Nō te rere moana Aotearoa
MARITIME NEW ZEALAND

Working safely in confined spaces

Guidelines for planning entry and working safely in confined and enclosed spaces on medium and large ships

Working safely in confined spaces

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Acknowledgement

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1. Overview

Investigations into confined space-related casualties are said to show that most are caused by poor training and knowledge of the correct entry procedures, or a disregard for them. [1]

It is therefore vital that everyone who works in or near a confined space is aware of their dangers, learns the correct entry procedures (whether or not it is a requirement of their role), and understands that confined spaces should not be entered without following proper precautions, even in an emergency.

These guidelines are for:

- operators, owners, masters and crew of medium and large New Zealand ships
- stevedore companies, contractors, ship builders or repairers working on-board ships
- surveyors
- classification societies in New Zealand and class surveyors
- Maritime NZ maritime officers, investigators and technical advisors.

Their purpose is to:

- highlight the dangers associated with confined spaces on ships, and some of the lethal hazards present
- identify how best to reduce the risks involved, and
- alert people to the hazards of poorly planned rescue attempts.

The guidelines are restricted to medium and large ships because a number of the suggested control measures will be inappropriate on many small vessels (for example, developing a written authority to work and communicating with the officer of the watch) and the level of expertise required to meet the guidelines is likely to be too onerous for many small operators (for example, having specialist training). Maritime NZ will produce guidelines for operators, owners, masters and crew of small ships in due course.

Australian Standard *AS 2865 Confined spaces* (hereafter called 'the Standard') covers confined and enclosed space work. Maritime New Zealand accepts this as reflecting the current state of knowledge on such work.

These guidelines provide an overview of the requirements and procedures in the Standard. They are not a substitute for the Standard, and Maritime NZ recommends that anyone who carries out confined or enclosed space work is familiar with the Standard and has specialist training as well. The Standard can be purchased at https://infostore.saiglobal.com/

Additionally, the International Maritime Organization (IMO) and SOLAS regulations specify requirements in relation to confined spaces, and nothing in these guidelines should be interpreted as negating those requirements. The IMO's International Safety Management (ISM) Code is reflected in section 1 of Maritime Rules Part 21, which concerns safety management systems. It applies to the following ships,

[1] Standard Club, A Master's Guide to Enclosed Space Entry, Version 2, August 2017.

regardless of the date of their construction.

- Passenger ships (including passenger high-speed craft)
- Oil tankers
- Chemical tankers
- Gas carriers
- Bulk carriers
- Cargo high-speed craft of 500 gross tonnage and above
- Cargo ships
- Mobile offshore drilling units of 500 gross tonnage and above.

Note that the general provisions of the Health and Safety at Work Act 2015 (HSWA) apply to confined and enclosed spaces associated with the operations of businesses. Section 30 of HSWA requires duty holders to eliminate or minimise risks to health and safety, so far as is reasonably practicable. Section 34 requires that persons conducting a business or undertaking (PCBUs) must consult, cooperate with and coordinate activities with all other PCBUs who have a duty in relation to the same matter as far as reasonably practicable. Compliance with the Standard and the IMO and SOLAS regulation would be relevant to, but would not necessarily determine, the question of whether or not HSWA obligations had been met.

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1.1 How these guidelines work: a plain English explainer

Section 6 of these guidelines sets out 14 control measures that PCBUs should consider to control the risks posed by the hazards associated with working in a confined space. These range from considering if the work can be done without entering the confined space through to considering if emergency equipment should be positioned ready for use at the entrance of the confined space.

The guidelines say you should consider these control measures – not that you have to implement them all. Maritime NZ recognises that a wide diversity of activities occurs in confined spaces on ships, and that the nature of confined spaces varies markedly. It also recognises that it will be impossible for some essential work to occur without entering into confined spaces. If you have considered a particular control measure and found it cannot be practicably applied, you should move on to the next control measure and consider what would be appropriate to apply in the particular context of the work to be done.

Note that if your industry sector has guidance setting out equivalent or higher standards, you may continue to use that.

2. Confined and enclosed spaces – serial killers

Confined and enclosed spaces have been likened to serial killers. Year after year people die when entering them to carry out work. In some cases multiple fatalities occur when would be rescuers also enter them and become victims themselves. Consider the following cases in New Zealand.

- Two men were killed by entering a ship's hold containing freshly milled logs that had caused oxygen depletion. The first man was overcome and fell from the ladder shortly after descending into the hold. The second man went to rescue him and was also overcome. A third man went to help them both but was held back from doing so.
- A deckhand on a fishing vessel cracked open a void space for venting and inspection by a surveyor, looked inside and dropped his phone. He fell unconscious in the void space when he tried to retrieve his phone.

The Standard Club's document, *A Master's Guide to Enclosed Space Entry*, Version 2, August 2017[2] cites a number of accidents that also make sobering reading. Examples include:

Poor rescue plan and incorrect use of rescue equipment

Three experienced seamen died inside a chain locker. Two were overcome while tying off an anchor chain to prevent it from rattling in the spurling pipe. The third was a crew member attempting to rescue his two colleagues. Despite entering the chain locker wearing an Emergency Escape Breathing Device (EEBD), he removed its hood after being constrained by the device. All three men died from lack of oxygen inside the chain locker caused by the ongoing corrosion of its steel structure and anchor chain.

Migration of oxygen-deficient air to an adjacent space

Two seamen collapsed in a store room. The chief officer entered the store to try to rescue the men but was forced to leave when he became short of breath and his vision was affected. The two seamen had been asphyxiated. The store was adjacent to the ship's forward cargo hold containing steel turnings. To allow for the drainage of sea water and the removal of cargo residue, a section of the vent trunking on either side of the cargo ventilation fan motor, located in the store, had been cut. This allowed a path for air from the self-heating cargo to enter the store. When tested later, the air in the cargo hold was found to contain only 6% oxygen and, as a result, the storeroom's atmosphere was oxygen deficient.

Carbon monoxide migration

A port state inspector boarded a totally enclosed free-fall lifeboat stowed aft of the accommodation/ engine housing. On entry, his personal gas meter alarmed. Investigation confirmed carbon monoxide had collected in the lifeboat. This was caused by the funnel exhaust being blown into the lifeboat due to the prevailing wind conditions during the voyage.

Oxygen-deficient atmosphere even after correct testing

An inspection was being carried out on a container ship's deep ballast tanks, which had been ventilated and tested before entry. However, when inspecting a smaller box-like structure within the tank, which was part of the ship's construction, the inspector's personal gas meter alarmed, showing a lack of oxygen. The poor atmosphere within the space may not have been detected previously due to the construction and layout of the space.

[2] http://www.nautinst.org/filemanager/root/site_assets/forums/enclosed_spaces/a-masters-guide-to-enclosed-space-entry.pdf

Fumigation incidents

A general cargo ship was loaded with grains and fumigated at the load port by applying aluminium phosphide pellets. During the short voyage, a crewman was found deceased in his cabin adjacent to the aft bulkhead of the hold. On investigation at the next port, high concentrations of phosphine gas (generated by the fumigation pellets) were found in the seaman's cabin. It is thought that the toxic gas migrated into the cabin, but initially no obvious leakage path was found, even after applying a smoke test. After descaling the area where the cabin and hold joined, some 'pin' holes were found in the steel work. All indications are that the seaman died of phosphine poisoning.

Warning!

Never trust your senses to determine if the atmosphere in a confined or enclosed space is safe. You cannot see or smell many toxic gases and vapours, nor can you determine the concentration of oxygen or flammable contaminants present.

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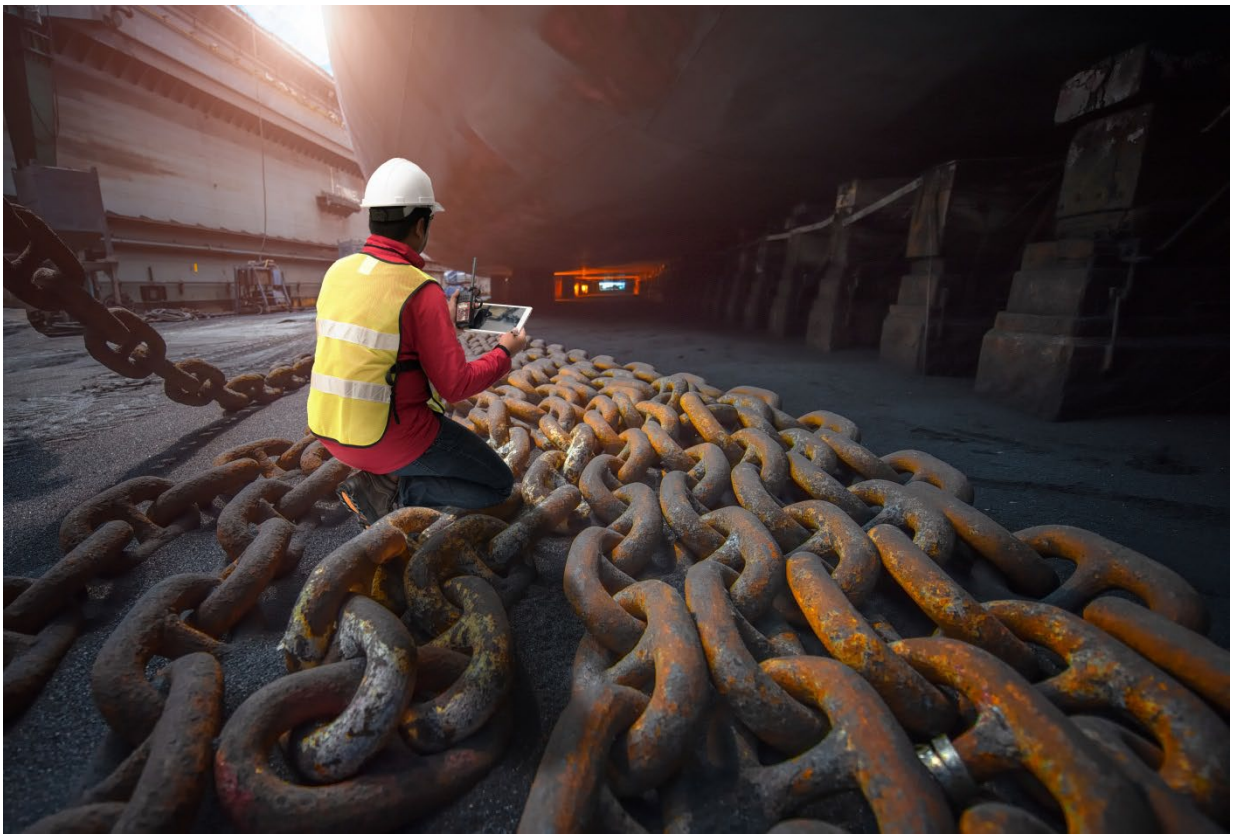

3. What is a confined or enclosed space?

Confined and enclosed spaces are essentially the same thing, so from here on these guidelines refer to them only as confined spaces. The Standard provides the following definition.

> Confined space
>
> An enclosed or partially enclosed space that is not intended or designed primarily for human occupancy, within which there is a risk of one or more of the following:
>
> a) an oxygen concentration outside the safe oxygen range
> b) a concentration of airborne contaminant that may cause impairment, loss of consciousness or asphyxiation
> c) a concentration of flammable airborne contaminant that may cause injury from fire or explosion
> d) engulfment in a stored free-flowing solid or a rising level of liquid that may cause suffocation or drowning.

Confined spaces are often characterised by limited openings for entry and exit, restricted natural ventilation and not being designed for continuous presence of workers. They may be present on a wide variety of vessels. Examples on ships may include, but are not limited to:

- cargo spaces
- double bottoms
- fuel tanks
- ballast tanks
- cargo pump-rooms
- cargo compressor rooms
- cofferdams
- chain lockers
- void spaces
- duct keels
- inter-barrier spaces
- boilers
- engine crankcases
- engine scavenge air receivers
- sewage tanks and adjacent connected spaces.

This list is not exhaustive and a list should be produced on a ship-by-ship basis to identify such spaces.

Section 30 of HSWA requires that any person with a duty imposed on them by that Act eliminates risks to health and safety, so far as is reasonably practicable, and if that is not possible, minimises those risks so far as is reasonably practicable. They must comply with this to the extent to which they have, or would reasonably be expected to have, the ability to influence and control the matter to which the risks relate.

This requires that hazards are identified that could give rise to reasonably foreseeable risks to health and safety.

Some spaces on ships do not meet the definition of a confined space but can still contain hazardous atmospheres. These include, for example, engine rooms, galleys (e.g. as a result of poorly maintained gas appliances), and other spaces into which a ship's exhaust may have been venting (including lifeboats). The hazards associated with these spaces should be identified and the risks assessed and controlled.

SOLAS vessels are required by law to compile a list of confined spaces on the ship and maintain a register. It is good practice to maintain a register of confined spaces on any kind of ship and make these available to all persons on board.

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4. What does the Standard require?

The Standard is consistent with the approach of HSWA. It requires PCBUs to:

- identify the hazards associated with working in the confined space and conduct a risk assessment
- control the risks posed by the hazards by:
    - elimination, so far as is reasonably practicable, and
    - if it is not reasonably practicable to eliminate risks to health and safety, minimisation so far as is reasonably practicable, including using personal protective equipment (PPE).

5. Identifying hazards and assessing risk

5.1 Identify the hazards

Before any work is undertaken in a confined space, a competent person should identify all of the hazards associated with entry to, exit from and work in the space. The Standard gives detailed information on hazard identification.

A competent person is a person who has, by a combination of training, education, experience, acquired knowledge and skills to enable him or her to:

a) make an informed assessment of the likelihood of an airborne contaminant being present or subsequently arising in a confined space, or
b) correctly perform a specific task associated with a confined space.

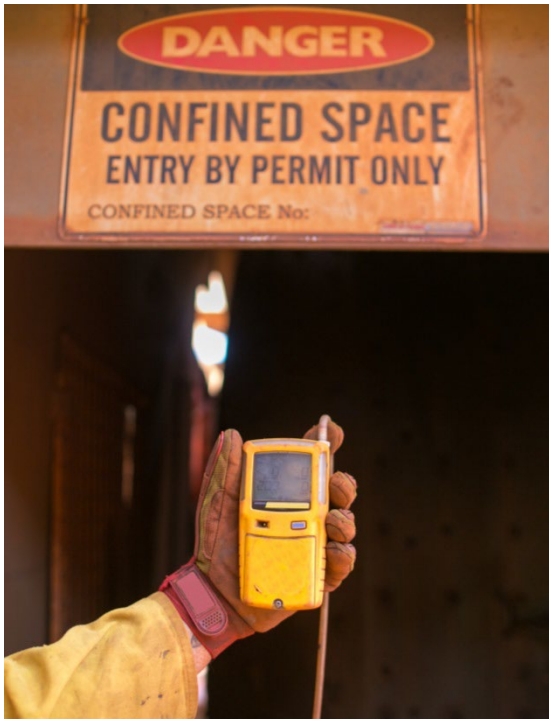
Appendix 1 of this document discusses different types of hazards.

5.2 Undertake a risk assessment and prepare a written report

A competent person should undertake a risk assessment for any work to be conducted in a confined space and prepare a written report on the risks before a written authority to work is issued. The competent person should consider the matters in the Standard and also the nature of the confined space, the estimated duration of the work, and any potential hazard inside the space.

One risk assessment may suffice for more than one confined space if the spaces are similar and the risk factors in the spaces are identical.

Appendix E in the Standard provides tools to help with risk assessments.



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6. Controlling the risks

The control measures should begin with elimination, followed by minimisation. You should consider the following.

6.1 Can work be done without entry to the confined space?

As a first step, always check to see if the work can be done with equipment from outside the confined space. The golden rule is: Don't go in if you don't have to. Work practices should be designed to minimise the need to enter confined spaces.

6.2 Isolate contaminants and moving parts, and potentially suspend pumping operations and cargo movements

Prevent accidental introduction of materials (e.g. steam, water or bulk materials), through piping, ducts, vents, etc. De-energise, lockout or tagout machinery.

Blank off pipelines or other openings and close valves. Tie valves or use some other means to indicate that they are not to be opened and place notices on the relevant controls. Inform the officer on watch.

Where necessary, suspend pumping operations or cargo movements when entry is being made into a dangerous space.

Ensure no works occur on the other side of a bulkhead that could alter the atmosphere in the confined space while a person is in it (for example hot works that could cause burning of paint).

6.3 Ventilate the confined space, and clean and purge it if necessary

Use a blower designed for the purpose to ventilate the confined space. When blowing air into the space, make sure a high volume of air is blown in at a low speed – this can be provided by trunking and a blower made especially for this purpose. Then test the air again for levels of oxygen and other gases to ensure that contaminants are reduced to a safe level.

Use a suitable cleaning method to remove harmful solids or sludges. This may in itself lead to the release of gases, so take precautions. Purge with fresh air to remove harmful gases or vapours.

When ventilating a confined space, as many access points as possible should be opened. The air intake of the hose should also be placed in an area that will draw in fresh air only.

Warnings!

- When opening the entrance to a potentially dangerous space, take precautions in case gases (unpressurised or pressurised) are released from the space.
- Never use pure oxygen, or a gas mixture with oxygen content greater than 21% by volume, to purge or ventilate a space: this can create a fire and explosion hazard.

6.4 Test, and if necessary monitor, the atmosphere

Appendix I of the Standard should be followed for atmospheric testing and monitoring.

Always be aware that oxygen-deficient areas may exist even when a confined space has been satisfactorily tested, and you should always suspect these will be present. This can be caused by the internal structure of the space, cargo, cargo residues and tank coatings, especially where the path of supply and outlet ventilation is obstructed by structural members or cargo.

A record of the testing should be retained for five years.

Particular care should be taken when working on pipelines and valves within the space. If conditions change during such work, the competent person should increase the frequency of atmospheric testing. Changing conditions that may occur include: increasing ambient temperatures; the use of oxygen-fuel torches or mobile plant; work activities in the enclosed space that could evolve vapours; work breaks; or if the ship is ballasted or trimmed during the work.

6.5 Select appropriate breathing apparatus if necessary

If the space cannot be ventilated, or if the work will contaminate the atmosphere (e.g. hot work, painting, sludge removal), use a suitable self-contained breathing apparatus or supplied-air respirator as specified in the Standard.

6.6 Selecting the right protective, safety and other equipment

If the authority to work identifies that PPE or any other equipment is necessary for work in the confined space, it should be accessible and suitable for the work to be carried out.

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6.7 Maintenance of equipment

All equipment provided for use in, or in connection with, entry to or work in a confined space or during an emergency response should be maintained to be fit for the purpose for which it was provided. A record of maintenance of the equipment should be retained for five years.

6.8 Issue a written authority for entry to work

The PCBU or person responsible for the work should issue a written authority – or confined space entry permit – as described in the Standard. Essentially, this authority is a safety checklist to make sure nothing is overlooked.

A record should be kept of everyone permitted to enter or work in the space under a written authority to work, and who enters into and exits from the space. This should be kept for five years after the time when it ceased to be valid or was withdrawn.

When any of the following occur during work permitted by a written authority to work, that authority to work should be considered no longer valid:

- there is a change of person who has direct control of entry to or work in the confined space
- there is a change in the work permitted under the authority
- the risk assessment ceases to be valid, or
- there is a break in work continuity.

Whenever an authority to work ceases to be valid, the confined space should be evacuated and the entrance closed or secured to prevent re-entry until there is another or revalidated written authority to work in that space.

Appendix H in the Standard provides a sample written authority.

6.9 Working with a stand-by person

Have a trained stand-by person to monitor the safety of the person entering and working inside the space, take action if an emergency arises, and communicate with the officer of the watch. Ensure there is a reliable system of communication – by voice, radio, hand signals, hard-wired communication, or other means.

6.10 Monitor and maintain control measures

Test the air in a confined space constantly as oxygen and gas levels in such spaces can change quickly. Be alert for any change in conditions.

6.11 Additional precautions when the atmosphere is known or suspected to be unsafe

If the atmosphere in a confined space is suspected or known to be unsafe, nobody should enter the space if a practical alternative exists. Entry should only be made for further testing, essential operation, safety of life or safety of a ship. The number of people entering the space should be kept to the minimum required.

Suitable breathing apparatus, e.g. of the air-line or self-contained type, should always be worn, and only personnel trained in its use should be allowed to enter the space. Air-purifying respirators should not be

used as they do not provide a supply of clean air from a source independent of the atmosphere within the space.

Persons entering confined spaces should be provided with calibrated and tested multi-gas detectors that monitor the levels of oxygen, carbon monoxide and other gases as appropriate.

Appropriate protective clothing should be worn, particularly where there is any risk of toxic substances or chemicals coming into contact with the skin or eyes of people entering the space.

6.12 If conditions change, evacuate the confined space

There should be a system for getting a worker out of the confined space quickly if anything goes wrong. This could include using a safety harness and safety line or rescue line.

Warning! If things go wrong

If you see someone lying motionless, even if at the bottom of a ladder in an enclosed space, DO NOT go in to carry out a rescue by yourself. Typically, personnel react by rushing into lethal atmospheres under the misconception that they will be able to save colleagues. But unplanned rescues are likely to end in tragedy.

When an emergency occurs the alarm should be sounded so that back-up is immediately available to the rescue team. Under no circumstances should the stand-by person enter the space before help has arrived and the situation has been evaluated. The safety of rescuers entering the space must be ensured.

6.13 Training

Provide training for all workers who may be involved in confined space work, including stand-by persons, to ensure they have the skills to safely do the work. Regularly reassess workers' competency for working in confined spaces.

Section 2.6 in the Standard sets out the requirements for training and assessment of competency and additional guidance for the provision of this is given in Appendix D of the Standard.

6.14 Confined space emergency procedures and equipment

Have a site-specific emergency procedure and emergency equipment for every confined space job. This will include:

- first aid
- firefighting equipment
- a rescue procedure for workers who may be injured or incapacitated
- PPE and RPE for rescuers
- an emergency contact details register.

Test rescue procedures to make sure they are safe and effective – it is not easy to extract a person from a confined space. When testing rescue procedures, make the situation as realistic as possible. The victim and the rescuer are likely to be wearing PPE and RPE that may make it more difficult to extract them.

Ship operators should ensure that all workers who may be involved in confined space work, including stand-by persons, have practised the emergency procedures before entry or work in any confined space occurs. Rescue procedures should be practised frequently enough to provide a level of proficiency that eliminates life-threatening rescue attempts and ensures an efficient and calm response to any emergency.

Before anyone enters a confined space in response to an emergency, they should be informed about the:

a) nature of the emergency
b) content of the written authority to work in the confined space; and
c) hazards and risks identified in the risk assessment for the confined space.

Emergency and first aid procedures appropriate to a confined space should be in a written document available to everyone who may enter or work in the confined space.

Emergency equipment – including resuscitation equipment – should be easily and quickly available to the stand-by person. The competent person should decide if it would be appropriate for this equipment to be positioned ready for use at the entrance to the confined space.

7. For further information

These guidelines provide an overview of the requirements and procedures in the Standard. They are not a substitute for the Standard, and anyone who carries out confined or enclosed space work needs to be familiar with the Standard and should have specialist training as well. The Standard can be purchased at https://infostore.saiglobal.com/

Appendix 1: Types of hazards

Some of the hazards of confined spaces on ships include:

- oxygen deficient atmospheres, which can cause unconsciousness, brain damage and death
    - oxygen deficiency can be caused by such things as: rusting steel (including chain); wood products; rotting or self-heating of any organic matter; drying paint or coatings; motors/petrol pumps; refrigerants and other gases; hot work (torching or welding); charcoal, coal, lignite and coal products; and many other types of cargo
- toxic atmospheres, containing gases, vapours, dusts or fumes that have poisonous effects on the body. Cleaning, painting or welding may produce dangerous vapours and fumes. Hydrogen sulphide, for example, is highly poisonous, often lethal and can evolve from fuel tanks, pipes, sewage and organic decomposition. Carbon monoxide damages a person's ability to absorb oxygen and this can also accumulate for days after exposure. Elevated concentrations of oxygen can also be toxic to humans: toxicity depends on a combination of oxygen concentration and exposure duration, and includes risk of neurological damage[3]
- uncontrolled introduction of steam, water, or other gas or liquid
- other atmospheric, engulfment, task-related and occupational hazards identified in the Standard.

Some of the hazards listed above relate to specific types of ships or cargo. These are discussed below.

Dangerous goods in packaged form

The atmosphere of any space containing dangerous goods may put at risk the health or life of any person entering it. Dangers may include: flammable, toxic or corrosive gases or vapours that displace oxygen; residues on packages; and spilled material. The same hazards may be present in spaces adjacent to the cargo spaces. Information on substance hazards is contained in the International Maritime Dangerous Goods (IMDG) Code, the Emergency Response Procedures for Ships Carrying Dangerous Goods (EmS) and Safety Data Sheets (SDS).[4]

If there is evidence or suspicion that leakage of dangerous substances has occurred, the precautions specified under 'Additional precautions when the atmosphere is known or suspected to be unsafe' in this document (Section 6.11) should be followed.

Workers who deal with spillages and/or remove defective or damaged packages should be appropriately trained and wear suitable breathing apparatus and appropriate protective clothing.

Note that dangerous goods may still be present due, for example, to undeclared or mis-declared dangerous cargo.

Liquid bulk

The tanker industry has produced extensive advice to operators and crews of ships engaged in bulk carriage of oil, chemicals and liquefied gases, in the form of specialist international safety guides. Information in the guides on enclosed space entry amplifies the

[3] https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/oxygen-toxicity
[4] See https://www.epa.govt.nz/industry-areas/hazardous-substances/guidance-for-importers-and-manufacturers/labelling-and-safety-data-sheets/

recommendations in this document and should be used as the basis for preparing entry plans.

Solid bulk

On ships carrying solid bulk cargoes, dangerous atmospheres may develop in cargo spaces and adjacent spaces. The dangers may include flammability, toxicity, oxygen depletion or self-heating, as identified in the shipper's declaration. For additional information, refer to the International Maritime Solid Bulk Cargoes (IMSBC) Code.

Use of Nitrogen as an inert gas

Nitrogen is a colourless and odourless gas. When used as an inert gas, it causes oxygen deficiency. This can occur in enclosed spaces and at exhaust openings on deck during purging of tanks, void spaces and cargo holds. One deep breath of 100% nitrogen gas will be fatal.[5]

Oxygen-depleting cargoes and materials

A prominent risk with such cargoes is oxygen depletion due to the inherent form of the cargo. This is discussed briefly under 'Identifying hazards and assessing risk' earlier in this document.

Fumigation

When a ship is fumigated, the detailed recommendations contained in the 'Recommendations on the safe use of pesticides in ships (MSC.1/Circ.1358)' should be followed. Spaces adjacent to fumigated spaces should be treated as if fumigated.

Toxicity of oil cargoes

Hydrocarbon gases are flammable as well as toxic. They may be present in fuel or cargo tanks that have contained crude oil or its products. Hydrocarbon gases or vapours may also be present in pump rooms and cofferdams, duct keels or other spaces adjacent to cargo tanks due to the leakage of cargo. The components in the vapour of some oil cargoes, such as benzene and hydrogen sulphide are very toxic.

Toxicity of other substances

Cargoes carried in chemical tankers or gas carriers may be toxic.

There is the possibility of leakage from drums of chemicals or packages of dangerous goods where there has been mishandling, incorrect stowage or damage due to heavy weather.

The trace components in inert gases such as carbon monoxide, sulphur dioxide, nitric oxide and nitrogen dioxide are very toxic.

The interaction of vegetable oils, animal oils or sewage with sea water may lead to the release of hydrogen sulphide, which is very toxic.

[5] Refer to the Guidelines on tank entry for tankers using nitrogen as an inerting medium (MSC.1/Circ.1401).

Hydrogen sulphide or other toxic gases may be generated where the residue of grain or similar cargoes permeates into or chokes bilge pumping systems.

Chemical cleaning, painting or repair of tank coatings may involve the release of solvent vapours.

Flammability

Flammable vapours may still be present in cargo or other tanks that have contained oil products or chemical or gas cargoes.

Cofferdams and other spaces that are adjacent to cargo and other tanks may contain flammable vapours if there has been leakage into the space.

Other

Although the inhalation of contaminated air is the most likely route through which harmful substances enter the body, some chemicals can be absorbed through the skin.

Some of the substances used on board ships and cargoes carried in chemical tankers and gas carriers are irritant or corrosive if permitted to come into contact with the skin.

The disturbance of rust, scale or sludge residues of cargoes of animal, vegetable or mineral origin, or of water that could be covering such substances, may lead to the release of toxic or flammable gases.