricted diets should discuss the need for supplementary salt with their doctor.

When working at extreme temperatures the working hours should be adjusted to avoid the most extreme temperatures during the day. Working in the evenings and early in the morning is often a good solution to avoid the most extreme conditions. How the body reacts to extreme temperatures is very individual. Never take any chances and pay careful attention when performing work in extreme temperature environment. Working speed and rest schedule should be adjusted according to the temperature.

### 6.2 Engulfment hazards

Loose, granular material stored in holds or tanks, such as grain, sand, coal, or similar material, can engulf and suffocate a person. The loose material can crust or bridge over and break loose under the weight of a person.

### 6.3 Noise

Noise within a confined space can be amplified by the design and acoustic properties of the space. Excessive noise cannot only damage hearing, but can also affect communication, such as causing a shouted warning to go unheard.

## 6.4 Falling objects

Workers in confined spaces should be mindful of the possibility of falling objects, particularly in spaces, which have a topside opening for entry, and where work is being done above the worker.

## 6.5 Slick/Wet Surfaces

Slips and falls can occur on a wet surface causing injury or death to workers. Also, a wet surface will increase the likelihood for and effect of electric shock in areas where electrical circuits, equipment, and tools are used.

# 7 Guidelines for use of personal gas detectors

For detection of any local pockets of gas or lack of oxygen the surveyor should use his portable oxygen or multi-gas meter with audible alarm features.

This is especially important when entering tanks and/or voids of complicated geometry with high possibility of "pockets of atmosphere" with low O<sub>2</sub>-content, and where rescue operations may be difficult.

Preferably a multi-gas meter should be used, capable of simultaneous monitoring of oxygen, combustible gases and hydrogen sulphide and carbon monoxide.

Note that CO sensors may also be sensitive to low concentrations of hydrogen (H<sub>2</sub>) therefore it is important to evaluate the possibility for CO/hydrogen in the space. Anodes will generate hydrogen when in use.

Most measuring equipment is sensitive apparatus with limitations for the range they are capable of measuring. Sensors in all measuring equipment may be destroyed if exposed to extreme measurements (e.g. above 100% LEL), clogged filters or catalyst poison (silicone, lead, sulphur and chlorous)

The personal protective instrument should be turned on before tank entry.

## 7.1 Function test and full calibration

The difference between a function (bump) test and a full calibration:

- A function (bump) test is defined as a means of verifying calibration by using a known concentration of test gas to demonstrate that an instrument's response to the test gas is within acceptable limits.
- A full calibration is defined as the adjustment of an instrument's response to match desired value compared to a known concentration of test gas.

A function (bump) test or full calibration of direct reading portable gas monitors should be made before each day's use in accordance with the manufacturer's instructions using appropriate test gas.

Any instrument that fails a function (bump) test must be adjusted by means of a full calibration procedure before further use.

Various standard types of calibration gases are available in handy size bottles. For calibration of all gas measuring equipment at least 2 points along the measuring range are needed to determine the accuracy.

### **Note:**

***Surveyors should never use their personal gas detectors to test a space for entry. Owner is responsible to make the space safe for entry.***

# 8 Survey preparations

## 8.1 Cleaning

Tanks and spaces to be surveyed must be sufficiently clean and free from water, scale, dirt and oil residues to reveal excessive corrosion, significant deformation, fractures, damage and other structural deterioration. There is no point in entering a tank if the bottom of the tank is not visible and the intention of the survey is to survey those areas. Tank cleaning can be performed with an existing fixed tank cleaning system.

However, in shadow areas portable washing machines may have to be used in order to achieve sufficient degree of cleanliness.

Generally, tank surveys should be avoided in tanks in which de-sludging operations are taking place since these operations can potentially raise gas levels.

When entering into a HFO, lube oil or diesel fuel tank, extra care should be taken when considering cleanliness and

atmosphere. Long term effects of exposure to substances found in these tanks are not well documented.

## **8.2 Lighting**

Whenever possible, natural lighting should be provided in the tank during inspection by opening all tank hatches. In general a pocket size backup light should always be carried when working in confined spaces in case of loss of light. Lighting in confined spaces may not be good and will normally be temporary arrangements cabled into the space or by torchlight.

## Checklist for Entry into Confined Spaces

**DO NOT ENTER A CONFINED SPACE UNTIL YOU HAVE CONSIDERED EVERY QUESTION AS WELL AS ANY OTHER ITEM OF CONCERN, AND HAVE DETERMINED THE SPACE TO BE SAFE. THE FINAL DECISION IS YOURS.**

YES NO

### 1. SAFETY MEETING

- Safety meeting is carried out prior to survey to discuss all aspects of safety measures?
- Will someone accompany you into the space?

### 2. PERMIT

(The permit is an authorization, usually in writing, that states that the space has been tested by a qualified person and that the space is safe for entry; what precautions, equipment, etc. are required; and what work is to be done.)

- Has a confined space entry permit been issued?
- Is the permit up to date?

### 3. VERIFICATION

- Are the instruments used in atmospheric testing properly calibrated?
- Was the person performing the tests a certified Marine Chemist, a Competent Person, or equivalent?
- Was the atmosphere in the confined space tested?

### 4. TESTING

- Was Oxygen at least 20.8 % but not more than 21%?
- Were toxic, flammable, or oxygen-diluting gases / vapours present?
  - Hydrogen sulphide
  - Carbon monoxide
  - Methane
  - Carbon dioxide
  - Other (list) \_\_\_\_\_
  - \_\_\_\_\_

YES NO

**5. MONITORING**

- Will the atmosphere in the space be monitored while work is going on?

**Remember – atmospheric changes occur due to the work procedure or the product stored and vessel movements and temperature changes. The atmosphere may change very quickly.**

**6. VENTILATION**

- Has the space been ventilated before entry?
- Will ventilation be continued during entry?
- Is the air intake for the ventilation system located in an area that is free of combustible dusts and vapours and toxic substances?
- If atmosphere was found unacceptable and then ventilated, was it re-tested before entry?

**7. ISOLATION**

- Has the space been isolated from other systems?
- Has electrical equipment been locked out?
- Have disconnects been used where possible?
- Has mechanical equipment been blocked, chocked, and disengaged where necessary?
- Have lines under pressure been blanked and bled?
- Have the necessary Notice boards been placed in the operations locations and at the confined space entry point?

**8. CLOTHING/EQUIPMENT**

- Is special clothing required (boots, chemical suits, glasses, etc.)?
- Is special equipment required (e.g. rescue equipment, communications equipment, heavy duty raft, life vests, etc.)?
- Are special tools required (e.g. spark proof, intrinsically safe)?

**9. TRAINING**

- Have you been trained in confined space entry and do you know what to look for?

YES NO

**10. STANDBY/RESCUE**

- Will there be a standby person on the outside in constant visual or auditory communication with the person on the inside?
- Will the standby person be able to see and/or hear the person inside at all times?

**Note:**

The surveyor should not enter a tank/compartament if breathing apparatus/gas masks is required.