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DEVELOPMENT OF A SAFETY REGULATORY FRAMEWORK TO SUPPORT THE REDUCTION OF GHG EMISSIONS FROM SHIPS USING NEW TECHNOLOGIES AND ALTERNATIVE FUELS

Proposed interim guidelines for the safety of ships using carbon capture and storage systems

Submitted by IACS

SUMMARY

Executive summary:	This document proposes interim guidelines for the safety of ships using onboard carbon capture and storage systems (OCCS), in response to gap G-34 identified by MSC 110. While OCCS are considered a potential means to reduce CO_2 emissions from ships, their installation and integration introduce additional safety considerations related to ship integration, CO_2 processing and storage, and the use of chemical treatment fluids. The proposed interim guidelines adopt a goal-based and risk-based approach to address these hazards, allowing flexibility to accommodate the wide variety of ship types and OCCS arrangements while ensuring an acceptable level of safety.
Strategic direction, if applicable:	3
Output:	3.8
Action to be taken:	Paragraph 15
Related documents:	MSC 110/21, MSC 110/WP.9; CCC 11/16; MSC 111/14 and MSC 111/WP.1/Rev.1

Introduction

1 MSC 110 endorsed the recommendations on addressing existing barriers and gaps related to alternative fuels and new technologies, as set out in annex 1 to document MSC 110/WP.9. Among these is gap G-34, which calls for the development of safety requirements for onboard carbon capture and storage systems on ships.

2 Furthermore, MSC 110 instructed the Sub-Committee on Carriage of Cargoes and Containers (CCC) to give priority, starting from CCC 12, to addressing gaps and barriers related to onboard carbon capture and storage systems (MSC 110/21, paragraph 6.56.2).

3 MSC 111 endorsed the work plan produced by CCC 11 (MSC 111/14, paragraph 2.16) for the development of a safety regulatory framework to support the reduction of GHG emissions from ships using new technologies and alternative fuels under the purview of the CCC Sub-Committee, as contained in annex 5 to document CCC 11/16 (MSC 111/WP.1/Rev.1, paragraph 6.4).

Background

4 In the context of the Organization's efforts to reduce greenhouse gas emissions from ships, onboard carbon capture and storage systems (OCCS) are being developed and proposed as a potential means to reduce emissions of carbon dioxide (CO_2) generated during ship operation.

5 While OCCS offer the potential to contribute to emissions reduction, their installation and integration on board ships introduce additional safety considerations. These considerations arise both from the integration of OCCS with ship systems and from the handling, processing and storage of CO_2 and associated chemical substances on board.

Discussion

6 IACS has carried out an assessment of the risks associated with OCCS and has identified a set of preventive and mitigation measures addressing the main hazard areas, as outlined below.

Ship integration

7 At the ship level, OCCS introduce integration-related risks, including but not limited to:

.1 interfaces with exhaust gas systems, which may affect exhaust flow, backpressure and machinery operation;

.2 impacts on ship stability and structural arrangements due to additional weight, modified load distribution and new equipment foundations; and

.3 increased demands on electrical power generation and distribution systems, requiring careful integration to ensure the continued availability of essential ship functions.

8 To address the integration-related risks introduced by OCCS, a combination of design, arrangement, monitoring and control measures has been identified, as follows:

.1 In relation to interfaces with exhaust gas systems, preventive measures focus on ensuring safe and continuous exhaust gas flow under all operating conditions. These include appropriate control of exhaust gas backpressure within machinery manufacturer's limits, prevention of reverse flow between exhaust systems, and the provision of fail-safe bypass arrangements to ensure continued machinery operation in the event of OCCS malfunction or shutdown.

.2 With regard to ship stability and structural arrangements, mitigation measures include assessing the effects of added weight, modified load distribution and new equipment foundations as part of the ship's structural strength and stability evaluation. For retrofitted installations, particular attention is given to the impact on propulsion and shafting systems, ensuring that alignment, bearing loads and structural margins remain within acceptable limits.

.3 To address electrical power integration risks, measures are identified to ensure that the ship's power generation and distribution systems are capable of accommodating the additional power demands of the OCCS during normal operation, start-up, shutdown and emergency conditions. These measures aim to maintain power quality, continuity and redundancy, and to ensure that the availability of essential ship functions is not adversely affected by the operation or failure of the OCCS.

CO_2 system

9 OCCS involve the processing, compression, liquefaction and storage of CO_2 on board. These functions introduce hazards associated with high pressure, low temperature and the asphyxiant properties of CO_2, as well as risks related to leakage, accumulation in enclosed spaces and safe personnel access.

10 To address these risks, preventive and mitigation measures have been identified, focusing on ensuring the integrity of pressure-containment systems, controlling hazardous atmospheres and protecting personnel. These measures include the use of equipment and piping designed for the applicable pressure and temperature conditions, arrangements to maintain storage parameters within design limits and to restrict CO_2 venting to situations necessary for the safety of the ship or to save life at sea. In addition, appropriate segregation, ventilation and drainage arrangements should be provided for spaces containing CO_2 systems, together with gas detection, monitoring and alarm systems, to enable early detection of CO_2 leakage or accumulation.

11 With regard to the risks associated with the processing and storage of CO_2, the IGC Code can serve as a relevant reference framework. However, certain adaptations are considered necessary to reflect the specific operational context of OCCS installations. In this respect, the following considerations are taken into account:

.1 OCCS may be installed on ships that are not designed or operated for the carriage of gases, and any unintended release of CO_2 could affect machinery spaces, service spaces or accommodation spaces where continuous human presence is expected and where CO_2 is not an anticipated hazard.

.2 By contrast, ships subject to the IGC Code are specifically designed, equipped and operated for the carriage of gases, with dedicated cargo areas, enhanced segregation and ventilation arrangements, and crews trained to manage gas-related hazards.

.3 Accordingly, the requirements of the IGC Code reflect a controlled and expected exposure scenario, whereas the application of similar provisions to OCCS installations necessitates a more precautionary approach, appropriate for a wider range of ship types and operating conditions.

.4 Therefore, while the IGC Code provides a valuable reference, certain adaptations may be warranted. For example, while the MSC 111-approved draft amendments to the IGC Code refer to alarm and shutdown thresholds of 5,000 ppm for CO_2 carriage as cargo (MSC 111/WP.1/Rev.1, paragraph 6.36), it may be appropriate to apply more conservative alarm and shutdown thresholds for OCCS installations.

.5 As a further example, while the IGC Code primarily associates tank overfill protection with cargo loading operations that are limited in duration and conducted as closely supervised activities supported by established operational procedures, CO_2 storage tanks are filled continuously during normal ship operation. This fundamental difference in operating mode, whereby filling occurs on a continuous basis rather than during time-limited supervised loading operations, justifies the application of percentage-based filling thresholds for continuously active alarms and automatic shutdown functions for OCCS installations, even though this approach is not fully aligned with the cargo-loading-oriented overflow protection philosophy of the IGC Code.

Chemical treatment fluids

12 OCCS concepts generally rely on the use of chemical treatment fluids, such as absorbents or solvents, to enable the capture and conditioning of CO_2. The storage, handling and transfer of such substances may introduce additional hazards, including flammability, toxicity, corrosiveness and chemical reactivity, which necessitate appropriate design and arrangement measures, as well as suitable instrumentation, monitoring and alarm arrangements, to ensure that abnormal conditions are detected in due time and that the safety of the ship and personnel is maintained.

Diversity of OCCS arrangements

13 OCCS may be installed on a wide variety of ship types, resulting in a large number of possible arrangements and configurations. In order to accommodate this diversity, while ensuring an acceptable level of safety, the safe installation and use of OCCS should be supported by a dedicated risk assessment for each ship. Such risk assessment should address the specific interfaces, layouts and operational scenarios of the ship concerned. This includes, for example, the evaluation of access arrangements to liquefied CO_2 storage tank rooms or hold spaces and their relationship with associated tank connection spaces, which may vary significantly from one ship to another. Given the wide range of possible configurations, such access arrangements cannot be adequately addressed through prescriptive requirements alone and therefore require case-by-case assessment to ensure that safe access, escape and operational control are provided for the specific installation.

Proposal

14 Based on the above considerations, IACS has developed draft interim guidelines providing a safety framework for the installation and integration of OCCS on board ships, as set out in the annex to this document, for consideration by the Sub-Committee.

Action requested of the Sub-Committee

15 The Sub-Committee is invited to consider the foregoing, the proposed interim guidelines set out in the annex, and to take action, as appropriate.

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ANNEX

DRAFT INTERIM GUIDELINES FOR THE SAFETY OF SHIPS USING CARBON CAPTURE AND STORAGE SYSTEMS

1 INTRODUCTION

1.1 The purpose of these Interim Guidelines is to provide a safety framework for the safe installation and integration of onboard carbon capture and storage systems (OCCS).

1.2 OCCS systems are being installed as a potential measure to reduce emissions of carbon dioxide (CO_2) generated during combustion. The installation and integration of such systems introduce new hazards and safety considerations, particularly in relation to the handling, processing, storage and containment of CO_2, and their interfaces with existing ship systems.

1.3 In support of this purpose, the Interim Guidelines establish safety goals and associated functional requirements intended to ensure that OCCS installations achieve an acceptable level of safety, while allowing sufficient flexibility in their technical design and implementation to accommodate the wide variety of potential OCCS arrangements and configurations across different ship types.

1.4 These Interim Guidelines address only the safety aspects related to the installation and integration of OCCS on board ships. They do not address system performance, operational efficiency, carbon accounting, or environmental effectiveness, which are outside the scope of this document.

2 GENERAL

2.1 Application

2.1.1 These Interim Guidelines address the safety requirements associated with the installation and integration of onboard carbon capture and storage systems (OCCS) on board ships, covering aspects such as materials, structural integrity, containment and storage tanks, piping systems, control and monitoring systems, safety systems, and overall ship integration, including the handling, processing, storage and containment of carbon dioxide (CO_2) and associated chemical treatment fluids.

2.1.2 These Interim Guidelines do not cover performance, operational efficiency, carbon accounting, or environmental effectiveness.

2.2 Definitions

2.2.1 For the purpose of these Interim Guidelines, the terms used have the meanings defined in the following paragraphs. Terms not defined have the same meaning as in SOLAS chapter II-2, the IGC Code and the IGF Code.

2.2.2 *Onboard carbon capture and storage system (OCCS)* is a system or arrangement installed on board a ship that captures carbon dioxide (CO_2) generated from fuel processing and/or combustion processes, separates it from other gases, conditions it as necessary, and stores it on board for subsequent off-loading or disposal. The definition includes all associated equipment, systems, and arrangements necessary for the capture, separation, compression, liquefaction, storage, monitoring, and safe handling of CO_2 on board.

2.2.3 *Liquefied CO_2 storage tanks* are tanks for the bulk storage of captured liquefied CO_2, considered as independent tanks as defined in the IGC Code. This definition also includes portable tanks used for the same purpose.

2.2.4 *CO_2 machinery handling spaces* are spaces where captured CO_2 is handled, such as but not limited to the spaces where the CO_2 compressors, heat exchangers, absorber, desorber and equipment and pumps for stripping, drying, liquefaction, and transfer are located.

2.2.5 *CO_2 tank room/hold space* is an enclosed space where a liquefied CO_2 storage tank is fitted.

2.2.6 *Chemical treatment fluid* is any liquid chemical agent used within an OCCS to facilitate the capture, absorption, regeneration, neutralization, or conditioning of CO_2, including absorbents, solvents, additives, inhibitors, or any other process fluid required for the chemical treatment stages of the OCCS.

2.2.7 *Post-combustion carbon emission abatement plant* is a system which is intended to deal with the carbon composites generated during combustion of carbon-containing fuel in a fuel consumer. It is the opposite of a pre-combustion carbon emission abatement plant, which is a system intended to deal with the carbon in the fuel, prior to its combustion in a fuel consumer.

2.2.8 *Full flow carbon capture plants* are carbon capture plants where the full amount of exhaust gases from fuel consumers is designed to flow through the carbon capture plant.

2.2.9 *Side streams carbon capture plants* are plants where the flow of exhaust gases from fuel consumers is divided into two or more streams, and one of them flows through the carbon capture plant.

2.2.10 *Absorber* is an OCCS component in which CO_2 is removed from a gas stream by chemical or physical absorption into a solvent, resulting in a CO_2-depleted gas exiting the absorber.

2.2.11 *Desorber* is an OCCS component in which the CO_2-laden solvent is heated or depressurized to release the absorbed CO_2, regenerating the solvent for reuse and producing a concentrated CO_2 stream for storage or disposal.

2.2.12 *Control location* is the location from which the OCCS is operated and supervised under normal operating conditions, and at which the relevant control, monitoring, and alarm functions are provided.

2.3 Alternative design

2.3.1 These Interim Guidelines contain functional requirements for all appliances and arrangements related to the installation of OCCS.

2.3.2 Appliances and arrangements of OCCS may deviate from those set out in these Interim Guidelines, provided such appliances and arrangements meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety to the relevant sections.

2.3.3 The equivalence of the alternative design should be demonstrated as specified in SOLAS regulation II-1/55 and approved by the Administration. However, the Administration should not allow operational methods or procedures to be applied as an alternative to a particular fitting, material, appliance, apparatus, item of equipment or type thereof which is prescribed by these Interim Guidelines.

3 GOAL AND FUNCTIONAL REQUIREMENTS

3.1 Goal

The goal of these Interim Guidelines is to ensure that OCCS, including arrangements for the handling, processing, storage and containment of carbon dioxide (CO_2) and associated chemical treatment fluids, are installed and integrated in a manner that achieves an acceptable level of safety through the identification, assessment and mitigation of associated risks, does not adversely affect the normal operation of the ship or the availability of essential ship functions, and remains robust under normal operating conditions and foreseeable abnormal and failure conditions.

3.2 Functional requirements

3.2.1 The OCCS installation should not adversely affect the normal operation of the ship, including propulsion, manoeuvrability, electrical power supply, availability of essential services, or the safety of personnel.

3.2.2 The OCCS should be able to be operated, controlled, monitored, isolated and shut down without compromising the safety of the ship or the continued availability of essential ship functions.

3.2.3 Hazards associated with the installation, integration and operation of the OCCS should be identified and addressed, including hazards arising from the handling, processing, storage and containment of carbon dioxide (CO_2) and associated chemical treatment fluids.

3.2.4 Piping systems, containment arrangements and overpressure relief arrangements associated with the OCCS should be of suitable design, materials, construction and installation for their intended application.

3.2.5 The OCCS should be adequately integrated with existing ship systems, taking into account interfaces with machinery, exhaust gas systems, electrical systems, control systems, accommodation spaces and other relevant arrangements.

3.2.6 Failure, malfunction or unavailability of the OCCS should not result in unsafe conditions for the ship, its crew or essential ship systems.

3.2.7 Adequate means should be provided to prevent, detect and mitigate hazardous conditions arising from the OCCS, including leakage, overpressure, abnormal temperatures and hazardous atmospheres.

3.2.8 Appropriate information, alarms and indications should be provided to support safe operation and timely response to abnormal conditions.

4 GENERAL PROVISIONS

4.1 **Goal**

The goal of this chapter is to ensure that all relevant risks associated with the installation and integration of OCCS are identified, assessed and addressed through appropriate mitigation measures, so as to achieve an acceptable level of safety for the ship, its crew and the continued normal operation of the ship.

4.2 Risk assessment

4.2.1 A risk assessment should be conducted to ensure that risks arising from the installation, integration and operation of OCCS, and affecting persons on board, the structural strength or the integrity of the ship, or the availability of essential ship functions are identified and addressed. Consideration should be given to hazards associated with the physical arrangement of the OCCS, its operation and its interfaces with ship systems.

4.2.2 The risks should be analysed using acceptable and recognized risk analysis techniques. The analysis should ensure that risks are eliminated wherever possible. Risks which cannot be eliminated should be mitigated as necessary. Details of risks, and the means by which they are mitigated, should be documented to the satisfaction of the Administration.

4.2.3 The risk assessment should address at least the following:

.1 absorption and desorption processes of OCCS;

.2 supply, storage, handling and unloading system (if installed) of chemical treatment fluid;

.3 compression, liquefaction, storage and unloading system of carbon storage system (if installed);

.4 location and impacts of OCCS equipment and liquefied CO_2 storage tanks;

.5 supply, storage, and handling of refrigerant for carbon dioxide liquefaction system;

.6 possible impact of operation or failure of the carbon capturing system on essential services;

.7 interfaces of the OCCS plant with the ship;

.8 control and safety system of the OCCS system;

.9 access arrangements to liquefied CO_2 storage tank room/hold spaces and/or access arrangement tank connection spaces; and

.10 installation of chemical fluid storage tanks.

4.2.4 The hazards to be considered should at least include the following:

.1 leakage of a chemical treatment fluid;

.2 leakage of CO_2;

.3 leakage of refrigerant for carbon dioxide liquefaction system;

.4 failure and malfunction of components of carbon capture and storage system;

.5 accidental incidents on board which may affect the OCCS system, e.g. dropped objects, fire and explosion; and

.6 risk of solid CO_2 formation or loss of refrigeration performance.

4.2.5 When assessing the expected risks, at least the following should be considered:

.1 toxicity and flammability of chemical treatment fluid;

.2 toxicity of CO_2; and

.3 toxicity and flammability properties of refrigerant.

5 SHIP INTEGRATION REQUIREMENTS

5.1 Goal

The goal of this chapter is to ensure that the OCCS are integrated into the ship in a manner that does not adversely affect the ship's structural integrity, stability, propulsion, electrical power supply or the availability of essential ship systems.

5.2 Functional requirements

This section is related to functional requirements 3.2.1 and 3.2.5. In particular, the following should apply:

.1 The installation of OCCS, including associated equipment, foundations and CO_2 storage, should be duly taken into account in the assessment of the ship's structural strength and stability, considering all relevant loading conditions.

.2 For retrofitted OCCS installations, the effects of added weight and altered load distribution should be evaluated, including potential impacts on propulsion systems, such as shaft alignment, bearing loads and related components.

.3 The electrical power generation and distribution systems should be capable of supporting the power demands of the OCCS during normal operation, start-up, shutdown and emergency conditions.

.4 The integration of the OCCS should not compromise the availability, reliability or performance of essential ship services, including propulsion, steering, power supply, navigation and safety systems.

.5 Appropriate arrangements should be provided to manage the load variations associated with OCCS operation so that power quality, continuity and redundancy of essential electrical systems are maintained.

.6 Failure, malfunction or shutdown of the OCCS should not result in unsafe conditions for the ship or lead to loss of essential functions necessary for the safe operation of the ship.

.7 The integration of the OCCS with exhaust gas systems should not result in unsafe exhaust gas flow conditions, including excessive backpressure, reverse flow, or unintended interaction between exhaust systems of different fuel consumers.

.8 Where exhaust gas streams from multiple fuel consumers are connected to a common OCCS, the system should prevent reverse flow and cross-communication between exhaust gas systems, including the transfer of exhaust gases or unburned fuel from one fuel consumer to another.

.9 The ship should be capable of maintaining a safe and continuous exhaust gas flow path for each connected fuel consumer under all relevant conditions, including OCCS malfunction, shutdown or loss of availability.

5.3 General provisions

5.3.1 The installation of OCCS, including associated equipment, foundations and CO_2 storage, should be taken into account in the assessment of the ship's structural strength and stability. For retrofitted installations, the effects of the added weight and altered load distribution on the propulsion shafting system, including shaft alignment and bearing loads, should be assessed, where applicable.

5.3.2 The ship's electrical system and power balance should be designed and arranged to take into account the operational power requirements of the OCCS, including normal operation, start-up, shutdown, and emergency conditions, to ensure that the supply to other essential ship systems is maintained in accordance with applicable IMO instruments.

5.4 Exhaust gas system integration

5.4.1 Where a post-combustion carbon emission abatement plant is fed from multiple exhaust-gas inlet streams, the arrangement should provide the following safety functions:

.1 prevention of reverse flow of exhaust gas, by means such as valves or equivalent isolation devices to avoid exhaust gas entering the manifolds of engines that are shut down;

.2 control of exhaust-gas backpressure within the allowable limits specified by the machinery manufacturer of each fuel consumer for all operating configurations; and

.3 provision of a bypass or equivalent arrangement to ensure safe and continuous operation of engines or combustion machinery when the abatement plant is unavailable or in fault condition (see 5.4.3).

5.4.2 Fuel consumers using gas or other low-flashpoint fuels should be provided with separate exhaust systems in accordance with paragraph 16.7.1.2 of the IGC Code or paragraph 10.2.4 of the IGF Code, as applicable. Notwithstanding this, the separate exhaust systems of two or more fuel consumers using the same gas or low-flashpoint fuel may be connected to a common OCCS, subject to flag acceptance, provided that the design ensures adequate separation between exhaust gas systems and prevents any unburned gas or exhaust gases from one fuel consumer from entering any other fuel consumer or exhaust gas system, thereby avoiding any cross-transfer of unburned or exhaust gases between fuel consumers.

5.4.3 Bypass arrangements for full flow carbon capture plants should be as follows.

5.4.3.1 Full flow carbon capture plants should be provided with a bypass arrangement suitable for the maximum and minimum exhaust gas flows from the combustion machinery to which they are connected, unless the carbon capture plant is capable of safely handling the maximum exhaust gas flows with the carbon capture plant out of operation, such that the combustion machinery to which it is connected can continue to operate.

5.4.3.2 Where a full flow bypass is fitted, the closing means should be arranged so that at least one exhaust gas flow path remains available at all times, either through the carbon capture plant or through the bypass, by application of the requirements in 5.4.3.3. The essential services necessary for maintaining the ship in normal operational and habitable conditions should not be impacted during the bypass activation.

5.4.3.3 In order to achieve such functionality:

.1 the activation of the bypass mode should be automatic for conditions which activate a shutdown of the carbon capture plant;

.2 an interlock arrangement should be provided to ensure that the bypass valves are open prior to blocking the exhaust gas flow into the carbon capture plant;

.3 a single failure in the system(s) controlling the valves and dampers should not prevent free exhaust flow;

.4 the bypass valves should be remotely operated from the control location;

.5 position indicators for the bypass valves should be provided in the local and remote control positions; and

.6 bypass valves should be of a fail-to-open type.

5.4.4 For side-stream carbon capture plants where the main exhaust gas flow path is not capable of accommodating the maximum exhaust gas flow generated by the connected combustion machinery:

.1 a by-pass arrangement should be provided; or

.2 alternatively, it should be demonstrated that the side-stream carbon capture plant is capable of safely handling the maximum exhaust gas flow when the plant is not in operation.

5.4.5 The bypass valves should be designed to remain operational under all relevant conditions and should be provided with appropriate means for inspection, cleaning or maintenance to prevent blockage or degradation of performance due to the accumulation of deposits, fouling, or other contaminants.

5.4.6 Means of measuring the exhaust gas differential pressure across the carbon capture plant should be provided.

6 CO_2 SYSTEM

6.1 Goal

The goal of this chapter is to ensure that carbon dioxide (CO_2) systems associated with OCCS, including CO_2 storage tanks, storage tank rooms or hold spaces, piping systems, and spaces containing CO_2 handling and processing equipment, are designed and arranged so that CO_2 is safely contained and managed, risks to the ship and personnel are minimized,and hazardous conditions are prevented or mitigated.

6.2 Functional requirements

This section is related to functional requirements 3.2.3, 3.2.4 and 3.2.7. In particular, the following should apply:

.1 CO_2 piping should be designed and routed to safely withstand all relevant operating conditions and to minimize the risk and consequences of leakage and be constructed from materials suitable for the fluids conveyed.

.2 Liquefied CO_2 storage tanks should be located and protected so that their structural integrity is maintained, external damage is mitigated.

.3 Venting or release of CO_2 should be limited to conditions necessary to protect the safety of the ship or to save life.

.4 Spaces containing liquefied CO_2 storage tanks should be arranged and constructed to confine leakage effects, withstand low-temperature exposure, and prevent degradation due to moisture or condensation.

.5 Hazardous atmospheres in CO_2 tank spaces should be able to be detected, mitigated through ventilation when required, and personnel entry should be controlled and supported by appropriate warnings.

.6 Spaces containing CO_2 processing equipment should be arranged, ventilated and monitored so that accumulation of CO_2 is prevented and abnormal operating conditions are detected in due time.

6.3 CO_2 piping requirements

6.3.1 CO_2 piping and associated process systems, including pumps, compressors and safety-valve exhaust lines, should be designed, constructed and installed in accordance with internationally recognized standards acceptable to the Administration or their recognized organizations, taking into account the design pressure, temperature and physical state of the carbon dioxide (CO_2) conveyed.

6.3.2 CO_2 piping should not be routed through accommodation spaces, service spaces or control stations.

6.3.3 CO_2 piping should be routed so that any condensate, or relief discharge, is led to a safe location.

6.4 Liquefied CO_2 storage tank requirements

6.4.1 Liquefied CO_2 storage tank, regardless of whether being portable or permanently installed, should be located at a distance inboard of not less than B/15 or 2 m, whichever is less, measured from the moulded line of the bottom shell plating at centreline and nowhere less than "d", where "d" = 0.8 m, from the moulded line of outer shell to ensure an appropriate protective distance from external damage, except when fitted on open deck.

6.4.2 Liquefied CO_2 storage tank should be located outside of accommodation spaces, service spaces, control stations and machinery spaces of category A, and should not be located forward of the collision bulkhead.

6.4.3 Liquefied CO_2 storage tanks installed in locations other than open deck areas should be arranged within designated spaces, referred to as liquefied CO_2 storage tank room/hold space, exclusively intended for the installation of such tanks.

6.4.4 With the exception of tanks designed to withstand full gauge vapour pressure of the CO_2 under conditions of the upper ambient design temperatures, tank pressure and temperature should be maintained at all times within their design range by one, or a combination of, the following methods:

.1 pressure accumulation;

.2 reliquefaction of vapours; and

.3 liquid cooling.

6.4.5 Venting of the CO_2 should only be allowed when necessary for the purpose of securing the safety of the ship or saving life at sea, or when resulting from damage to a ship or its equipment.

6.4.6 Liquefied CO_2 storage tanks of type C, as defined in paragraph 4.23 of the IGC Code, and associated process pressure vessels used for onboard carbon capture and storage systems, should be designed, constructed, tested, approved and surveyed in accordance with internationally recognized standards acceptable to the Administration or their recognized organizations.

6.4.7 The following requirements of the IGC Code applicable to independent CO_2 tanks type C (pressure CO_2 tanks) are relevant and should be applied to OCCS, as applicable:

.1 4.3 Functional requirements;

.2 4.8 Supporting arrangements;

.3 4.9 Associated structure and equipment;

.4 4.10 Thermal insulation;

.5 4.11 General;

.6 4.12 Permanent loads;

.7 4.13 Functional loads;

.8 4.14 Environmental loads;

.9 4.15 Accidental loads;

.10 4.16 General;

.11 4.17 Structural analyses;

.12 4.18 Design conditions;

.13 4.19 Materials;

.14 4.20 Construction processes;

.15 4.23 Type C independent tanks; and

.16 4.23.6 Testing.

6.5 Liquefied CO_2 storage tank room/hold space requirements

6.5.1 Liquefied CO_2 storage tank room/hold spaces below deck should be separated from machinery and boiler spaces, accommodation spaces, service spaces, control stations, chain lockers, domestic water tanks and from stores by a single gastight bulkhead of all-welded construction forming an A-0 class division.

6.5.2 Where access to a CO_2 storage tank room/hold space or tank connection space is provided from another enclosed space, access doors should open outwards in the direction of escape. Bulkheads and decks, including doors and other means of closing any openings forming the boundaries between such spaces and adjacent enclosed spaces, should be gastight.

6.5.3 Where liquefied CO_2 storage tanks are installed in enclosed room or hold spaces, the room/hold space should be provided with suitable drainage arrangements. The drainage system should not be connected to the machinery space.

6.5.4 The materials used in construction of the liquefied CO_2 storage tank room/hold spaces should be protected from potential leakages or should have a design temperature corresponding to the temperature they can be subject to in a leakage scenario.

6.5.5 The liquefied CO_2 tank room/hold spaces should be maintained under a controlled dry air atmosphere, with dry air supplied by suitable air-drying equipment. The dry-air condition may be maintained without continuous operation of the mechanical ventilation system, provided that the required dryness of the space is ensured. The requirement for dry air should not apply when CO_2 is carried at ambient temperature or when the tank design ensures that no moisture condensation can occur.

6.5.6 The ventilation systems serving the liquefied CO_2 storage tank room/hold spaces should be provided with monitoring and control arrangements to ensure that the systems are available for operation when required, including prior to personnel entry or in abnormal conditions. Such arrangements should include at least the following:

.1 the operational status of the ventilation systems should be continuously monitored in the control location;

.2 means should be provided to control the ventilation systems from the control location; and

.3 an alarm should be initiated at the control location in the event of loss or failure of the required ventilation when the system is in operation or required to be available.

6.5.7 Where the liquefied CO_2 storage tank room/hold space ventilation system is not continuously operated, appropriate warnings should be provided at the space entrances to indicate the presence of a potentially hazardous atmosphere and the need for ventilation and atmosphere verification prior to entry.

6.6 CO_2 machinery handling spaces

6.6.1 CO_2 handling machinery for the compression, cooling, drying, and liquefaction process should be located in a dedicated machinery space, unless supported by a risk assessment, classified as auxiliary machinery space for passenger ships carrying more than 36 passengers and other machinery spaces for other types of ships.

6.6.2 CO_2 machinery handling spaces should be provided with mechanical ventilation, separated from other ventilation systems and should be of the extraction type. The ventilation capacity should be, as a minimum, as follows:

.1 6 air changes per hour in spaces with only desorber equipment; and

.2 30 air changes per hour in CO_2 handling spaces.

6.6.3 The suction points for exhaust should be fitted at the floor level of the room/space.

7 CHEMICAL TREATMENT FLUID SYSTEM

7.1 Goal

The goal of this chapter is to ensure that chemical treatment fluids used in OCCS are safely stored, transferred and handled, such that risks to personnel, the ship and essential systems arising from flammability, toxicity, corrosiveness, leakage or fire exposure are minimized.

7.2 Functional requirements

This section is related to functional requirements 3.2.4 and 3.2.7. In particular, the following should apply:

.1 Chemical treatment fluids should be selected, stored, transferred and handled in a manner that limits hazards arising from their physical and chemical properties, including flammability, toxicity, corrosiveness and reactivity.

.2 Storage tanks, piping systems and associated containment arrangements should be designed, constructed, routed and segregated such that their integrity is maintained under relevant operating and fire-exposure conditions, and the consequences of leakage are minimized.

.3 Leakage, spillage and drainage of chemical treatment fluids should be collected, contained and directed to dedicated systems, preventing the spread of hazardous substances within the ship and enabling timely detection of abnormal conditions.

.4 Monitoring and alarm arrangements should provide timely indication of conditions that may compromise the safe containment of chemical treatment fluids.

.5 Spaces containing chemical treatment fluid storage or handling equipment, should be arranged and ventilated so as to prevent the accumulation of hazardous atmospheres and to enable safe personnel occupation.

7.3 General requirements

7.3.1 The flashpoint of the chemical treatment fluid should be above 60°C. In the case that the chemical treatment fluid has a flashpoint below 60°C or is toxic, the requirements should be decided on a case-by-case basis and as part of the risk assessment.

7.3.2 Arrangements for chemical treatment fluid tank and transfer should be made to allow the replacement and refilling of the fluid, in accordance with the transfer facility procedures and in line with the operating manual of the plant.

7.4 Chemical treatment fluid piping

7.4.1 Piping systems containing chemical treatment fluid and associated process systems, including pumps, and vent exhaust lines, should be designed, constructed and installed in accordance with internationally recognized standards acceptable to the Administration or their recognized organizations, taking into account the design pressure, temperature and physical state of fluid conveyed, including relevant hazards such as causticity, corrosiveness, chemical reactivity and thermal effects, associated with chemical treatment fluids such as aqueous solutions of sodium hydroxide ($NaOH$) or calcium hydroxide ($Ca(OH)_2$).

7.4.2 Pipes and piping systems containing chemical treatment fluid should be constructed of steel or other equivalent materials with a melting point above 925 °C, in order to maintain their integrity under fire exposure. However, downstream of the chemical treatment fluid tank outlet valve, (hereafter referred to as the "tank valve") the use of type-approved plastic piping may be accepted without a fire-endurance test, provided that:

.1 the tank valve is of metal-seated construction; and

.2 the tank valve is arranged as fail-to-closed or with quick closing from a safe location outside the space in the event of fire.

7.4.3 Pipes and piping systems containing chemical treatment fluid should be constructed from materials compatible with the chemical properties of the fluid, or should be protected by an appropriate corrosion-resistant coating.

7.4.4 Chemical treatment fluid piping should not be routed through accommodation spaces, service spaces or control stations.

7.4.5 Arrangements for chemical treatment fluids should ensure that drainage is contained and directed to a dedicated, closed collection system. This collection system should be segregated from the ship's bilge and from drainage systems serving other spaces, including machinery spaces.

7.4.6 Drip trays or coamings should be provided beneath flanges, valves and equipment where leakage may occur and arranged to drain to the collection systems.

7.4.7 Collection tanks should be fitted with level monitoring and alarm arrangements, providing alarm indication at the control location.

7.5 Chemical treatment fluid storage tanks

7.5.1 Where chemical treatment fluid is stored in integral storage tanks, they should be segregated, except on those surfaces bound by shell plating, by cofferdams, void spaces, pump-rooms, empty tanks or other similar spaces so as to not be located adjacent to accommodation, control stations, cargo spaces containing cargoes which react with chemical treatment fluids in a hazardous manner, and any food stores, oil tanks or fresh water tanks. Where a cofferdam is impracticable, alternative arrangements in consideration with risk assessment should be demonstrated.

7.5.3 Chemical treatment fluid storage tanks should be designed and constructed in accordance with internationally recognized standards acceptable to the Administration or their recognized organizations, taking into account the chemical properties and hazards of the fluids carried. The installation of such tanks should be arranged having regard to structural strength and stability considerations of the ship.

7.5.4 Materials used for chemical treatment fluid storage tanks, drip trays and other containment arrangements should be chemically compatible with the fluids handled and capable of maintaining their integrity under the expected operating and fire-exposure conditions, including for alkaline chemical treatment fluids such as aqueous solutions of sodium hydroxide (NaOH) or calcium hydroxide ($Ca(OH)_2$), as applicable.

7.6 Chemical treatment fluid room

7.6.1 The independent chemical treatment fluid storage tanks should be located outside of accommodation spaces, service spaces and control stations, and should not be located forward of the collision bulkhead. The independent chemical treatment fluid storage tank can be located in the CO_2 machinery handling spaces. In this case, the requirement for both spaces should apply.

7.6.2 Spaces where independent chemical treatment fluid storage tanks are located should have a mechanical ventilation of extraction type with at least 6 air changes/hour that is independent from the ventilation system of other spaces. The ventilation system should be capable of being controlled from outside the compartment.

8 INSTRUMENTATION, ALARMS, MONITORING AND CONTROL

8.1 Goal

The goal of this chapter is to ensure that OCCS are provided with adequate instrumentation, monitoring, alarm and control arrangements so that the system can be safely operated, hazardous conditions are detected in due time, and appropriate automatic or manual safety actions can be initiated to protect the ship, its crew and the continued normal operation of the ship.

8.2 Functional requirements

This section is related to functional requirements 3.2.2, 3.2.6, 3.2.7 and 3.2.8. In particular, the following should apply:

.1 Parameters necessary for the safe operation of the OCCS and their supporting systems should be monitored and indicated at appropriate locations.

.2 Operating conditions of critical OCCS components, including CO_2 storage, processing and handling equipment, should be able to be continuously monitored or assessed to ensure operation within intended limits.

.3 Alarm arrangements should provide timely warning of abnormal conditions that may lead to hazardous situations if no action is taken.

.4 Automatic safety actions, including shutdown or isolation of the OCCS or parts thereof, should be initiated where necessary to prevent escalation of hazardous conditions.

.5 Manual means should be provided to initiate safety actions from designated control locations and from locations that allow rapid shutdown prior to evacuation of OCCS-related spaces.

.6 Instrumentation, alarms and indications should be arranged so as to support crew awareness, decision-making and timely response to abnormal conditions.

.7 Where set-points, alarm levels or shutdown thresholds are applied, they should be established in accordance with the design limits of the OCCS and ensure safe operation.

8.3 General provisions

8.3.1 Indications of parameters necessary for the safe and effective operation of the carbon capture and storage system should be provided at the control location.

8.3.2 The required safety actions are given in table 1.

8.3.3 Shutdown systems intended for manual activation from the control location should be provided with means for activation at that location. In addition, manual shutdown activation points should be located adjacent to the exits of the following spaces:

.1 liquefied CO_2 storage tank room for independent tanks located below deck; and

.2 CO_2 machinery handling spaces.

8.3.4 For control and safety system of OCCS installations, the requirements in chapter 13 and paragraph 18.10 of the IGC Code should be taken into account, where applicable.

8.4 Instrumentation of liquefied CO_2 storage tanks

8.4.1 Liquefied CO_2 storage tanks should be fitted with liquid level gauging devices and provided with a high liquid level alarm.

8.4.2 Liquefied CO_2 storage tanks should be provided with devices for indicating cargo temperatures.

8.4.3 The vapour space of each CO_2 storage tank should be provided with a direct-reading gauge for pressure monitoring. In addition, an indirect pressure indication and a high-pressure alarm should be provided at the control location.

8.5 Instrumentation of liquefied CO_2 storage tank room/hold space

8.5.1 Gas detection should be fitted in the liquefied CO_2 storage tank room/hold space, associated airlocks (if fitted), and the ventilation ducts with audible and visible alarms in the control location, based on the following thresholds:

.1 activation of an alarm in case of detection of CO_2 concentration in excess of 1500 ppm; and

.2 initiation of system shutdown in case of detection of CO_2 concentration in excess of 5000 ppm.

8.5.2 Means for detecting any leakage should also be provided.

8.6 Instrumentation of CO_2 machinery handling spaces

8.6.1 Gas detection should be fitted in the liquefied CO_2 machinery handling spaces, associated airlocks (if fitted), and the ventilation ducts with audible and visible alarms in the control location, based on the following thresholds:

.1 activation of an alarm in case of detection of CO_2 concentration in excess of 1500 ppm; and

.2 initiation of system shutdown in case of detection of CO_2 concentration in excess of 5000 ppm.

8.6.2 The absorber and desorber should be provided with temperature monitoring arrangements. In this regard:

.1 temperature should be continuously monitored at locations representative of the operating conditions of the absorber and desorber;

.2 a high-temperature and a low-temperature alarm should be provided for each absorber and desorber;

.3 temperature indication and alarms should be available at the control location; and

.4 alarm set points should be established in accordance with the system design limits and should ensure safe operation of the system.

8.7 Instrumentation of chemical treatment fluid storage tanks

8.7.1 Chemical treatment fluid storage tanks should be fitted with:

.1 a visual and audible high-level alarm which indicates when the liquid level in the tank approaches the normal full condition; and

.2 an overflow-control system which comes into operation when the tank liquid level exceeds the normal full condition, and gives a visual and audible alarm in the engine control room.

8.7.2 Means should be provided for measuring and monitoring the chemical treatment fluid temperature in the tank.

8.7.3 Collection tanks should be fitted with level monitoring and alarm arrangements, providing alarm indication at the control location.

Table.1 Parameter for Indication, alarm and safety functions

Monitoring parameters	Alarm	Alarm activation criteria	OCCS Automatic shutdown activation criteria
CO_2 storage tank			
Tank level[1]	X	H	HH
Tank pressure	X	L	LL
	X	H	
Chemical treatment fluid tank			
Tank level[1]	X	H	HH
Tank temperature	X	H	HH
	X	L	LL
Absorber-desorber system			
Desorber temperature	X	H	HH
	X	L	
Absorber temperature	X	H	
	X	L	
Leak detection	X (CO_2)		X
	X (chemical fluid leak)		
Ventilation loss	X (CO_2 Tank hold space)		X
	X (CO_2 handling space)		X
CO_2 Pipeline pressure	X	L	
Gas detection system[2]	X	H	HH

Notes:

1 The high-level alarm should be activated at a level corresponding to not more than 95% of the loading limit, and the shutdown should be activated at a level corresponding to not more than 98% of the loading limit. For the liquefied CO_2 storage tank, the loading limit should be determined in accordance with the provisions of chapter 15 of the IGC Code.

2 Gas detection alarm and shutdown should be activated at least 1,500 ppm and 5,000 ppm of CO_2, respectively.