CHAPTER 10

Enclosed Spaces

This chapter describes the hazards associated with entering enclosed spaces and the tests to be carried out to determine whether an enclosed space is safe to enter. The conditions for entry are set out, as well as the precautions to take before entering and while work is being carried out in an enclosed space.

> **Masters should be aware that national legislation may mean that terminal requirements for enclosed space entry might differ from this guidance.**

10.1 Introduction to enclosed space entry safety

Despite the precautions that operators take to protect personnel entering enclosed spaces, deaths and injuries still happen. This chapter recommends protections and controls that can reduce the risk from entering enclosed spaces.

The most effective way to eliminate the risk is not to enter an enclosed space. Given this:

- Ship operators and Masters should ensure that personnel enter enclosed spaces only when there is no practicable alternative.
- Where there is no alternative, the operator should ensure that procedures for safe entry are in place.
- Masters should verify that procedures for entering enclosed spaces are fit for purpose, robustly implemented and followed and that every entry is planned in line with these procedures, no matter how often they happen.

Enclosed space incidents tend to fall into two categories:

1. Controlled entries: the entry is intended but the preparation and execution of the entry plan is not robust enough. This leads to an incident involving workers inside or outside of the space, including those carrying out gas testing. This category includes intentional entries to respond to emergencies.
2. Accidental entries: while doing routine tasks such as taking items from a storage locker, checking spaces or looking into a tank, personnel unwittingly enter an enclosed space that is unable to support life.

The Master and key crew members involved in the steps for entering enclosed spaces are:

- Responsible Person: a person authorised to permit entry into an enclosed space and having sufficient knowledge of the procedures to be established and complied with on board to ensure that the space is safe for entry.
- Competent Person: a person with sufficient theoretical knowledge and practical experience to make an informed assessment on the likelihood of a dangerous atmosphere being present or subsequently arising in a space.

  The Competent Person and the Responsible Person may be the same person.
- Attendant: a person who is suitably trained in the procedures within the SMS, maintains a watch over those entering the enclosed space, maintains communications with those inside the space and initiates emergency procedures in the event of an incident occurring (IMO Resolution A.1050(27)). An Attendant has no other duties besides those listed.

10.2 Safety management for entering enclosed spaces

10.2.1 General

The operator's procedures need to identify those spaces on board that are enclosed spaces. The spaces will have one or more of these characteristics:

- Limited openings for entry and exit.
- Poor natural ventilation.
- Not designed for continuous worker occupancy.

Without effective ventilation any enclosed space may become hazardous (see section 10.4). A hazardous space is an enclosed or confined space where the atmosphere may endanger the life or health of any person entering it. The hazards are:

- Oxygen deficiency.
- Toxic and/or flammable gases, including hydrocarbon vapours and toxic contaminants.
- IG, including nitrogen.
- Oxygen enrichment.

All operator and tanker specific procedures should also refer to established national requirements.

To safely manage any entry into an enclosed space, crew members should be trained and regularly drilled in enclosed space safety. This should include familiarisation with atmosphere testing instruments and onboard procedures for recognising, evaluating and controlling the associated hazards.

All procedures and measures to mitigate hazards should account for the possibility that simple human error can reduce their effectiveness (see chapter 7).

The nature of the enclosed space will determine the particular hazards. All enclosed spaces should be marked with clear signs and procedures should be drawn up to ensure that any entry is done safely. Identifying these spaces and procedures means that all the personnel involved, including those entering any of the spaces, should understand the:

- Nature of the atmosphere.
- Mitigating measures.
- PPE requirements.
- Emergency action.

All operator and tanker procedures should clearly identify those personnel whose roles are important to ensure the safe management of enclosed spaces. These are:

- Responsible Person.
- Competent Person.
- Attendant.
- Duty officer/engineer.
- Personnel entering space.

Any decision that entry is necessary should first be reviewed, by the Competent Person, against possible alternatives that remove the need for personnel to enter the space. If after this detailed review the entry is still necessary, no attempt should be made to enter the space, even under controlled conditions, until its atmosphere has been tested as safe.

10.2.2 Managing controlled entry into enclosed spaces

Several factors, either independently or collectively, could influence the successful outcome of an entry. They need to be taken into account so that measures can be put in place to mitigate them.

The measures include:

Avoid entry where there are alternatives

The most reliable way to reduce risk from enclosed spaces is to avoid entry. The need to enter enclosed spaces can be eliminated by design and potential entries can be kept to a minimum by removing any need to enter, e.g. relocating stored items, essential equipment or controls, planning for internal work to be done in dry-dock and using technology such as drones for survey work. This may include challenging unnecessary operational activity, such as tank washing.

Leadership should demonstrate standards and listen to concerns

Those with influence over other members of crew can make entries safer. They promote and oversee the standards set out in the operator's procedures and should live by those standards and never enter an enclosed space or ask anybody else to enter until all the requirements have been met. They should demonstrate that their decisions are for the benefit of safety, overriding commercial or time pressures. Finally, they need to listen and respond when a more junior member raises a concern (see chapter 7).

Allow plenty of time

Time pressure can affect the behaviour of those entering the space and those planning to enter. They can be influenced by a desire to be efficient or by external pressures. This should be anticipated and guarded against. When it is not possible to avoid a long or complex task, the Responsible Person and other supervisors should take measures to mitigate the particular risks caused. In all cases, external pressure from the port or terminal should be resisted in the planning and conduct of such operations.

Plan and test rescue provisions

Early in the planning stage, the equipment necessary for the safe entry should be identified, rigged and tested. The personnel entering the tank should have been properly trained and regularly drilled in using the equipment, including for emergencies or tank rescue. This training should be undertaken before entry is authorised to remove any hesitation in the equipment's use.

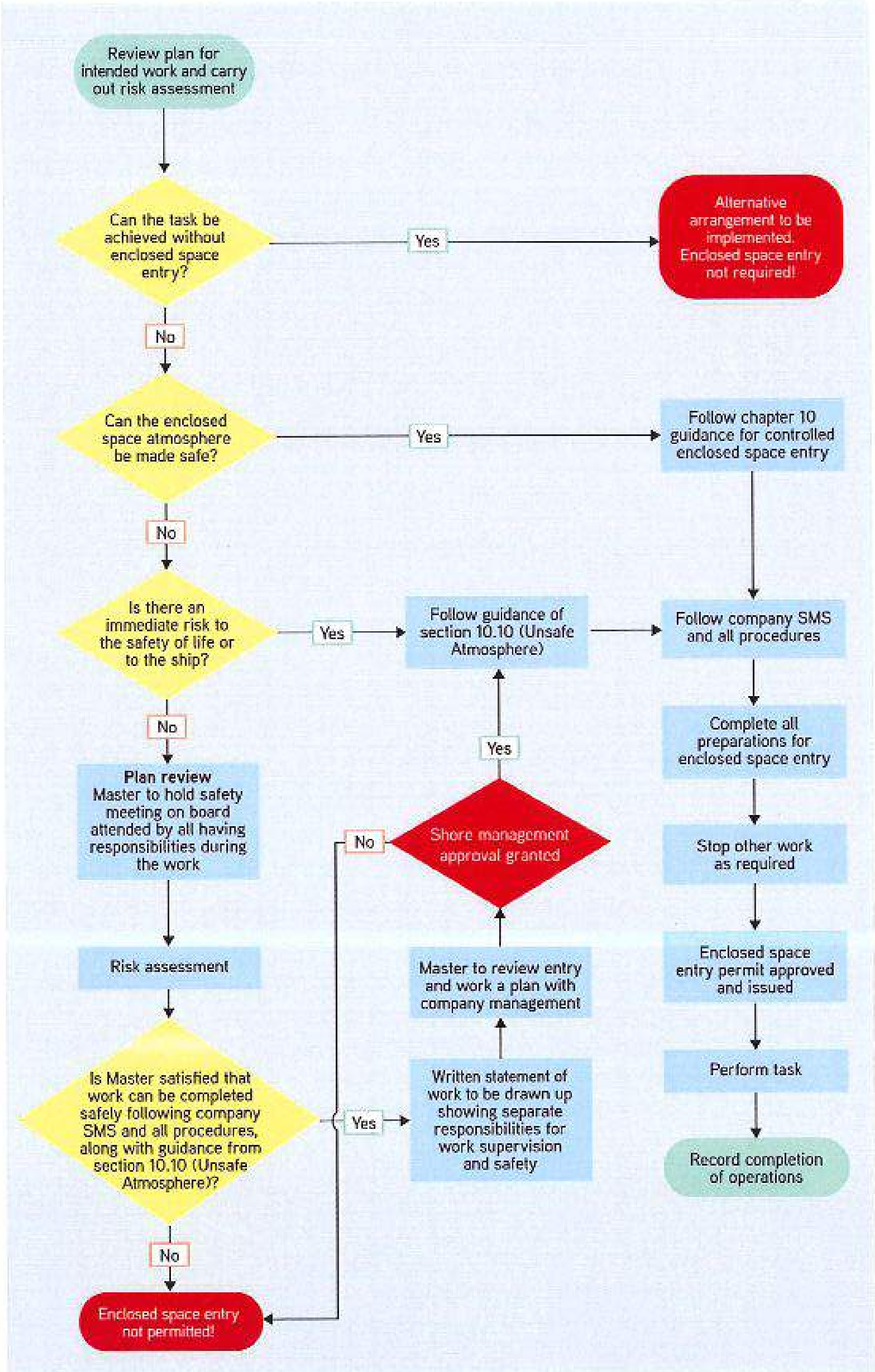

Figure 10.1: Enclosed space entry decision flowchart

Prepare the space

All spaces to be entered should be fully prepared in line with the assessed risks and the agreed plan. The space may need cleaning and should be gas tested to confirm the preparation has been successful. It may also need to be isolated to ensure it remains at the required standard for entry:

- Cleaning: all spaces need to be assessed to see if their current or previous use has the potential to create an unsafe atmosphere. If the result leaves any doubt, the space should be cleaned to eliminate the components that create the uncertainty.
- Testing: the atmosphere should be fully tested, which may include several locations and remote areas in the space. The first test can pose the greatest risk from an unknown atmosphere or fumes. To mitigate this, only personnel trained to use gas detection equipment should test atmospheres.
- Isolation: where possible, use the most reliable methods of isolation. Removing pipe spools or fitting in-line spades eliminates the consequences of accidentally opening valves into the space. Isolate all lines that enter a space, e.g. ballast water, bunker, utilities, etc., to reduce the chances of introducing a hazardous material. To avoid errors, isolations should be double-checked independently by two people.

Keep access secure

Clearly identify any space that is to be entered but remains open in the meantime, e.g. for gas freeing. Warning signs are useful but often not enough on their own. Consider using physical barriers such as a barricade or net.

Safe and secure breathing

Inadvertent connections to non-breathing air systems, accidentally closing an air supply or a diminishing supply can all create risks. Personnel connected to any air supply, e.g. fixed air-line or Self-Contained Breathing Apparatus (SCBA), should monitor the supply and the safe escape route in case of air supply failure.

The risk increases significantly when entering spaces where the atmosphere is harmful or unknown. Protective equipment (even SCBA) is a less reliable control than a proven safe atmosphere. Spaces where the atmosphere will not support life or where it is uncertain should not be entered except under exceptional circumstances, e.g. an emergency. If this is the case, the highest level of scrutiny is required and entry should only be undertaken with SCBA under strictly controlled conditions (see section 10.10).

Control the work

Any planning should consider the possibility of personnel in the space being unaware that they are getting into difficulty. This can be a result of the nature of the work (hot, heavy, noisy, with lighting and/or communications difficulty) or due to the hazards such as oxygen deficiency.

A risk assessment should account for these factors and build suitable controls into the plan. This way anybody in trouble can be spotted and removed as quickly as possible.

The challenges of being an Attendant

The role of the Attendant, keeping watch outside the space, is vital. However, it can be a monotonous task that is prone to declining alertness and communication issues.

Keeping the Attendant engaged and alert is critical to the safety of the personnel in the space. The Attendant should have clear instructions on what they should and should not do. They should maintain their attention and they should not be distracted by other activities.

Regular communication and status checks with the command centre, e.g. bridge, and personnel in the space is one way to achieve this. A protocol or checklist may also be helpful.

Reliability of communication

Those inside and outside the enclosed space should be able to communicate with each other at all times. Regular communication checks should be made at pre-agreed intervals. A failure to respond is cause to raise the alarm.

Very High Frequency/Ultra High Frequency (VHF/UHF) communication may not be suitable where it is known that reception may be unreliable or noisy. In this case, consider and test the possibility of positioning Attendants with line of sight to workers or using other remote communications or monitoring.

Responding to a crisis

Injuries and deaths from entering enclosed spaces often occur when personnel give in to a strong instinct to help. A delayed response from the rescue team can make this worse. It may take them several minutes to muster and ready themselves, during which time Attendants may become increasingly concerned for those in the space. They may believe – wrongly – that they can hold their breath or are fit enough not to be affected in the same way as those inside. Giving them a clear list of tasks at this time, e.g. raise the alarm but do not enter the space/opening, keep talking to the personnel inside, set up equipment outside or brief the command centre and rescue team when they arrive, is a proven technique for keeping them focussed. Reinforce this during the toolbox talk with scenarios asking them what they would do if someone collapsed and if the rescue team were delayed.

10.2.3 Managing enclosed spaces not planned for entry

Use physical barriers to stop accidental or unauthorised entry to enclosed spaces. During the planning phase, consider the circumstances that might lead to these incidents.

Systematic identification

All spaces with a hazardous or potentially hazardous atmosphere, e.g. chain lockers, should be clearly identified and ship's personnel should be made aware of them during their induction.

Systematic elimination

Use a hierarchy of control processes (see section 4.2.3) to reduce the number and/or dangers from these enclosed spaces, e.g. alternative storage solutions or regularly opening spaces to natural ventilation.

Preventing accidental entry

Several methods can help to prevent accidental entry.

Where tools are needed to open the compartment, a sign alone may be effective but should be clear:

'Entry under a permit only'

Where a compartment can be opened with quick release latches/handles/wing nuts/motorised latches, the hatch/door should be secured against accidental entry.

Where hatches, tank lids or any other openings need to be open for checks, e.g. gas levels, positive means should be provided to prevent personnel putting their head or body into the space, e.g. grills or netting.

Responding in an emergency

Victims of accidental entries are likely to be discovered by passers-by, who should resist the desire to enter the space to attempt rescue.

PART 1 General Information
PART 2 Tanker Information
PART 3 Marine Terminal Information
PART 4 Ship/Shore (Tanker/Terminal) Interface

All ship's personnel should be trained and tested in the specific tasks when somebody is in danger in an enclosed space. This includes raising the alarm and the importance of not entering the space.

Additional tasks, e.g. such as talking to the person in the space and briefing the rescue team when they arrive, are effective distraction techniques to prevent an individual from entering the space to help.

All personnel should be clearly instructed that they can do more to help the victim if they stay outside and help the rescuers. This training should not be restricted to Attendants.

10.3 Identifying enclosed spaces

Any area or space may have, or develop, some of the characteristics of an enclosed space and may present similar safety risks.

The SMS should identify potential locations, occasions and activities that may create an enclosed space.

The operator should carry out a risk assessment to identify all the enclosed spaces on board the tanker. This risk assessment should be available on board and periodically revisited to ensure it remains valid.

The operator should also clearly outline the process to determine a space as enclosed in the SMS.

A list of identified enclosed spaces should be available on board every ship and these spaces should be clearly marked. Examples include:

Cargo tanks	**Chain lockers**	**Duct keels**
Double bottoms	Freshwater tanks	Engine room bilge, sludge and other tanks
Fuel tanks	IG scrubber units	Boilers
Ballast tanks	Cofferdams	Engine crank cases
Cargo pumprooms	Void spaces	Engine scavenge spaces
Sewage tanks	Lube oil tanks	Thruster spaces

The Master should ensure that all entrances to unattended enclosed spaces on the ship are kept closed or otherwise secured against entry.

Although cargo pumprooms are defined as enclosed spaces, they have equipment, characteristics and risks that require additional special precautions and procedures. These are covered in section 10.12.

Some spaces that do not meet the criteria for an enclosed space may have an unsafe atmosphere and should be subject to the enclosed space entry procedures. A list should identify these spaces on every tanker. Examples include:

Forecastle store	Paint lockers	Battery lockers
Ballast water treatment room	Gas bottle storage lockers	Carbon dioxide (CO_2) rooms
Lockers within the cargo area	Crane motor trunks	Enclosed lifeboats
Tank cleaning heater rooms	Ballast pumprooms	Deck tunnel/trunk space

Other spaces, in either the cargo or non-cargo deck area during operations, may be identified by risk assessment.

10.4 The hazards of enclosed space atmospheres

One or more of the following conditions can make enclosed space atmospheres hazardous:

- Oxygen deficiency.
- Toxic and/or flammable gases, including hydrocarbon vapours and toxic contaminants.
- IG, including nitrogen.
- Oxygen enrichment.

10.4.1 Oxygen deficiency

When an enclosed space is left closed and unventilated, the natural process of oxidisation of steel, i.e. rusting, may reduce the oxygen within the space, causing the atmosphere to become oxygen deficient.

The use of IG or nitrogen will also reduce the oxygen content of a tank.

The risk of an oxygen deficient atmosphere will be increased when the spaces:

- Have contained water.
- Have been subjected to damp or humid conditions.
- Have contained IG.
- Are next to, or are connected to, other inerted tanks.

The nominal oxygen level in fresh air is 20.9% by volume (local atmospheric variations mean this reading may be impossible to obtain in practice, and modern digital instruments may put it between 20.80% and 20.95%). Any space with an atmosphere less than this should not be entered until the reason has been found and corrective measures that are shown to be effective have been taken.

When the oxygen supply to the brain is depleted, people become dizzy and disorientated and develop a headache before losing consciousness. By the time they are aware of the symptoms, they may not be able to act rationally or leave the space safely. Permanent brain damage is a risk after just four minutes in an oxygen deficient atmosphere.

At oxygen concentrations approximately:

- Between 20% and 16%: pulse and breathing rates drop and mental functions are impaired.
- Below 14%: severe symptoms, which include increasing fatigue, emotional upset, poor judgment and faulty coordination. Further reductions in the oxygen content lead to nausea, vomiting, permanent heart damage and loss of consciousness.
- Below 5%: a coma may rapidly occur, requiring emergency oxygen for any chance of survival.

People cannot detect these conditions and cannot react rapidly enough to escape the space or put on emergency equipment. The effects of oxygen depletion noted above will make it more likely that a person will be unable to react appropriately.

10.4.2 Presence of toxic and/or flammable gases

Spaces that have previously contained toxic and/or flammable cargoes are dangerous, even if the space has been cleaned, tested and previously found to be safe for entry. Examples include:

- Toxic and/or flammable cargoes that are absorbed by tank coatings (especially epoxy), which then release vapours after cleaning.
- Cargo residues trapped in tank fittings, e.g. heating coils or behind tank coatings. Cargo pumps and vapour lines may release vapours after initial cleaning.
- Cargo may have leaked into compartments, including pumprooms, cofferdams, permanent ballast tanks and tanks next to those that have carried cargo.
- Sludge and scale in a tank that has been declared gas free may give off further flammable gases if disturbed or subjected to a rise in temperature.

Suspect the presence of gas in empty tanks or compartments if non-volatile cargoes have been loaded into non-gas free tanks or if a common ventilation system could allow the free passage of vapours from one tank to another.

Carry out checks before entering any compartment where recent cargo may have contained toxic contaminants or gases, e.g. aromatic hydrocarbons, benzene, hydrogen sulphide (H_2S), mercaptans, as residues could be present.

When preparing to enter a ballast tank or void space, the space should be tested for hydrocarbon vapour and H_2S.

Technologies such as ballast water treatment systems introduce an additional risk of gases to enclosed spaces that would not normally be expected on tankers. For this reason, where ballast water treatment systems are fitted, the precautions noted in section 10.3 should be followed.

Some examples of ballast water treatment systems are:

- Electrolysis based systems that may generate hydrogen gas.
- Chemical injection systems that inject different chemicals.
- Ozone based systems.

10.4.3 Risk from Inert Gas including nitrogen

IG produced from boiler flue gas or an IG generator may contain carbon monoxide (CO) and CO_2, both of which can cause death.

CO is a toxic gas that may be present in cargo tank atmospheres after gas freeing and in spaces containing components of the IG plant.

CO_2 is not toxic but is a smothering hazard. Adequate ventilation is required to maintain a normal oxygen level in air of 21% by volume in the space and to eliminate any hazard.

Nitrogen is a colourless and odourless gas that will cause oxygen deficiency in confined spaces, and at exhaust openings on deck, during the purging of tanks and void spaces.

Air normally contains 78% nitrogen and 21% oxygen, with the remaining 1% made up of CO_2 and other gases. When breathing, part of this oxygen is absorbed by the blood inside the lungs while CO_2 passes from the blood back into the air.

The addition of nitrogen reduces the oxygen content and lowers CO_2 levels in the blood. CO_2 in the blood stimulates the breathing reflex and when nitrogen replaces it this reflex is inhibited. As a result, the lungs are not stimulated to work harder to compensate for the lack of oxygen and breathing stops.

People exposed to nitrogen gas are not aware of any danger and may even feel a state of euphoria before they lose the stimulus to breathe and are asphyxiated. Exposure to high concentrations of nitrogen is usually fatal unless immediate action is taken.

10.4.4 Oxygen enrichment

Even a small increase in the oxygen level in the air can create a hazardous atmosphere. It becomes easier to start a fire, which will then burn hotter and more fiercely than in normal air. It is also harder to put the fire out. A leaking valve or hose on an oxygen cylinder in a poorly ventilated room or confined space can quickly increase the oxygen concentration to a dangerous level.

The main causes of fires and explosions when using oxygen are:

- Oxygen enrichment from leaking equipment.
- Use of materials not compatible with oxygen.
- Use of oxygen in equipment not designed for oxygen service.
- Incorrect or careless operation of oxygen equipment.

10.5 General precautions

Entry doors or hatches leading to enclosed spaces should be secured against entry and when entry is not required warnings should be exhibited.

If a door or hatch cover is opened to naturally ventilate an enclosed space, it may wrongly be taken to indicate a safe atmosphere. A person stationed at the entrance or a physical barrier, e.g. a secured bar, rope or chain across the opening with an attached warning sign, could prevent accidental entry.

Remember that general working environment risks, including slips, trips and falls, are also risks in enclosed spaces. A number of accidents have involved falls from height inside enclosed spaces. It is important to look at rescue and recovery access to all appropriate parts of the enclosed space, as well as the entry and exit of rescuers and their equipment.

Regardless of the number of spaces being entered, each space should have its own designated Attendant.

The space to be entered should be segregated from all other spaces that contain or may contain a non-gas free atmosphere. All common line valves should be secured in the closed position and labelled.

Any pipelines in the space being entered should be prepared to allow safe entry, including water flushing and draining where necessary.

Suitable notices should be clearly displayed to warn and inform personnel about the dangers of entering enclosed spaces.

When entry is not required, doors or hatches leading to enclosed spaces should always be secured against entry and warning signs posted. The operator should ensure that their enclosed space entry procedures are available and understood by all personnel involved.

Where entry into enclosed spaces is required while a ship is alongside (e.g. into cargo tanks for cleaning or inspection), this should be discussed with the terminal and all procedures and precautions for entry agreed. This may, in certain circumstances, require the cessation of cargo operations while entry operations are underway to eliminate risks arising from:

- The incorrect operation of valves and lines on oil or products being handled.
- An inability to adequately manage all safety aspects arising from SIMOPS.
- The potential for resource limitations and work overload issues.

10.6 Authorisation of entry

No one should open or enter an enclosed space unless:

- Authorised by the Master or the nominated Responsible Person.
- Appropriate safety procedures have been followed.

An enclosed space entry permit should be issued by the Master or the nominated Responsible Person and completed by the personnel who are to enter the space before they enter.

10.7 Requirements for enclosed space entry

10.7.1 Control of entry into enclosed spaces

A Competent Person, designated by the company's SMS, should conduct a preliminary risk assessment (see section 4.2.2 risk assessment) to identify the potential hazards and appropriate safeguards. This should take into account previous cargoes carried, the ventilation, structure, coating type and other relevant factors.

The risk assessment should include a review of the task, the number of personnel needed to do it safely and requirements for an effective emergency response. This preliminary assessment should also determine the potential for a hazardous atmosphere developing due to leakage from an adjacent space.

The controls needed for safe entry vary according to the task and results of the risk assessment. In most cases, an entry permit is an effective way of ensuring and documenting that essential precautions have been taken and that these recognise the potential for changes in the tank atmosphere conditions to arise. Where necessary, physical safeguards should be put in place to ensure safety, which should include use of a LO/TO system for isolation for cargo tank valves, hydraulic systems and cargo pumps that could be hazardous if operated inadvertently.

Controls should also include physical barriers to prevent confined spaces being accidentally opened. Where tools are needed to gain access, a sign may be sufficient. Where access to an enclosed space can be opened by hand, it should be physically secured against unauthorised access.

10.7.2 Atmosphere tests before entry

No one should enter an enclosed space until the atmosphere is confirmed safe.

The atmosphere should be tested using suitable instruments for oxygen, flammable gases or vapours, CO, H_2S and other toxic gases as appropriate.

Before the space is entered it should be thoroughly ventilated. The length of time to ventilate depends on the size and construction of the space, the capacity and efficiency of the ventilation system, the level of contamination and the density of the vapour to be displaced.

It also depends on the size and position of openings to the space. Well placed openings improve the flow of air and will help ensure that all areas within the space are effectively ventilated.

Tank atmospheres may be contaminated by leaks from adjacent tanks or by the improper operation or failure of cargo, vapour and IG lines and valves.

For entry purposes, steady readings of all of the following should be obtained before the enclosed space entry permit can be approved and entry permitted:

- Oxygen: any space with less than 21% oxygen by volume should NOT be entered until the reason for the low level has been established and resolved. If any doubt remains about the causes of the oxygen deficiency, the space should still be considered hazardous.
- Flammable vapour: the concentration of flammable vapour is below 1% of the LFL before anybody can enter.
- Occupational Exposure Limit (OEL): no more than 50% of the OEL of any toxic vapours and gases.

If these conditions cannot be met, apply additional ventilation to the space and re-test after a suitable interval.

The potential for false or unrepresentative sample readings arising from eddies or pockets of gas, or for gas regeneration arising from sludge or scale, should be considered in the pre-entry testing phase. Ventilation should be stopped at least ten minutes before testing to ensure an accurate reading. Depending on experience, size of the space and potential risk factors, a longer period with ventilation stopped may be necessary to ensure accurate results.

In addition, the likelihood of isolated pockets of gas should always be considered and, therefore, samples should be drawn from many different locations and levels within the enclosed space using instruments with pumps and extension hoses. It is recommended that, as a minimum, this should be undertaken at top, middle and tank bottom levels, as well as in areas where personnel are expected to be present during entry.

The location of gas or vapour in a space will vary according to the relative density. When denser than air it will fall and when lighter than air it will rise. Gas and vapour will tend to remain where the ventilating airflow is least effective.

Testing and measuring should only be carried out by crew trained and proficient in using the instruments. Testing instruments should be maintained, calibrated and checked for correct operation in accordance with the manufacturer's instructions.

Testing instruments should only be used to measure the gases they are designed for and operated within the limits set by the manufacturer.

Even after a space has been made gas free and found to contain a safe atmosphere, local concentrations of gas may still exist.

The IG pressure of adjacent tanks should be lowered, but kept positive, to reduce the possibility of leaks between tanks. Personnel should remain alert to the possibility of hydrocarbon or IG leaks from adjacent spaces or from pipelines running through the tank.

10.7.3 Enclosed space entry permit

On completion of the initial gas testing the ventilation fans should be restarted and continue to operate throughout the period of the entry as a condition of the entry permit that should be approved and issued before allowing personnel to enter an enclosed space.

The entry permit should have a clear period of validity that does not exceed 12 hours and remain valid only as long as the permit conditions are met.

It should also state the maximum permitted time between atmosphere-testing of spaces and when they are entered by personnel, as well as the maximum time permitted between testing while the space is occupied. It is recommended this period should not exceed 30 minutes between testing and that records of the tests are maintained, and this should be defined in the operator's SMS. If two or more spaces are to be entered at the same time, ensure that enough resources, personnel, emergency/rescue equipment and gas monitoring equipment is available. No matter how many spaces are being entered, each should have its own designated Attendant (i.e. one person per space), who is in constant attendance at the entrance and is in direct contact with the Responsible Person.

During multiple simultaneous entries, consider monitoring the workload and its potential impact on Attendants and others involved in the operation.

The administrative burden can be simplified by restricting approvals, such as entry permits, so that all cargo tanks safe to enter are shown on one document. This can also avoid overlapping permits and reduce any possible confusion about which approval applies to which tank.

If such a system is used, it should be rigorously controlled to ensure that existing permits are cancelled and that the atmospheres of all named tanks are correctly tested at the time a permit is issued. This is to prevent an extension by default of a period of validity.

If one or more tanks named on the permit are tested and found to be unsafe to enter, the whole permit is cancelled. A new permit will then need to be issued for all tanks. The permit process should be supplemented by positively marking tank lids with notices indicating which tanks are safe to enter and negatively marking tanks that are not safe to enter. Indicate which cargo tanks are safe by marking (or tagging) all appropriate tank entry hatches. The marking should be unambiguous. The absence of a safe to enter mark should prohibit entry.

One condition of the entry permit should be that, if the named enclosed space is vacated for any reason, e.g. a refreshment break, ventilation should be continued during the break and the atmosphere of the enclosed space should be fully re-tested before re-entry. Unlike in the pre-entry testing phase (see section 10.7.2), once the space has been found to be gas free and the permit issued, ventilation should not be stopped for this testing unless the conditions for a safe re-entry have been broken.

Entry permits should be cancelled if any onboard emergency situation or emergency alarm is raised during the period of validity. Permits may only be re-issued once the emergency has been dealt with. Permits should be re-issued with the same tests and level of rigour as if it were an initial entry (see section 10.7.2).

The Responsible Person supervising enclosed space entry should confirm that:

- All permit conditions are implemented and functioning effectively.
- All crew entering the space are properly trained in enclosed space entry procedures and are familiar with the operator's safety and emergency procedures.
- The person entering the space has reviewed and signed the enclosed space entry permit.
- The completed enclosed space entry permit that authorises entry has been issued, filed and a copy(ies) posted.
- The scope of any other permits valid for work in the space during tank entry are understood. The withdrawal of the enclosed space permit will automatically cancel any other associated permits.
- A reliable system of communication has been established and tested and is understood by the Responsible Person, those entering the space and the Attendant.
- A system is in use to record crew members entering and leaving the space.
- The duty officer or duty engineer is aware of the enclosed space entry operations.
- A toolbox talk has been carried out with all parties on site.
- All personnel (crew members or outside contractors) entering the space understand that they should leave immediately if any gas detector alarm is activated.

Regardless of whether ship's crew or outside contractors are entering an enclosed space, the Attendant should always be a member of the crew who is familiar with the ship's emergency procedures.

All equipment used during the entry should be in good working condition and inspected before use.

A copy of the entry permit should be prominently displayed at the site entrance to the space to inform crew members of the precautions to take when entering the space and of any restrictions on the activities permitted within the space.

The entry permit should be cancelled if the ventilation of the space stops or if any condition required by the permit changes.

10.8 Precautions during entry into enclosed spaces

Once the tank has been confirmed as safe for entry with an entry permit issued, and before anybody enters to carry out work, an initial entry should be made to ensure the space is safe for work. This initial entry should be carried out by one or two crew members, depending on the size, nature and layout of the space. Each should carry an Emergency Escape Breathing Device (EEBD) and a personal gas monitor. They should check the tank atmosphere thoroughly, paying particular attention to the work locations and areas inaccessible for testing from the deck. The results of this local atmosphere test should be recorded as required by the SMS.

This is especially important in spaces with a complicated internal structure that is difficult to ventilate.

All personnel entering a space should be aware that the entry permit only certifies that the space has been tested as safe for entry. They should also understand that the tank conditions could change during the period of entry as a result of personnel moving around or undertaking work in an enclosed space. The dangers of isolated concentrations of gas that may be present, or arise from the stirring up of sludge or opening of lines or valves, should always be considered as this could result in a rapid rise of gas, making the space hazardous and requiring evacuation.

For this reason, ventilation should continue while the space is occupied and work is carried out within the space and all personnel in the space should wear a functioning personal gas monitor. It is essential that while personnel are in an enclosed space, further tests are regularly undertaken to determine if the levels of oxygen and contaminants remain within safe limits. Testing from outside should continue at appropriate intervals and should be undertaken before re-entry after a temporary break.

Provided the conditions for issuing the original entry permit have not changed (and permit cancelled), ventilation should not be stopped while the above mentioned re-entry gas testing is carried out.

If ventilation stops, or any of the criteria for entering the space are not maintained for any reason, the space should be evacuated immediately and the original permit cancelled.

Everyone entering the space should carry a personal multi-gas detector. Carrying a personal gas monitor is not a substitute for pre-entry, subsequent re-entry and ongoing testing from outside the space.

If there is any doubt about the oxygen level or the presence of toxic or flammable gases, the space should be evacuated immediately.

In an emergency, under no circumstances should the Attendant enter the space.

10.9 Work in enclosed spaces

10.9.1 General requirements

All work carried out in enclosed spaces should be conducted under the control of the SMS. All conditions for entry, including the entry permit, should be observed.

Extra precautions may be needed to ensure there is no loose scale, sludge or combustible material near the work site, which, if disturbed or heated, could give off toxic or flammable gases. Maintain effective continuous ventilation. Direct it towards the work area if possible. Monitor the atmosphere externally at regular intervals. Also monitor the personal multi-gas detectors carried by the personnel entering enclosed space. Before re-entering the space after a break, the atmosphere should be re-tested. Personnel should leave the space immediately if they begin to feel dizzy or unwell, or when any alarm is activated.

10.9.2 Opening equipment and fittings

Before opening cargo pumps, pipelines, valves or heating coils, flush them thoroughly with water and drain. Even after flushing some cargo may remain, which could be a source of flammable or toxic gas. Whenever this equipment is to be opened, the risk assessment should identify the minimum safe working practices, including any need for additional gas tests.

10.9.3 Use of tools

Inspect all tools before they are used. Do not use worn or damaged tools. Tools should not be carried into enclosed spaces. Instead, to avoid them being dropped, they should be lowered in a plastic bucket or canvas bag. Before any hammering or chipping, or any power tool is used, the Responsible Person should be satisfied that there is no likelihood that hydrocarbon vapour is present in the work area.

10.9.4 Use of electric lights and electrical equipment

Use only approved safety lighting or intrinsically safe electrical equipment in enclosed spaces that are liable to hydrocarbon vapour re-contamination.

Non-approved lights or non-approved electrical equipment should not be taken into an enclosed space unless the compartment is designated safe for hot work by an approved safe system of work, including a hot work permit.

10.9.5 Removal of sludge, scale and sediment

When removing sludge, scale or sediment from an enclosed space, periodically test for gas and maintain continuous ventilation throughout the time the space is occupied.

Gas concentrations may increase in the immediate area around the work, so care should be taken to ensure that the atmosphere remains safe.

10.9.6 Use of work boats

Any work involving work boats in cargo tanks presents additional hazards that should be managed by the operator's SMS.

Work boats used for tank repair work and tank inspections should be fit for the task. Before and during their use in an enclosed space, observe all the conditions for entry, including an entry permit (see section 10.5). The following precautions should also be taken:

- Open all deck apertures, e.g. tank washing plates, and maintain effective continuous ventilation while personnel are in the tank.
- Use the work boat only when the water surface is calm.

- Use the work boat only in tanks containing clean ballast water.
- Check that the water level in the tank is stationary or falling. On no account should it be rising while the boat is in use.
- Ensure all personnel working in the space are wearing buoyancy aids.
- Appoint a Responsible Person to act as lookout at the top of the tank. If the boat is working at a point remote from the tank hatch, position an additional lookout a little way down the access ladder at a point that provides a clear view of the boat.

10.10 Entering enclosed spaces with atmospheres known or suspected to be unsafe

Entering any space that has not been proved safe should only be considered when no practical alternative exists.

In any situation, other than the safety of life or the ship where the Master has ultimate responsibility, it is essential that permission is obtained from the operator and a safe system of work is agreed for entering a space that has not been proved safe.

The Master should issue a written statement declaring that there is no practicable alternative to the proposed method of entering the space and that it is essential for the safe operation of the ship.

Except where there is an immediate risk to the safety of life or the ship and it is agreed that such an operation is necessary, a risk assessment should be carried out and a safe system of work developed in agreement with the operator.

Positive pressure type breathing apparatus should always be used during an emergency entry into a space that is known to contain:

- Toxic vapours or gas.
- Oxygen deficiency.
- Contaminants that cannot be effectively dealt with by air purifying equipment.

The Responsible Person should continuously supervise the operation and should ensure that:

- Requirements in section 10.7.3 are followed.
- Personnel involved are well trained in using breathing apparatus and aware of the dangers of removing their face masks while in the unsafe atmosphere.
- Positive pressure breathing apparatus is used.
- Number of personnel entering the tank is kept to a minimum.
- Personnel are in the space for the shortest time possible.
- Spare sets of breathing apparatus, a resuscitator and rescue equipment are outside the space, along with a rescue team wearing breathing apparatus.
- All essential work is carried out in a way that will avoid creating an ignition hazard.
- If personnel are not connected to a lifeline, another suitable way is used to locate them while they are inside the space.

10.11 Rescue and evacuation from enclosed spaces

If someone is injured in an enclosed space, the first action is to raise the alarm. While speed is often vital and it is a human reaction to go to the aid of a colleague in difficulty, rescue operations should not be attempted until proper help and equipment have been mustered. Impulsive and ill-prepared rescue attempts often cause additional and unnecessary casualties.

Carry out regular drills and exercises to practice rescues from enclosed spaces. It is essential that all members of a rescue team know what is expected of them.

10.11.1 Evacuation from enclosed spaces

If any of the conditions stated on the entry permit change or it is suspected that the conditions in the space have become unsafe after personnel have entered the space, they should be ordered to leave immediately. They should not be permitted to re-enter until the situation has been re-evaluated and the safe conditions stated on the entry permit have been restored.

10.11.2 Organising rescue and recovery from enclosed spaces

The rescue procedures for enclosed spaces should be well planned and regular drills held to improve their effectiveness. Regular training for the emergency rescue team is essential.

Emergency rescue team members should be:

- Prepared for the physical and technical demands of rescues in enclosed space.
- Well trained in all rescue team duties.
- Familiar with the rescue equipment, which should be easily deployable.
- Capable of fulfilling any role within the rescue team.

10.11.2.1 Composition of the rescue team

The rescue team should consist of dedicated team members with roles defined in the SMS. All rescue team members should be trained and experienced in rescue operations and be familiar with the ship's emergency procedures.

Although a designated team offers major advantages, it is essential that backup personnel are also identified in case somebody is unavailable.

10.11.2.2 Team roles

The rescue team should consist of:

- Team leader: this should be a senior officer whose role is to direct the rescue effort. The team leader should not be in the team that enters the enclosed space.
- Entry team: while the number should be kept to a minimum, at least two should enter the space to carry out the rescue.
- Backup team: these should rig the rescue equipment, ensuring that the entry team has the equipment and support necessary to carry out the rescue and to monitor the enclosed space atmosphere. One crew member should help the rescue team leader with communications and to maintain a record of events.

10.11.2.3 The rescue operation

As soon as they are aware that somebody in the space is in difficulty, the Attendant should raise the alarm. The method of raising the alarm should be agreed and tested in advance, together with a way to communicate the details of the emergency.

The rescue team needs to know the nature of the incident and how many people are affected. During an enclosed space entry, the rescue team personnel should not be carrying out any duties that would hinder their ability to respond immediately to an alarm. They should proceed straight away to the entrance to the space, taking any necessary additional equipment. Nobody should enter the space without the team leader's permission.

Unless it has been positively shown that the atmosphere in the enclosed space is safe to breath, the rescue team should wear appropriate protective equipment and use SCBAs. Only after a full test has confirmed that the enclosed space atmosphere is safe should the team proceed without breathing apparatus.

On reaching the casualties the team should check if they are still breathing. Any casualties not breathing should be removed as soon as possible for resuscitation.

Any casualties who are breathing should have their injuries assessed before they are removed from the space. If the condition of the atmosphere in the enclosed space is not verified as safe, the casualty should be given an independent air supply.

During the incident, the team leader and backup team should:

- Monitor the rescue team and ensure spare air supplies are available.
- Rig rescue equipment, e.g. hoists.
- Monitor the atmosphere of the space.
- Communicate with the ship's command team.
- Arrange additional lighting, ventilation and improve access to the space if necessary.

Casualties should be removed with the most appropriate equipment, such as stretchers, lifting harnesses and hoisting apparatus.

10.11.2.4 Resuscitation

Tanker and terminal personnel with safety responsibilities should be trained in resuscitating people who have been overcome by toxic gases or fumes, or whose breathing has stopped after an electric shock, drowning or some other cause.

Most tankers and terminals have a special resuscitation apparatus. The crew should be aware of its location and be trained in its proper use.

The apparatus should be stowed where it is easily accessible. It should not be kept locked up. The instructions should be clearly displayed. The apparatus and the contents of cylinders should be checked frequently in line with the Planned Maintenance System (PMS). Adequate spare cylinders should be carried.

10.12 Cargo pumproom entry precautions

Cargo pumprooms should be seen as enclosed spaces and the recommendations of this chapter should be followed as closely as possible. However, because of their location, design and the operational need for crew to enter the space routinely, pumprooms present a particular hazard and require special precautions.

A cargo pumproom contains the largest concentration of cargo pipelines of any space within the ship and leaks of volatile products from any part of this system could quickly generate a flammable or toxic atmosphere.

10.12.1 Cargo pumproom entry procedures

Before anyone enters a cargo pumproom, it should be thoroughly ventilated, the oxygen content of the atmosphere verified and the atmosphere checked for hydrocarbons or any toxic gas associated with the current or recent cargoes.

Atmosphere testing should be conducted with portable gas equipment. A fixed gas detection system can be used if it:

- Is correctly calibrated and tested.
- Provides gas readings as a percentage of the LFL as accurately as portable gas equipment.
- Provides toxic gas readings equivalent to portable gas equipment.
- Provides oxygen readings equivalent to portable gas equipment.
- Is located at representative locations within the pumproom.

Written procedures should control pumproom entry. These procedures should:

- Be based on a risk assessment.
- Ensure that risk mitigation measures are followed.
- Ensure that entries into the space are recorded.

A communications system should provide links between the pumproom, navigation bridge, engine room and cargo control room. Audible and visual repeaters for essential alarm systems, e.g. the general alarm and the fixed extinguishing system alarm, should also be installed in the pumproom.

Crew members in the pumproom and those outside should be able to communicate at all times. Regular communication checks should be made at agreed intervals. Any failure to respond is a cause to raise the alarm.

Do not use VHF/UHF communication as a primary method if it is known that reception may be unreliable or noisy. Where communication by VHF/UHF is difficult, an Attendant should be positioned at the pumproom top and a visual and remote communication procedure should be in place.

With a view to minimising entry, review how often crew members enter the pumproom for routine inspection during cargo operations.

Notices should be displayed at the pumproom entrance prohibiting entry without formal permission and to indicate the presence of personnel in the space.

10.12.2 Cargo pumproom ventilation

Given the potential presence of hydrocarbon gas in the pumproom, mechanical ventilation by extraction is required in a safe atmosphere.

Ships built after July 2002 must have continuous monitoring of the pumproom atmosphere and an audible and visual alarm system that activates when the hydrocarbon gas concentration in the pumproom exceeds a pre-set level, which should not be more than 10% LFL.

The pumproom ventilation should be interlocked with the pumproom lighting so that the ventilation operates when the lights are switched on. This does not apply to emergency lighting.

During cargo handling, the pumproom ventilation system should be operating at the correct (lower) suction. If fitted, the gas detection system should be functioning correctly. Ventilation should be continuous until access is no longer required.

10.13 Respiratory Protective Equipment

Several different types of RPE are available on tankers.

Under the ISM Code, the operator is responsible for providing the level of equipment needed to manage all the operational and safety activities on the ship. In most cases, the RPE needed to do this will exceed the minimum requirements of SOLAS fire safety provisions.

Cartridge or canister face masks will not protect the user against concentrations of hydrocarbon or toxic vapours or against oxygen deficiency. They should never be used in place of breathing apparatus.

10.13.1 Self-Contained Breathing Apparatus

This is a portable supply of compressed air contained in a cylinder or cylinders attached to a carrying frame and harness worn by the user. Air is provided to the user through a face mask, which can be adjusted to give an airtight fit. A gauge indicates the pressure in the cylinder and an audible alarm sounds when the supply is running low. Only positive pressure type SCBAs are recommended for use in enclosed spaces because they always maintain a positive pressure within the face mask.

When using the equipment:

- Check the pressure gauge before use.
- Test the audible low pressure alarm before use.
- Check the face mask and adjust it to ensure it is airtight. Facial hair may affect the mask's seal. In this case, another person should wear the apparatus and make the entry. Alternatively, use other specialist equipment that allows for facial hair.
- Monitor the pressure gauge frequently during use to check the remaining air supply.
- Allow plenty of time for leaving the hazardous atmosphere.
- Exit immediately if the low pressure alarm sounds. The duration of the air supply depends on the weight and fitness of the user and the extent of their exertion.

If users suspect at any time that the equipment may not be operating satisfactorily or are concerned about the integrity of the face mask seal, they should exit the space immediately.

10.13.2 Air-line breathing apparatus

Compared to using self-contained equipment, an air-line breathing apparatus enables personnel to stay in an enclosed space longer.

The equipment consists of a face mask supplied with air through a small diameter hose leading outside the space, where it is connected to compressed air cylinders or an air-line served by a compressor. If the ship's air supply is used it should be properly filtered and monitored for toxic or hazardous constituents. The hose is attached to the user by a belt or other arrangement, which can be quickly disconnected in an emergency. A flow control valve, or orifice, regulates air to the face mask.

If the air supply is from a compressor, it will include an emergency supply of air cylinders should the compressor fail. In an emergency, the user should leave the space immediately.

A trained and Competent Person should be in control of the air-line pressure. If normal working pressure cannot be maintained, they should make the change to the alternative supply.

When using the air-line breathing apparatus:

- Check and adjust the face mask so that it is airtight. Facial hair may make this harder to achieve.
- Check the working pressure before each use.
- Check the audible low pressure alarm before each use.
- Keep the air-lines clear of sharp projections to avoid any damage.
- Ensure the air hose does not exceed the manufacturer's maximum recommended length.

If there is any doubt about the efficiency of the equipment, the user should leave the space immediately.

Users should carry a reserve air cylinder that is permanently connected so that in the event of an interruption of airflow from the primary supply source, switchover to emergency air supply is immediately achieved, avoiding any interruption in the airflow. An EEBD is not recommended for this purpose.

10.13.3 Emergency Escape Breathing Device

EEBDs are for emergency escape and should not be used as the primary means for entering spaces or compartments with unsafe atmospheres.

This is a compressed air breathing set a person can use to escape a compartment where the atmosphere has become hazardous. It is required that EEBDs be provided for escape from fires in machinery or accommodation spaces. Additional sets should be provided as emergency escape equipment for enclosed space entry. Each set lasts a minimum of ten minutes.

The device can be one of two types:

Compressed air Emergency Escape Breathing Device

This consists of an air cylinder, reducing valve, air hose, face mask or hood and a flame retardant high visibility bag or jacket. It is normally a constant flow device, providing compressed air at a rate of approximately 40 litres per minute, giving a 10–15 minute duration, depending on the capacity of the cylinder. Compressed air EEBDs can normally be recharged on board with a conventional SCBA compressor. The pressure gauge, supply valve and hood should be checked before use.

Re-breathing Emergency Escape Breathing Device

This normally consists of a robust watertight carrying case, compressed oxygen cylinder, breathing bag, mouthpiece and a flame retardant hood. It is designed for single use. When the hood is placed over the user's head and the set activated, exhaled air is mixed with compressed oxygen inside the breathing bag to allow the wearer to breath normally when escaping from a hazardous atmosphere.

10.13.4 Equipment maintenance

A Responsible Person should examine all RPE at regular intervals.

Defects should be made good promptly and a record should be kept of inspections and repairs. Air cylinders should be recharged as soon as possible after use.

Air cylinders that are damaged or corroded should be removed from service and either repaired or replaced. All cylinders should be hydrostatically tested as required by the appropriate administration's regulation.

Masks and helmets should be cleaned and disinfected after use. Any repair or maintenance should be carried out strictly according to the manufacturer's instructions.

10.13.5 Stowage

Breathing apparatus should be stowed fully assembled in a place where it is readily accessible. Air cylinders should be fully charged and the adjusting straps kept slack. Units should be available for emergencies in different parts of the ship.

10.13.6 Breathing apparatus training

All crew members should receive practical demonstrations and undergo training in the use of breathing apparatus.

Formal shore based training may supplement onboard training and is particularly beneficial for personnel identified as potential members of the rescue team.

Only trained personnel should use self-contained and air-line breathing apparatus. Incorrect or inefficient use can endanger the user's life.