**ANNEX 28**

**RESOLUTION MSC.581(110)**
**(adopted on 27 June 2025)**

**REVISED RECOMMENDATIONS FOR ENTERING ENCLOSED SPACES ABOARD SHIPS**

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 15(j) of the Convention on the International Maritime Organization regarding the functions of the Assembly in relation to regulations and guidelines concerning maritime safety,

RECALLING ALSO its adoption, by resolution A.864(20), of *the Recommendations for entering enclosed spaces aboard ships*, and by resolution A.1050(27), of the *Revised recommendations for entering enclosed spaces aboard ships*, incorporating therein recommendations for entering cargo spaces, tanks, pump-rooms, fuel tanks, cofferdams, duct keels, ballast tanks and similar enclosed spaces,

RECALLING FURTHER that SOLAS regulation III/19.3.6 requires enclosed space entry and rescue drills, SOLAS regulation XI-1/7 requires the carrying of atmosphere testing instrument for enclosed spaces, and SOLAS chapter IX and the ISM Code require management for the safe operation of ships,

RECALLING that the Maritime Safety Committee is requested to keep the revised recommendations under review and amend them as necessary,

BEING CONCERNED about the continued loss of life resulting from personnel entering shipboard spaces in which the atmosphere is unable to support life, owing to oxygen depletion, oxygen enrichment, toxicity or flammability,

BEING AWARE of the work undertaken in this regard by the International Labour Organization, Governments and segments of the private sector,

RECOGNIZING that organizational leadership plays a crucial role in successful implementation of this guidance by empowering shipboard staff to make the right decisions,

HAVING CONSIDERED, at its […] session, the recommendation made by the Sub-Committee on Carriage of Cargoes and Containers at its tenth session,

1 ADOPTS the *Revised recommendations for entering enclosed spaces aboard ships*, as set out in the annex to the present resolution;

2 INVITES Governments to bring the annexed Revised Recommendations to the attention of shipowners, ship operators, seafarers, port and terminal operators and port workers, urging them to apply them, as appropriate, to all ships and operations;

3 INVITES the Assembly to revoke resolution A.1050(27) and to endorse the action taken by the Maritime Safety Committee.

ANNEX

# REVISED RECOMMENDATIONS FOR ENTERING ENCLOSED SPACES ABOARD SHIPS

## Preamble

The objective of these recommendations is to encourage the adoption of safety procedures and the development of sound practices aimed at preventing casualties to, and enhancing the safety of, personnel entering or working in enclosed spaces where there may be an oxygen-deficient, oxygen-enriched, flammable and/or toxic atmosphere. Additionally, in the event of an emergency within an enclosed space, these recommendations provide guidance for an appropriate, planned and considered response complying with ship-specific enclosed space rescue plans.

Investigations into the circumstances of enclosed space accidents have shown that a failure to systematically identify the hazards, assess the risks and implement an appropriate entry procedure remains a significant factor in many accidents. Likewise, the complex structure of some spaces on board ships creates problems with appropriate ventilation, illumination and movement within the space. Organizational leadership on ship and shore plays a crucial role in successful implementation of this guidance by empowering shipboard staff to make the right decisions.

These recommendations apply to all types of ships and provide guidance to ship operators, seafarers and shore personnel to work on board ships. It should be noted that on ships where entry into enclosed spaces may be infrequent, for example, on certain passenger ships or small general cargo ships, the dangers may be less apparent, and accordingly there may be a need for increased vigilance.

These recommendations are intended to complement national laws or regulations, accepted standards or particular procedures which may exist for specific trades, ships or types of shipping operations.

It may not be practicable to apply all of these recommendations to all situations; however, when applying these recommendations becomes impracticable, every endeavour should be made to observe the intent of the recommendations, and attention should be paid to the hazards that may be involved in the specific entry and mitigations required to reduce the risks to an acceptable level.

## 1 INTRODUCTION

The atmosphere in any enclosed space may be oxygen-deficient or oxygen-enriched and/or contain flammable and/or toxic gases or vapours. Such unsafe atmospheres could also subsequently occur in a space previously found to be safe. Unsafe atmospheres are likely to be present in spaces that are connected to a space containing a hazardous atmosphere and may also be present in spaces adjacent to those spaces where a hazard is known or suspected to be present.

1.1 An unsafe atmosphere can also quickly occur in a space previously found to be safe, including cargo holds and tanks where the hatch covers and tank covers have been open for some time. Unsafe atmospheres can occur in frequently visited working areas and stores, such as forecastle head spaces, pump-rooms, compressor rooms, inert gas rooms and other spaces that are adjacent to, or connected to, spaces containing a hazardous atmosphere. These spaces include cargo holds containing cargo that depletes oxygen and/or emits toxic, flammable or explosive gases, or is under fumigation.

1.2 An unsafe atmosphere can also occur in void spaces, cofferdams, pipe tunnels and also in accommodation areas and engine-rooms adjacent to or connected to cargo holds containing hazardous cargo or under fumigation due to a failure in the means of sealing the connection between the cargo space and the adjacent spaces.

1.3 The emission of toxic, flammable or explosive gases from cargo tanks, fuel tanks, slop tanks and sewage tanks can also give rise to a potentially dangerous situation around open access hatches, manholes and ventilators on deck.

## 2 DEFINITIONS

2.1 *Enclosed space* means a space which may contain a hazardous atmosphere or lack of oxygen and has any of the following characteristics:

.1 limited openings for entry and exit;

.2 inadequate ventilation; or

.3 not designed for continuous human occupancy.

This includes but is not limited to spaces that are diverse in their characteristics such as cargo holds, bilge spaces, ballast and other tanks, pump-rooms, chain lockers and engine crankcases.

2.2 *Connected space* means a space that is connected, by either permanent or temporary means (such as a door), to a source space that may contain a hazardous atmosphere. For clarity, a space separated by a manual door, even if watertight, should be considered as "connected" as it is impossible to tell from outside the space whether it is open or closed or indeed properly sealed. A connected space should be treated as containing a hazardous atmosphere until testing proves otherwise. The nature of the connection may lead to a "trapped hazardous atmosphere".

2.3 *Adjacent space* means a space that shares a common boundary with a compartment that may contain a hazardous atmosphere. Such a space has no openings, temporary or permanent, into the hazardous compartment whatsoever and is designed to be a contiguous barrier. Such a space may only contain a hazardous atmosphere in the event of failure of that barrier. Precautions should relate to the possibility of such a failure.

2.4 *Trapped Hazardous Atmosphere* means a hazardous atmosphere that may be trapped in a connected space in a manner that causes that space's atmosphere to fill and/or to empty at a different rate to the source space. Such a space, while recognized as containing the same atmosphere, should be treated independently to the source space, and should be assumed to contain a hazardous atmosphere until proved otherwise by testing. For example, a trapped atmosphere may remain even after the cargo in the source space is discharged.

2.5 *Competent person* means a person with an operational level of competency to make an informed assessment of the likelihood of a dangerous atmosphere being present or subsequently arising in the space.

2.6 *Responsible person* means a person in a management level on board a ship (i.e. master, chief mate, chief engineer officer or second engineer officer) of competency and authorized by the shipping company to permit entry into an enclosed space.

2.7 *Attendant* means a person maintains a watch over those entering the enclosed space, to maintain communications with those inside the space and to initiate the emergency procedures in the event of an incident occurring.

2.8 *Enclosed Space Register* means a ship-specific register which lists all enclosed spaces on board the ship, along with their connected spaces and adjacent spaces, their hazards, associated risk mitigations if applicable, and how the atmosphere in these spaces may change depending upon the nature of cargo carried or the content of the space, and which forms a part of the safety management for enclosed spaces.

## 3 SAFETY MANAGEMENT FOR ENTRY INTO ENCLOSED SPACES

3.1 A safety strategy should be adopted in order to prevent accidents on entry into enclosed spaces in a comprehensive manner by the company, in consultation with the ship. This should include an **Enclosed Space Register**, which should be produced on a ship-by-ship basis to identify enclosed spaces, the hazards of those spaces, assessment of risks under the differing conditions likely to arise in the space and the risk mitigation measures required to be put into place prior to entry. This should also include an assessment of how the atmosphere in these enclosed spaces may be impacted by the contents of the spaces themselves, such as in case a ship stores treated sewage or grey water temporarily in its ballast water tanks, or the contents of connected spaces or adjacent spaces, including cargo, fumigants, fuel oils, slops, oxygen-depleting conditions and the physical or structural arrangement of the space.

3.2 The company should ensure that all relevant information relating to the hazards of the cargo, as submitted by the shipper in accordance with the applicable requirements of SOLAS regulation VI/2, the International Maritime Solid Bulk Cargoes Code (IMSBC Code), the International Maritime Dangerous Goods Code (IMDG Code), the IBC Code and the International Gas Carrier Code (IGC Code), is provided in a format that is understandable to the ship's crew and distributed to those on board who may be exposed to these hazards.

3.3 The company should ensure that the procedures for entering enclosed spaces are included and implemented among the key shipboard operations concerning the safety of the personnel and the ship, in accordance with paragraphs 6.4, 7 and 12.3 of the International Safety Management (ISM) Code.

3.4 The company should ensure that all relevant crew members are given adequate training in the safety management of enclosed spaces as per paragraphs 6.3 and 6.5 of the ISM Code.

3.5 The company should ensure that adequate time has been allowed for any planned enclosed space activity, and that undue time pressure, either explicit or implied, is avoided as this has been found to be a causal factor of many enclosed space accidents.

3.6 The company should elaborate a procedural implementation scheme which provides for comprehensive training in the maintenance, calibration and use of atmospheric testing equipment in such spaces. This training should be recorded, and individual crew members who have been deemed competent in the maintenance, calibration and use of atmospheric testing equipment should be listed.

3.6.1 The competent and the responsible persons should be trained in enclosed space hazard recognition, evaluation, measurement, control and elimination, using standards acceptable to the Administration. The competent person should have received adequate training along with sufficient theoretical knowledge and practical experience to make an informed assessment of the likelihood of a dangerous atmosphere being present or subsequently arising in the space. The responsible person should have sufficient knowledge of the procedures to be established and complied with on board and received adequate training, in order to ensure that an enclosed space is safe for entry and occupancy. The attendant should be adequately trained within the safety management system.

3.6.2 All crew members should be trained, as appropriate, in enclosed space safety, including familiarization with onboard procedures for recognizing, evaluating and controlling hazards associated with entry into enclosed spaces.

3.7 The company should identify and provide the necessary equipment such as ventilation devices, atmosphere testing equipment, breathing apparatus and personnel recovery apparatus to facilitate safe entry and rescue from an enclosed space. The equipment provided should be suitable for the intended use. A careful study of the operational profile should be carried out and all necessary equipment should always be on board in operational condition. Consideration should be given to the appropriate use of technology to assist in the hazard identification and mitigation of enclosed space entry. Crew members should be trained in the use of equipment necessary to facilitate rescue from an enclosed space and a record of this training should be maintained.

3.8 The company should ensure that rescue drills from enclosed space identified in their Enclosed Space Register are undertaken regularly as required by SOLAS regulation III/19.3.6 using the equipment provided to facilitate a rescue from an enclosed space. Such drills should focus on different aspects of operations involving enclosed spaces. SOLAS regulation III/19.3.6 requires:

.1 checking and use of personal protective equipment required for entry;

.2 checking and use of communication equipment and procedures;

.3 checking and use of instruments for measuring the atmosphere in enclosed spaces;

.4 checking and use of rescue equipment and procedures; and

.5 instructions in first aid and resuscitation techniques.

3.9 Internal audits by the company and external audits by the Administration of the ship's safety management system should verify that the established procedures[1] are followed and are consistent with the safety strategy referred to in these recommendations.

3.10 The company should establish criteria to manage additional risks involved during simultaneous operations (SIMOPS) where one of the operations includes an enclosed space entry. The criteria should consider the assessment of personnel and resources available in case of an emergency following an enclosed space entry.

[1] Established procedures include resolution A.1050(27) as amended, the IMSBC Code, the BLU Code, the IMDG Code, the IBC Code, the IGC Code, *Recommendations on the safe use of pesticides in ships applicable to the fumigation of cargo holds* (MSC.1/Circ.1264), *Guidelines on tank entry for tankers using nitrogen as an inerting medium* (MSC.1/Circ.1401) and other accepted standards and industry codes of practice, as relevant.

3.11 The company should ensure that single person entry into an enclosed space is not permitted.

## 4 IDENTIFICATION OF THE HAZARDS AND ASSESSMENT OF RISK

4.1 The company should ensure that a risk assessment is conducted to identify all enclosed spaces on board the ship and that the identified enclosed spaces are recorded in the Enclosed Space Register, which should be maintained on board the ship as well as ashore. This Enclosed Space Register and risk assessment should be kept up to date as appropriate to ensure its continued validity, particularly after loading and during the carriage of cargoes which may adversely affect the safety of the atmosphere within a space. A reassessment should also be made when the contents of the space change, such as in case a ship stores treated sewage or grey water temporarily in its ballast water tanks. The company should consider the use of appropriate technology to assist in the hazard identification and mitigation. The Enclosed Space Register and risk assessment should form the basis of the development of the enclosed space emergency response plan (appendix 1). It is recommended that the enclosed space emergency response plan be reviewed after each drill so that its effectiveness can be assessed and, if necessary, improvements made.

4.2 As entries for enclosed spaces other than cargo spaces may be different, there is a need to record information for the benefit of personnel involved. Every ship should have an Enclosed Space Register, the information within which may form the basis of a risk assessment. The Enclosed Space Register should contain:

.1 physical layout of the space and access and egress points, including of connected spaces, if any;

.2 physical hazards in the space, e.g. vertical ladders, unguarded openings, poor lighting, wet or slippery conditions, excessive heat;

.3 connection to adjacent spaces;

.4 specific hazards within the space, for example, the effect of ballast water treatment method on the atmosphere within ballast tanks;

.5 if used, information related to additional technology, helping to determine enclosed space condition;

.6 information related to fixed and portable ventilation systems including equipment and where the equipment is stored;

.7 estimated time taken to achieve the air changes for safe entry, using forced or natural ventilation;

.8 lighting and means for temporary lighting including intrinsically safe lighting where appropriate;

.9 means for atmosphere testing;

.10 any pertinent information that would assist the risk assessment process;

.11 locking and "Safe to enter"/"Unsafe to enter" signage arrangements; and

.12 the equipment necessary to facilitate emergency rescue from the space.

4.3 In order to ensure safety from the outset, entry and occupancy, a competent person should make an assessment of any potential hazards in the space to be entered, taking into account the characteristics of the previous and current cargo carried with Safety Data Sheets (SDS) and cargo information, ventilation of the space, coating of the space and other relevant factors. Opening of an enclosed space should be subject to a risk assessment, taking into consideration the potential for release of dangerous gases or potential to create an explosive atmosphere: the competent person's assessment should determine the potential for the presence of an oxygen-deficient, oxygen-enriched, flammable or toxic atmosphere, which includes carbon monoxide (CO) and carbon dioxide ($CO_2$) as well as other toxic or asphyxiant gases. The competent person should bear in mind that the ventilation procedures for an adjacent or connected space may be different from those for the enclosed space itself. The details of the assessment should be recorded in a standard format, and maintained on board the ship.

4.4 The nature of the hazards that may be present should be fully understood by those on board the ship, both crew and shore-based personnel, and those ashore managing the ship.

4.5 The procedures to be followed for testing the atmosphere in the space and for entry should be decided on the basis of the assessment. These will depend on whether the assessment shows that:

.1 there is minimal risk to the health or life of personnel entering the space; or

.2 there is no immediate risk to health or life, but a risk could arise during the course of work in the space; or

.3 a risk to health or life is identified.

4.6 Where the assessment indicates minimal risk to health or life or potential for a risk to arise during the course of work in the space, the precautions described in sections 5 to 8 and 10 should be followed, as appropriate.

4.7 Where the assessment identifies a risk to life or health, if entry is to be made, the additional precautions specified in section 9 should also be followed.

4.8 Throughout the assessment process, there should be an assumption that the space to be entered is considered as hazardous until positively proved to be safe for entry.

## 5 AUTHORIZATION OF ENTRY

5.1 No person should open or enter an enclosed space unless authorized by the master or a responsible person nominated by the master and the appropriate safety procedures laid down for the particular ship have been followed.

5.2 Entry into enclosed spaces should be planned and the use of an entry permit system, which may include the use of a checklist, should always be used where the assessment identifies any risk to health or life. Prior to the entry of a space, an enclosed space entry permit should be issued by the master or the responsible person nominated by the master, and complied with at all times by the competent person included in the work especially those who enter the space. An example of the enclosed space entry permit is provided in appendix 2. The validity of the permit should be specified based on the risk assessment and should never be longer than eight hours.

5.3 Additional permits may be required depending upon the ship's safety management system (SMS) and the activity being planned within the enclosed space. These permits may include energy isolation permits, electrical isolation permit, hot work permit, working at height permit or the completion of documents such as Job Hazard Analysis.

5.4 Shore personnel should be provided with information on the hazards associated with enclosed spaces that may be present aboard the ship.

## 6 GENERAL PRECAUTIONS

6.1 Access to enclosed spaces should be carefully managed on ships where shore personnel regularly enter cargo spaces to load and discharge cargoes, especially on bulk carriers ~~and~~ general cargo ships. These recommendations are complementary to the requirements of the International Ship and Port Facility Security (ISPS) Code. It is recommended that a basic schematic plan of the ship's spaces should be placed at the gangway or at other access points of the ship clearly indicating which spaces are safe to enter, and which spaces are not. The plan should outline the enclosed space entry procedures that should be complied with by both ship and shore personnel before any entry is permitted. The use of simple safe to enter and unsafe to enter symbols is recommended. The plan should be time-stamped and dated and amended as necessary by the responsible person. This may also be beneficial on ships where large numbers of shore personnel are being employed on the ship, such as in dry dock or ship repair facilities. An example of a ship's schematic plan is contained in appendix 3.

6.2 Before any personnel are authorized to enter any cargo space containing any cargo, the competent person should carry out a risk assessment of the cargo; identification of the physical characteristics of the cargo space(s) concerned; and the operations to be carried out, and the responsible person should:

.1 where it is necessary for shore personnel to enter any such spaces, conduct a pre-operational risk assessment prior to commencement of cargo operations or arrival of shore personnel. When hazards are identified a joint risk assessment with terminal representatives responsible for operations on board the ship, or with other appropriate shore personnel, should be conducted; and

.2 identify and agree to the precautions required during entry and enclosed space entry permit arrangements to be used.

6.3 Entry doors or access hatches leading to enclosed spaces should at all times be secured against entry unless the spaces have been risk assessed, atmospherically tested as required and declared safe for entry. The ship may use a system of seals similar to those recommended in the ISPS Code. Suitable portable signage, which is easily understandable by the vessel's crew and also by shore personnel engaged on the ship at this time and in the port, indicating the hazards should be posted on entry doors or access hatches leading to an enclosed space. An example of such signage is contained within appendix 3. These signs should be updated when the space becomes safe for entry or when a safe space becomes unsafe.

6.4 A door or hatch cover which is opened to provide natural ventilation of an enclosed space may, wrongly, be taken to be an indication of a safe atmosphere and therefore it is recommended to station an attendant at the entrance or use a mechanical or physical barrier, such as a locked bar or chain positioned across the opening with an attached warning sign, to prevent accidental entry. It is recommended that operations such as these are included in the watch handover activity.

6.5 The master or the responsible person should determine that it is safe to enter an enclosed space by ensuring that:

.1 potential hazards have been identified in the risk assessment and as far as possible isolated or made safe;

.2 the space has been thoroughly ventilated by natural or mechanical means to remove any toxic or flammable gases identified in the hazard identification process gases;

.3 the atmosphere of the space has been tested using certified and calibrated instruments to ascertain that the space contains 20.9% oxygen. If the testing indicates that the level of oxygen is less than 20.9%, or indicates the presence of even low levels of flammable or toxic gases, then the space should be treated as one where the atmosphere is known or suspected to be unsafe, as described in section 9;

.4 the space has been declared safe for entry and properly illuminated;

.5 a suitable system of communication between all parties for use during entry has been agreed and tested, and the evacuation signals have been agreed upon;

.6 personnel entering the space are wearing personal gas detection equipment that has been properly calibrated and is capable of monitoring the levels of oxygen, carbon monoxide and any other gases identified in the risk assessment;

.7 an attendant has been nominated and properly instructed;

.8 rescue and resuscitation equipment has been positioned, tested and ready for immediate use at the entrance to the space and a rescue plan detailing the rescue arrangements has been agreed. Where ship or shore personnel are working in more than one cargo space at the same time, the rescue equipment should be positioned at a designated central location. In the event of an emergency in any one space, all personnel working in other spaces should be instructed to stop work immediately and exit the space;

.9 personnel are provided with the appropriate personal protective equipment for the entry and subsequent tasks; and

.10 the required permits have been issued, authorizing entry.

6.6 The precautions in sub-paragraphs .6 to .8 of paragraph 6.5 above may not be applicable to every situation described in this section. The responsible person authorizing entry should determine whether personal gas detectors, an attendant and the positioning of rescue equipment at the entrance to the space are necessary.

6.7 Only trained and authorized personnel should be assigned the duties of entering, functioning as attendants or acting as members of rescue teams. Ships' crews with rescue and first aid duties should be drilled periodically as required by SOLAS regulation III/19.3.6 in rescue and first aid procedures. Training should include as a minimum:

.1 identification of the hazards likely to be faced during entry into enclosed spaces and whilst within the space, in particular the rapidity with which oxygen may be depleted in a space by corrosion or biological means especially in higher ambient temperatures. The pace at which oxygen gets depleted increases exponentially when ventilation is stopped (fan or other equipment in case of forced ventilation, and closing a vent or damper in case of natural ventilation) or other characteristics or properties of the contents or structure of the space. While higher ambient temperatures can increase the rate of oxygen depletion, it should be assumed that the rate of depletion will always be very rapid, regardless of the ambient temperature;

.2 an explanation of how the pace at which oxygen is depleted will increase exponentially when ventilation is stopped (fan or other equipment in case of forced ventilation, and closing a vent or damper in case of natural ventilation), or when hatch covers are closed;

.3 identification and use of the various sources of information on the hazards associated with individual solid bulk and liquid bulk cargoes, and the precautions to be adopted when entering spaces containing such cargoes, or their residues;

.4 awareness of the fact that when a person or persons in an enclosed space shows signs of adverse health effects, that they should always assume that these effects are due to an oxygen-depleted or toxic atmosphere in the space, and that they should not enter it themselves;

.5 recognition of the signs of adverse health effects caused by exposure to hazards during entry;

.6 knowledge and experience in the use of personal protective equipment required for entry;

.7 rescue, first aid, Cardio Pulmonary Resuscitation (CPR) techniques and evacuation procedures;

.8 knowledge and experience in the use of communication equipment and procedures;

.9 knowledge and experience in the use of instruments for measuring the atmosphere;

.10 knowledge and experience in the use of rescue equipment and procedures;

.11 knowledge of the IMO/WHO/ILO Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG), where appropriate; and

.12 knowledge of use of emergency and the first aid equipment for chemical tankers (IBC Code section 14.3) and for gas carriers (IGC Code section 14.3), where appropriate.

6.8 All equipment used in connection with entry should be in good working condition and inspected and tested prior to use.

6.9 As far as practicable, enclosed space entry should be carried out during hours of daylight or normal working hours of the ship to ensure ready availability of reserve personnel in the event of an emergency.

## 7 TESTING THE ATMOSPHERE

7.1 The gas detection equipment should be appropriate for the cargo that the ship has carried and is carrying considering information provided in the shipper's declaration, the Safety Data Sheets (SDS), the IMDG Code, the IMSBC Code, International Bulk Chemical Code (IBC Code) and the IGC Code. The gas detection equipment, including devices for testing $CO_2$, should be capable of operating correctly even in oxygen-depleted atmosphere.

7.2 Appropriate testing of the atmosphere of a space should be carried out with properly calibrated equipment by persons trained in the use of the equipment. The manufacturers' instructions should be strictly followed. Testing of the atmosphere of a space should be carried out before any person enters the space and at regular intervals thereafter until all work is completed. Where appropriate, the testing of the atmosphere of a space should be carried out at as many different levels and areas as is necessary to account for gas stratification, and obtain a representative sample of the atmosphere in the space. In some cases, it may be difficult to test the atmosphere throughout the enclosed space without entering the space (e.g. the bottom landing of a stairway or complex areas of the structure within the space) and this should be taken into account.

7.3 All ships should carry at least two sets of gas detection equipment as required by SOLAS regulation XI-1/7, taking into account the *Guidelines to facilitate the selection of portable atmosphere testing instruments for enclosed spaces as required by SOLAS regulation XI-1/7* (MSC.1/Circ.1477). Any ship which may carry a cargo capable of generating hazardous vapours and which requires regular entry into the cargo space for cleaning or inspection should carry two sets of gas detection equipment in addition to those required by SOLAS regulation XI-1/7 for assessing the risk to personnel entering the space. The use of flexible hoses or fixed sampling lines, which reach remote areas within the enclosed space, may allow for safe testing without the need to enter the space.

7.4 After completion of a suitable risk assessment targeted to the space to be entered steady readings of all of the following should be obtained:

.1 20.9% oxygen by volume;

.2 the level of carbon dioxide has been checked and is less than 0.5% by volume (5,000 ppm);

**Note:** National requirements may differ when determining the safe atmosphere range for gases stated above.

.3 less than 1% of lower flammable limit (LFL) on a suitably sensitive combustible gas indicator, where the assessment has determined that there is potential for flammable gases or vapours; and

.4 less than 50% of the occupational exposure limit (OEL) of any toxic vapours and gases.

7.5 If these conditions cannot be met, additional ventilation should be applied to the space and retesting should be conducted after a suitable interval. Entry should be allowed only after all the above conditions are met. When the atmosphere remains, or is suspected to be unsafe, then the guidance contained within section 9 should apply.

7.6 Any gas testing should be carried out with ventilation to the enclosed space stopped, and after conditions have stabilized, in order to obtain accurate readings.

7.7 Where the assessment has determined that there is potential for the presence of toxic gases and vapours, appropriate testing should be carried out, using fixed or portable gas or vapour detection and/or monitoring equipment. The readings obtained by this equipment should be below the occupational exposure limits for the toxic gases or vapours given in accepted national or international standards, in accordance with paragraph 7.4. It should be noted that testing for flammability or oxygen content does not provide a suitable means of measuring for toxicity, nor vice versa.

7.8 It should be emphasized that the internal structure of the space, cargo, cargo residues and tank coatings may also present situations where oxygen-deficient areas may exist, and should always be suspected, even when an enclosed space has been satisfactorily tested as being suitable for entry. This is particularly the case for spaces where the path of the supply and outlet ventilation is obstructed by structural members or cargo.

## 8 PRECAUTIONS DURING ENTRY

8.1 The atmosphere should be tested frequently whilst the space is occupied, and persons should be instructed to leave the space should there be any sign of deterioration in the conditions.

8.2 Persons entering enclosed spaces should be provided with calibrated and tested personal gas detection instrument or instruments that monitor the levels of oxygen, carbon dioxide, flammable gases or vapours, toxic gases (including carbon monoxide), and any other gases identified in the risk assessment.

8.3 Ventilation should be maintained while the space is occupied. After a break and before re-entry, the atmosphere must be retested, the results verified as being acceptable then recorded. In the event of failure of the ventilation system, any persons in the space should leave immediately.

8.4 Particular care should be taken when working on piping and valves within the space which may contain hazardous gases, vapours or liquids. If conditions change during the work, increased frequency of testing of the atmosphere should be performed. Examples of changing conditions are as follows – increase or decrease in ambient temperature, the need to use oxygen fuel torches or other welding equipment, the need to use a mobile plant, other activities in the space that may involve development of vapour such as cleaning debris, collecting sediments, painting within the enclosed spaces, changes in the ship's trim and list while working within the enclosed space. Conditions can also deteriorate during work breaks because of changes to the ventilation, the disturbance of bilge contents, sludge or stagnant water, or the leakage of external contaminants into the space. Depending on the result of the testing, a decision should be made as to whether it is safe to continue working.

8.5 In the event of an emergency, under no circumstances should the attendant enter the space before help has arrived and the situation has been evaluated to ensure the safety of those entering the space to undertake rescue operations. Only properly trained and equipped personnel should perform rescue operations in enclosed spaces.

## 9 ADDITIONAL PRECAUTIONS FOR ENTRY INTO A SPACE WHERE THE ATMOSPHERE IS KNOWN OR SUSPECTED TO BE UNSAFE

9.1 In preparing to enter an enclosed space, every effort should be made to ensure that it is safe to do so in order to undertake the activity required within the space. Entry into enclosed spaces where the atmosphere is known or suspected to be unsafe requires very careful consideration, including an assessment of the hazards, residual risks and mitigations that need to be undertaken. Spaces that have not been tested should be considered unsafe for persons to enter.

9.2 When considering the planned work activity within an enclosed space where the atmosphere is known or suspected to be unsafe, suitably designed and constructed breathing apparatus of positive pressure type should always be worn, and only personnel trained in its use should be allowed to enter the space. Air-purifying respirators, dust masks and canister face masks do not provide a supply of clean air from a source independent of the atmosphere within the space and should not be used. Emergency Escape Breathing Devices (EEBDs) are not suitable to use for entry into enclosed spaces.

9.3 Notwithstanding paragraph 6.5.6, persons entering enclosed spaces that may contain a suspected atmospheric hazard should be provided with calibrated and tested personal gas detector suitable for the gas or gases assessed as likely to occur in the space.

9.4 Rescue harnesses should be worn and unless impractical, lifelines should also be used. A means to facilitate evacuation from the enclosed space should be available and ready for use, as per emergency response plan.

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

9.6 The advice in section 11 concerning actions to be taken in an emergency is particularly relevant in this context.

## 10 HAZARDS RELATED TO SPECIFIC TYPES OF SHIPS OR CARGO

### 10.1 Dangerous goods in packaged form

10.1.1 The atmosphere of any space containing dangerous goods may put at risk the health or life of any person making an entry. Dangers may include flammable, toxic, corrosive or asphyxiant gases or vapours, residues on packages and spilled material. The same hazards may be present in spaces adjacent or connected to the cargo spaces. Information on the hazards of specific substances is contained in the IMDG Code, the SDS and the Shipper's Declaration. If there is evidence or suspicion that leakage of dangerous substances has occurred, the precautions specified in these recommendations should be followed.

10.1.2 Personnel required to deal with spillages or to remove defective or damaged packages should be appropriately trained and wear suitable breathing apparatus and protective clothing commensurate with the task.

### 10.2 Liquid bulk

The industry has produced extensive advice to managers, operators and crews of ships engaged in the bulk carriage of oil, chemicals and liquefied gases, in the form of specialist safety guides. Information contained in the guides on enclosed space entry amplifies these recommendations. In particular, for chemical tankers as defined in SOLAS regulation VII/8, the diversity of bulk liquid chemicals carried in some cargo tanks and the limitations in vapour detection technologies may pose complications that require specific and targeted mitigation.

### 10.2.1 Safety information

Safety information[2] for the correct handling and carriage of liquid bulk and gas cargoes is set out in the SDS or other cargo information provided by the shipper to the master. Such information should be made available to all ship and shore personnel involved in the handling of the cargo, cargo slops and tank cleaning.

### 10.2.2 Use of nitrogen as an inert gas[3]

Nitrogen is a colourless and odourless gas that, when used as an inert gas, causes oxygen deficiency in enclosed spaces and at exhaust openings on deck during purging of tanks and void spaces and use in cargo holds. It should be noted that one deep breath of 100% nitrogen gas will prove fatal.

## 10.3 Solid bulk

On ships carrying solid bulk cargoes, dangerous atmospheres may develop within cargo spaces, connected and adjacent spaces. The hazards may include flammability, toxicity, oxygen depletion, carbon dioxide and/or carbon monoxide generation, or self-heating, as identified in the shipper's declaration and/or in the individual schedules in appendix 1 of the IMSBC Code. Solid bulk cargoes listed in the IMSBC Code should be carried in accordance with the provisions of the Code, including precautions, atmosphere testing, ventilation and other requirements specified. Solid bulk cargoes that are not listed in the IMSBC Code should be carried in accordance with section 1.3 of the Code, including the conditions for carriage and handling as determined by the relevant competent authorities. Grain cargoes and timber cargoes other than those listed in the IMSBC Code[4] may also cause oxygen depletion and toxic gas emissions, primarily carbon dioxide, in cargo holds and connected and adjacent spaces.

### 10.3.1 Enclosed hold access trunks

10.3.1.1 In certain designs of hold access, a stair arrangement, sometimes referred to as the "Australian Ladder", substitutes for a vertical ladder. On some ships these are contained within enclosed protective structures that are open only at the top and bottom of the hold. When a cargo that presents the risk of a hazardous atmosphere is loaded, this "connected" space will quickly adopt atmospheric attributes similar to that of the source space. The enclosed Australian ladder access should not be used until it has been fully ventilated, tested and confirmed to be safe. It should be noted that such spaces are difficult to ventilate, unless cargo blocking the bottom of the ladder is removed.

10.3.1.2 When hatches are opened to ventilate the above cargo space at discharge, the hazardous atmosphere often gets trapped in the access trunk.

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2 16.2.3.1 of the IBC Code and 18.3.1 of the IGC Code.

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

4 Refer to the International Code for the Safe Carriage of Grain in Bulk (resolution MSC.23(59) (amended by resolution MSC.552(108)) and the Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 2011 (resolution A.1048(27)).

10.3.1.3 Where such type of access trunk is fitted on ships, the nature of the hazard should be identified outside the entrance to the space and should be listed in the Enclosed Space Register. When a cargo which may generate a hazardous atmosphere is loaded, the access door/hatch should be locked with a dedicated and unique locking arrangement, distinct from all other such arrangements, from the commencement of loading until the space is certified safe for entry by testing after completion of discharge.

10.3.1.4 Entry of personnel into a cargo hold using a hold vertical ladder should only be permitted when:

.1 the atmosphere in the hold has been tested and found to be safe;

.2 wearing a personal gas detector;

.3 wearing a safety harness; and

.4 an emergency response plan is in place.

### 10.3.2 Working spaces with connections to cargo holds

In certain designs of general cargo ships, bulk carriers and tankers, doors and ventilation trunks of cargo spaces, as well as pipework connecting to cargo spaces, are connected directly into working spaces such as forecastle workspaces, stores rooms, windlass hydraulics, bow thruster and other machinery rooms. When a certain cargo is stowed in the cargo space, there is a risk that gas or vapours from the cargo will penetrate into the connected working space. These working spaces should be identified as "connected spaces" and consideration should be given to use of certified safe type of electrical equipment for an explosive atmosphere. When the cargo space contains a hazardous atmosphere and, given the propensity for hazardous atmospheres to be trapped in those spaces, these connected spaces should continue to be considered hazardous until the atmosphere is ensured to be gas free by the test.

### 10.3.3 Oxygen-depleting cargoes and materials

A prominent risk associated with solid bulk cargoes is the potential for a hazardous atmosphere in an enclosed space due to the inherent nature of the cargo, including oxygen depletion and toxic or flammable gas emissions from materials that are flammable or toxic, or are liable to oxidation, self-heating, or to the emissions of toxic gases when wet. The individual schedules for solid bulk cargoes in the IMSBC Code list typical cargoes currently shipped in bulk, together with advice and guidance on their properties and methods of handling. Cargoes which possess a chemical hazard which could give rise to a dangerous situation on a ship are classified in the Code as group B. However, certain cargoes which are classified as group A or group C, including scrap metal, i.e. neither group A&B nor group B, can also possess properties which could give rise to a dangerous situation on a ship, depending on the condition and characteristics of the particular shipment. The cargoes named below are examples of cargoes that have caused many fatal accidents due asphyxiation, explosion and fire in cargo holds and adjacent and connected spaces on bulk carriers and general cargo ships:

.1 Coal;

.2 Wood products – general, including logs, timber, saw logs pulp wood, roundwood

.3 Wood chips and wood pellets;

.4 Metal Sulphide Concentrates, including zinc concentrates, lead concentrates and copper concentrates;

.5 Ferrous;

.6 Seed cake cargoes containing residues of processed oily vegetables including bran pellets, oil cake, palm kernel, copra and other residues as listed in the individual schedules for the different seed cake cargoes in the Code; and

.7 Scrap metal.

Grain cargoes and timber not in a bulk cargo form (stowed in cargo hold one by one) are also liable to cause oxygen depletion and the emission of $CO_2$ in cargo holds and adjacent spaces, while these cargoes are not covered by the IMSBC Code.

**10.4 Hazards related to steel**

10.4.1 For scrap steel cargoes or other steel-related spaces such as chain lockers, the process of oxidation will change the composition of the atmosphere by depleting oxygen through the process of rusting. Results of steel-related experiments are given in appendix 4.

10.4.2 The speed of the oxygen depletion varies depending on temperature, moisture content, degree of exposure of steel to air, etc.

**10.5 Specific dangers associated with carbon dioxide**

10.5.1 When organic cargoes are being transported the oxygen in the air is absorbed into the cargo and through microbiological degradation carbon dioxide is emitted.

10.5.2 The absorption of oxygen and the subsequent emission of carbon dioxide from the organic cargo has the potential to make the hold or connected space unsafe for humans. The process of oxidation of the cargo will produce an atmosphere within the hold or connected space unsafe for humans, especially where carbon dioxide has accumulated to form a concentrated pocket within the enclosed space.

10.5.3 The impact of release of carbon dioxide into the space in relatively low concentrations of 4% is that exposure may lead to serious oxygen depletion. This may result in permanent brain damage, coma, even death. The atmosphere in the space will be harmful to life, not only due to oxygen deficiency but also because of the toxic concentration of carbon dioxide.

10.5.4 Relying on existing tables of oxygen depletion levels and dangers may be inadequate when organic cargoes are being transported, as the oxygen levels in the cargo hold may remain in the region of 17% to 14% when a 4% or more $CO_2$ level is reached. The adoption of a more appropriate oxygen danger table relevant to the carriage of organic cargoes is vital to raise awareness of the dangers within the industry. See section 10.6.

10.5.5 The speed of the oxygen depletion and the emission of $CO_2$ will depend on temperature, cargo moisture content and permeability of the space in addition to atmospheric pressure variations.

10.5.6 It should be highlighted that death caused by carbon dioxide can precede death resulting from oxygen deficiency in organic types of cargoes. This issue should be understood by the person carrying out the hazard analysis.

10.5.7 Ships carrying organic solid cargoes in bulk should continue to test for $CO_2$ prior to entry into enclosed spaces and frequently thereafter, as organic cargoes continue to emit $CO_2$.

10.5.8 A carbon dioxide or other toxic gas laden atmosphere "looks normal" as there is no sensory indication to cause alarm regarding the dangers within the enclosed space.

### 10.6 Information on acceptable and unacceptable levels of gases

Appendix 5 provides information on acceptable and unacceptable levels of oxygen, carbon dioxide and carbon monoxide. Other national guidance may exist and should be taken into account as applicable.

### 10.7 Fumigation

When a ship's cargo is fumigated, the relevant recommendations[5] [6] [7] should be followed. Spaces connected to fumigated spaces should be treated as if fumigant gas could penetrate into them from the adjacent or connected cargo space. Apart from the fatalities due to mistaken, unauthorized or accidental entry into cargo spaces under fumigation, a significant proportion of the fatal accidents that have occurred during in-transit cargo fumigation have resulted from fumigant gas leaking into ships' accommodation areas, including cabins, as well as forecastle head spaces, ballast tanks, other adjacent spaces and on deck. The mishandling of fumigant materials has also caused fires and explosions on ships. Continuous monitoring of the atmosphere of connected and adjacent spaces that are designed for continuous occupation, or are frequently visited working areas, is recommended.

## 11 ACTION TO BE TAKEN IN THE EVENT OF AN EMERGENCY

11.1 The guidance contained in resolution A.1072(28)[8] should be understood and form the basis of any emergency response plan. In the event of an emergency in an enclosed space the ship's crew should follow the ship-specific enclosed space emergency response plan. In an emergency the ship's crew, or any shore personnel, should **NEVER** perform rescue entering an enclosed space independently, but should always follow the agreed rescue plan.

11.2 The urge to enter an enclosed space where an accident has occurred is immense and should be always resisted. Many enclosed space accidents have been compounded by the good intentions of inadequately equipped ad hoc rescue attempts where the would-be rescuers have themselves become casualties.

11.3 If in port, a simple explanation of the enclosed space procedures placed at the entry to the ship together with an agreed emergency response plan will greatly assist the efficient rescue of any casualties following an enclosed space accident occurring on board the ship. A clear understanding of the response required by ship and shore rescue teams will be most advantageous, even essential.

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5 MSC/1/Circ.1264 on *Recommendations on the safe use of pesticides in ships applicable to the fumigation of cargo holds* as amended by MSC/1/Circ.1396 *Amendment to the recommendations on the safe use of pesticides in ships applicable to the fumigation of cargo holds*.

6 MSC/1/Circ.1358 on *Recommendations on the safe use of pesticides in ships*.

7 MSC/1/Circ.1361/Rev.1 on *Revised recommendation on the safe use of pesticides in ships applicable to the fumigation of cargo transport units*.

8 Resolution A.1072(28) on *Revised guidelines for a structure of an integrated system of contingency planning for shipboard emergencies.*

11.4 It is critical that the ship has an enclosed space emergency response plan, which is easily understood, regularly practised, verified as effective and followed precisely. The emergency response plan should form a part of the company SMS.

11.5 Equipment should be provided for the ship's crew to utilize in the event of an enclosed space accident. Such equipment should fall into three main categories:

.1 Equipment to test and verify the enclosed space atmospheric conditions and determine the hazards to life and the mitigations necessary prior to entry;

.2 Equipment to ensure the safety of the rescue party such as self-contained breathing apparatus (SCBA), lifelines, harness, etc.; and

.3 Equipment to facilitate the safe recovery of a casualty, such as recovery hoist, stretchers and resuscitation equipment.

11.6 The rescue of a casualty should be undertaken in a steady, controlled and methodical way. The aim is the safe rescue of the casualty without needlessly endangering the lives of those undertaking the rescue operation.

11.7 An example of an Enclosed Space Emergency Response Plan is contained in appendix 1.

## 12 CONCLUSION

Failure to systematically identify the hazards of a space and the risks associated with entry can rapidly lead to fatality inside the space. Rigid observance of the principles and procedures outlined above will provide a reliable basis for assessing the risks of entering such spaces and taking the necessary precautions to counter the danger.

## APPENDIX 1

## EXAMPLE OF AN ENCLOSED SPACE EMERGENCY RESPONSE PLAN

### Enclosed Space Emergency Response Plan

Speed is of great importance when responding to an enclosed space rescue situation. However, it should be borne in mind that ill-prepared rescue attempts, without proper equipment and human assistance, can lead to more casualties. The following are steps that should be taken during an enclosed space rescue situation:

.1 alarm has been sounded and information on the specific kind of emergency, including, location of the incident has been announced;

.2 crew muster at their designated muster location;

.3 consult the Enclosed Space Register or Permit to Work, where details of the specific enclosed space in question are given. Pay particular attention to unique details of the enclosed space such as vertical ladders in the space, Australian ladders, access and egress points and any others to make rescue easier;

.4 as per the drill plan, the rescue team should don the self-contained breathing apparatus (SCBA) and prepare to enter the space and await instructions from the on-scene commander;

.5 as time is of essence in enclosed space emergencies, the master should assess whether to alert the telemedical assistance service (TMAS) or to alert other medical assistance at shore to give support for the rescue team on board and give more time for the shore-based rescue resources to arrive to ship;

.6 in case the ship is at sea, possible deviation to a port of refuge should also be considered;

.7 rescue team should have an on-scene commander, who will lead the rescue while one or more members will be assisting the commander;

.8 the on-scene commander assesses the risks and the conditions for the rescue team and briefs on possible dangers present such as oxygen deficiencies, slippery surface, darkness, possible fire;

.9 the on-scene commander should guide the team to act in the quickest but safest manner. Noting also, the actions should not lead to further casualties;

.10 once the casualty has been reached, they should be evacuated from the space in the quickest and safest manner possible. Should there be more than one casualty, due regard should be given to rescue them in the quickest possible manner. However, in most cases, it is only possible to rescue them one after the other. The on-scene commander should decide on the order of rescue of the casualty. The use of a safe stretcher should be considered; and

.11 once the casualty is clear of the danger zone, the first aid team should administer first aid and, if necessary, conduct medical procedures such as CPR to revive the casualty. Shore medical assistance should be consulted.

## APPENDIX 2

## EXAMPLE OF AN ENCLOSED SPACE ENTRY PERMIT

This permit relates to entry into any enclosed space and should be completed by the master or the responsible person and by any persons working with the space including those entering the space, e.g. competent person and attendant.

### General

Location/name of enclosed space

Reason for entry……..

This permit is valid from:_____ hrs Date…….

to:_____ hrs Date…….

(See Note 1)

### Section 1 - Pre-entry preparation

(To be checked by the master or nominated responsible person)

Yes No

- Has the space been thoroughly ventilated by mechanical or natural means as appropriate?
- Has the space been segregated by blanking off or isolating all connecting pipelines or valves and electrical power/equipment?
- Has the atmosphere in the space been tested and found safe for entry? (See note 12)
- Pre-entry atmosphere test readings:
  - oxygen %vol 20.9%: By:
  - flammable gas % LFL (less than 1%)
  - toxic gases ppm (less than 50% OEL of the specific gas) Time:
  - $CO_2$ less than 0.5% by volume (5,000 ppm)

(See note 3)

- Have arrangements been made for frequent atmosphere checks to be made while the space is occupied and after work breaks?
- Have arrangements been made for the space to be continuously ventilated throughout the period of occupation and during work breaks?
- Are access and illumination adequate?
- Is the rescue equipment as identified appropriate for the space being entered, e.g. hoist, winch and tripod, ready for deployment?

| | Yes | No |
|---|---|---|
| • Is rescue and resuscitation equipment available for immediate use by the entrance to the space? | | |
| • Has an attendant been designated to be in constant attendance at the entrance to the space? | | |
| • Has the officer of the watch (bridge, engine-room, cargo control room) been advised of the planned entry? | | |
| • Has a system of communication between all parties been tested and emergency signals agreed? | | |
| • Are emergency and evacuation procedures established and understood by all personnel involved with the enclosed space entry? | | |
| • Is all equipment used in good working condition and inspected prior to entry? | | |
| • Are personnel properly clothed and equipped? | | |

**Section 2 – Pre-entry checks**
(To be checked by each person entering the space)

| | Yes | No |
|---|---|---|
| ● I have received instructions or permission from the master or responsible person nominated by the master to enter the enclosed space | | |
| ● Section 1 of this permit has been satisfactorily completed by the master or responsible person nominated by the master | | |
| ● I have agreed and understood the communication procedures | | |
| ● I have agreed upon a reporting interval of ------minutes | | |
| ● Emergency and evacuation procedures have been agreed and are understood | | |
| ● I am aware that the space must be vacated immediately in the event of ventilation failure or if atmosphere tests show a change from agreed safe criteria. | | |

**Section 3 – Entry into a space where the atmosphere is known or suspected to be unsafe**
(To be checked jointly by the master or responsible person nominated by the master and the person who is to enter the space)

| | Yes | No |
|---|---|---|
| ● Those entering the space are familiar and trained with the use of any breathing apparatus to be used | | |
| ● The breathing apparatus has been tested as follows: | | |
| - gauge and capacity of air supply | | |
| - low pressure audible alarm if fitted | | |
| - face mask - under positive pressure and not leaking | | |

- The means of communication has been tested and emergency signals agreed

- All personnel entering the space have been provided with Personal gas monitors, portable lighting, and, where practicable, rescue harnesses lifelines

Yes No

- Those entering the space are familiar with the personal gas monitor they are wearing and its operation has been checked

Signed upon completion of sections 1, 2 and 3 by:

| | | |
|---|---|---|
| Master or nominated responsible person | Date | Time |
| Attendant | Date | Time |
| *Person entering the space* | Date | Time |

**Section 4 – Personnel entry**
**(To be completed by the responsible person supervising entry)**

Names

Time in Time out

**Section 5 – Completion of job**
(To be completed by the responsible person supervising entry)

| | | |
|---|---|---|
| • Job completed | Date | Time |
| • Space secured against entry | Date | Time |
| • The officer of the watch has been duly informed | Date | Time |

Signed upon completion of sections 4 and 5 by:

Responsible person supervising entry ..... Date ..... Time .....

**THIS PERMIT IS RENDERED INVALID SHOULD VENTILATION OF THE SPACE STOP OR IF ANY OF THE CONDITIONS NOTED IN THE CHECKLIST CHANGE**

**Notes:**

1 The permit should contain a clear indication as to its maximum period of validity. As a default, the maximum period should be eight hours. If persons exit the space and leave it unattended this voids the Permit and a re-inspection is required.

2 In order to obtain a representative cross section of the space's atmosphere, samples should be taken from several levels and through as many openings as possible. Ventilation should be stopped for about 10 minutes before the pre-entry atmosphere tests are taken, and then recorded.

3 Tests for specific toxic contaminants should be undertaken depending on the nature of the previous contents of the space.

**APPENDIX 3**

**EXAMPLE OF AN ENCLOSED SPACE WARNING SIGNS**

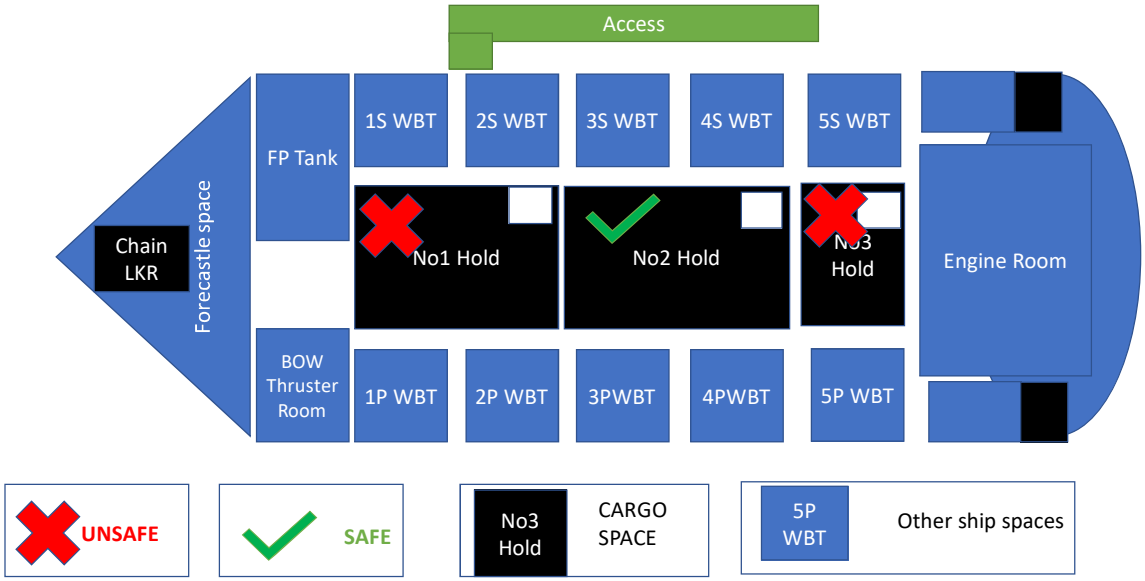
**EXAMPLE OF A SIMPLIFIED SHIP SPACE DIAGRAM TO BE PLACED AT THE SHIPS ACCESS POINT**


A space which is unsafe to enter, to be displayed at the entry points to the space. The descriptive text can be considered optional and may be displayed in the ship's operational language


A space which is safe to enter and all necessary measures to ensure the safety as required by the ships SMS have been implemented ensuring the safety of those entering it

To be displayed at the access point to the space

The descriptive text can be considered optional and may be displayed in the ship's operational language




Example of a simplified diagram to be placed at the ship's access point to assist shore personnel in identifying safe and unsafe spaces on board the ship.

## APPENDIX 4

## STEEL-RELATED EXPERIMENTS – TABLE OF FINDINGS

| Type of steel-related experiment | Cargo type | Free airspace in hold (μ) | Temp °C | Depletion time in hours to oxygen level of: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 20% | 19.5% | 18% | 15% | 12% | 10% | 6% | 3% | 1% |
| Closed Experiment | Scrap Metal | 90% | 10°C | 0.96 | 1.45 | 3.44 | 8.04 | 13.84 | 18.08 | 28.30 | 37.38 | - |
| Closed Experiment | Scrap Metal | 90% | 23°C | 0.19 | 0.30 | 0.46 | 0.80 | 1.21 | 1.56 | 2.41 | 12.67 | - |
| Open Vented | Scrap Metal | 90% | 10°C | 1.26 | 1.91 | 4.14 | 10.33 | 17.97 | 24.06 | 38.84 | 52.38 | 75.75 |
| Open Vented | Scrap Metal | 90% | 23°C | 0.59 | 0.84 | 1.55 | 3.12 | 4.64 | 5.68 | 8.03 | 10.13 | 12.00 |
| Chain Locker | Anchor Chain | 94% | 10°C | 3.08 | 4.53 | 9.13 | 18.46 | 30.37 | 38.48 | 58.17 | 77.25 | 95.83 |
| Chain Locker | Anchor Chain | 94% | 23°C | 1.44 | 2.05 | 3.83 | 8.03 | 13.25 | 17.25 | 27.17 | 36.50 | 46.08 |
| **Chain Locker Refreshment** | | | | **Refreshment time in hours to oxygen level of:** | | | | | | | | |
| **Type of steel-related experiment** | **Locker type** | **Free airspace in tank (μ)** | **Temp °C** | **3%** | **6%** | **9%** | **12%** | **15%** | **18%** | **19%** | **19.5%** | **20%** |
| Chain Locker Refreshment | Anchor Chain | 94% | 10°C | 0.09 | 0.18 | 0.33 | 0.52 | 0.85 | 1.65 | 2.45 | 3.45 | 6.75 |
| Chain Locker Refreshment | Anchor Chain | 94% | 23°C | 0.15 | 0.25 | 0.37 | 0.53 | 0.83 | 1.59 | 2.04 | 2.49 | 3.42 |
| **Double Bottom Tank** | | | | **Oxygen Depletion time in hours to oxygen level of:** | | | | | | | | |
| **Type of steel-related experiment** | **Bare Steel %** | **Free airspace in tank (μ)** | **Temp °C** | **20%** | **19.5%** | **19%** | **18%** | **17%** | **16%** | **15%** | **14%** | **13%** |
| Double Bottom Tank | 48.75% | 100% | 12°C | 7.75 | 15.50 | 26.33 | 47.08 | 88.58 | 115.67 | 157.25 | 198.75 | 216.13 |
| Double Bottom Tank | 48.75% | 100% | 23°C | 0.90 | 1.65 | 3.20 | 9.13 | 18.43 | 30.51 | 45.94 | 65.72 | 86.37 |
| Double Bottom Tank | 42.56% | 100% | 23°C | 0.91 | 2.34 | 4.49 | 11.74 | 24.79 | 42.53 | 67.14 | 92.75 | 126.74 |
| Double Bottom Tank | 36.56% | 100% | 23°C | 0.96 | 2.77 | 5.66 | 14.30 | 28.54 | 50.00 | 72.58 | 99.45 | 138.20 |

| Double Bottom Tank | | | | Oxygen Depletion time in hours to oxygen level of: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Type of steel-related experiment** | **Bare Steel %** | **Free airspace in tank (µ)** | **Temp °C** | **20%** | **19.5%** | **19%** | **18%** | **17%** | **16%** | **15%** | **14%** | **13%** |
| Double Bottom Tank | 30.47% | 100% | 23°C | 1.21 | 3.91 | 7.38 | 17.03 | 30.31 | 51.55 | 77.32 | 99.92 | 135.81 |
| Double Bottom Tank | 24.37% | 100% | 23°C | 1.46 | 4.02 | 7.86 | 20.47 | 41.97 | 71.03 | 104.02 | 137.92 | 169.86 |

This table was taken from annex 1 of document CCC 9/8/3.

## APPENDIX 5

## INFORMATION ON ACCEPTABLE AND UNACCEPTABLE LEVELS OF GASES

### Oxygen

The table below has been ascertained from the experimental findings provided in documents CCC 9/8/3, CCC 9/INF.9 and CCC 9/INF.10.

| | **Oxygen Danger Levels – Organic Cargoes** |
|---|---|
| **% $O_2$** | **Danger Levels** |
| 20.9 | Oxygen concentration in normal air. |
| 20.73 | Workplace Exposure Limit of 35 ppm for CO Level is reached. |
| 20.26 | Workplace Exposure Limit of 0.5% for $CO_2$ Level is reached. |
| 20 to 17 | Impaired coordination. |
| 17 | Commencement of Equivalent ceiling exposure limit of 3% $CO_2$ in cargo hold, and extreme danger at 800 ppm CO. |
| 16 to 14 | Exposure to 4% $CO_2$ gas in cargo holds can lead to serious oxygen deprivation resulting in permanent brain damage, coma, even death.<br>Immediately dangerous to life and health at 1200 ppm CO.<br>The time to reach the fatal level and the oxygen prevailing will vary with cargo type and conditions. |

### Carbon dioxide

The table below has been ascertained from the published guidance from the Occupational Safety and Health Administration (OSHA) (United States Department of Labor) and the American Conference of Governmental Industrial Hygienists (ACGIH) & Minnesota Department of Health recommendations.

| Carbon dioxide ($CO_2$) | | Danger levels |
|---|---|---|
| [ppm] | [%] | |
| 250 – 400 | 0.025 - 0.04 | Normal background concentrations in outdoor ambient air |
| 400 - 1,000 | 0.04 - 0.1 | Concentrations typical of occupied indoor spaces with good air exchange |
| 1,000 – 2000 | 0.1 - 0.2 | Complaints of drowsiness and poor air quality |
| 2,000 – 5,000 | 0.2 - 0.5 | Headaches, sleepiness and stagnant stuffy air, Poor concentration, loss of attention, increased heart rate and slight nausea may also be present |
| 5,000 | 0.5 | Workplace exposure limit (as 8 hour TWA[9]) in most countries |
| 30,000 | 3 | Ceiling exposure limit (not to be exceeded) for a 10 minute period |
| 40,000 | 4 | Exposure may lead to serious oxygen deprivation resulting in permanent brain damage, coma or death |
| 50,000 | 5 | Strong respiratory stimulation, dizziness, confusion, headache, shortness of breath |
| 80,000 | 8 | Dimmed sight, sweating, tremor, unconsciousness and **possible death** |

**Carbon monoxide (CO)**

Carbon monoxide (CO) is toxic and flammable.[10] It is invisible, colourless, odourless and tasteless and it has no warning properties whilst the cargo space looks normal. When CO is inhaled into the lungs, it combines with the haemoglobin in the blood and haemoglobin is no longer available to transport oxygen. The nervous system, brain, heart and lungs are dramatically affected. Relying on existing tables of oxygen depletion levels and dangers may be inadequate when cargoes that may emit carbon monoxide is carried, as the oxygen levels in the cargo space may remain in the region of 17% to 14% when 1200 ppm or greater CO level is reached. The adoption of a more appropriate carbon monoxide table with additional danger levels at 400 ppm and at 800 ppm where the symptoms are "Headaches, dizziness and nausea in 45 minutes with death in less than two hours", and at 1200 ppm where the conditions are "Immediately dangerous to life or health. Death from carbon monoxide can precede death from oxygen deficiency in organic types of cargo."

***

[9] Time weighted average (TWA): The TWA for the exposure to a chemical can be used when both the chemical concentration and time for exposure varies over time. It is thus used as the average exposure to a contaminant to which workers may be exposed without adverse effect over a period such as in an 8-hour day or 40-hour week (an average work shift). They are usually expressed in units of ppm (volume/volume) or $mg/m^3$.

[10] For example, according to the IMDG Code, "CARBON MONOXIDE, COMPRESSED" is UN 1016, class 2.3, subsidiary hazard 2.1, "Flammable, toxic, odourless gas. Explosive limits: 12% to 75%. Slightly lighter than air (0.97)."