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GUIDELINES FOR ONBOARD CARBON CAPTURE SYSTEMS

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Chapter 1 General

1.1 General provisions

1.1.1 This Guidelines is applicable to Onboard Carbon Capture Systems (OISC) installed to reduce CO_2 emissions onboard the ships.

1.1.2 This Guidelines provides the classification requirements for the design, onboard installation and arrangement, control and monitoring, survey and testing, etc. of OISC. The conventional ship systems and/or equipment shared with OISC is to comply with relevant requirements of international conventions, codes, and IS Class (ISC) rules.

1.1.3 This Guidelines applies to OISC using organic amine as decarbonization agent. Special consideration is to be given for the OISC using other types of decarbonization agent or methods.

1.1.4 In addition to the provisions of this Guidelines, OISC is also to comply with the relevant requirements of the Rules for Classification of Sea-going Steel Ships (the ISC Rules) or other applicable rules and the requirements of the competent authorities.

1.2 Functional and objective requirements

1.2.1 This guidelines intends to provide standards for the design, installation and arrangement on board, survey and testing, and operational safety of OISC to minimize the harm that the installation and operation of OISC may cause to ships, crew members and the environment.

1.2.2 To achieve the aforementioned objectives, the design, onboard installation and arrangement of OISC are to meet the following functional requirements:

(1) Applicable to the environmental and working conditions of operations on board the ships;

(2) Effectively handling CO_2 in the exhaust gas of the combustion unit connected to it;

(3) Minimizing the impact of OISC installation and operation on the combustion unit as much as possible, ensuring that the combustion unit can operate continuously and that operating parameters, power output, etc. are always maintained within the design range;

(4) The mechanical properties, chemical composition, manufacturing, and testing of the materials used are to meet the relevant requirements of the Rules for Materials and Welding (the ISC Material Rules), and anti-corrosion measures is to be considered (if applicable);

(5) Preventing the accidental accumulation or diffusion of flammable, explosive, and toxic gases;

(6) Preventing the leakage and diffusion of chemicals such as absorbents;

(7) Preventing damage to crew members or other system equipment caused by high/low temperature, high pressure and operating equipment;

(8) Taking appropriate fire detection, prevention and extinguishing measures in response to potential fire risks;

(9) Considering the impact of the installation and arrangement of OISC on hull structures, stability, load lines, bridge room visibility;

(10) Taking appropriate control, monitoring, and safety protection measures to ensure the safe and reliable operation of OISC;

(11) Facilitating survey, maintenance and renewal of internal parts and components for relevant systems and equipment.

1.3 Definitions and abbreviations

1.3.1 Definitions applicable to this Guidelines are as follows:

(1) Onboard Carbon Capture System means a complete system that uses decarbonization agents to capture CO_2 from the exhaust gas of combustion units on board the ships, generally consisting of absorber unit, desorber unit, CO_2 compression and liquefaction unit, CO_2 storage and unloading system, absorbent circulation system, decarbonization agent storage and supply system, steam heating system, auxiliary system, etc.

(2) Combustion unit means engines, boilers and/or other combustion device (excluding incinerators) that use carbonaceous fuels on board the ships.

(3) Chemical absorption method means a type of method that absorbs CO_2 in the form of a chemical reaction through a chemical absorbent and desorbs CO_2 in the form of a chemical reaction under specific conditions.

(4) Decarbonization agent means various chemical substances that use chemical absorption method to remove CO_2 from the exhaust gas of combustion unit, such as organic amine, calcium oxide, etc., and it refers to organic amine in this Guidelines.

(5) Absorbent means a solution formed by mixing decarbonization agent with water in a certain proportion.

(6) Rich solution means the solution formed by an absorbent after absorbing CO_2 within the absorber unit.

(7) Lean solution means the solution formed by separating CO_2 from a rich solution through a desorber unit.

(8) Absorber unit means a system that captures and absorbs CO_2 from the exhaust gas of combustion unit on board the ships, generally consisting of exhaust cooling units, CO_2 absorption towers, nozzles, additional pipelines, etc.

(9) Desorbor unit means a system that desorbs gaseous CO_2 from a rich solution through heating, generally consisting of a desorption tower, reboiler, nozzles, CO_2 cooling unit, additional pipelines, etc.

(10) OISC residue means the substances separated from the absorbent filters or other residues generated by OISC.

(11) CO_2 compression and liquefaction system means a system composed of compressor, gas-liquid separator, heat exchanger (condenser), etc., used for CO_2 liquefaction.

(12) Exhaust cooling unit means a device that reduces the inlet exhaust temperature of the absorption tower through pre-washing or heat exchange, etc.

(13) Reboiler means a device that uses heat exchange and other methods to reach the desorption temperature again for the rich solution and the Rich solution that has not been fully decomposed and absorbed.

(14) Absorbent circulation system means the one between the absorber unit and desorber unit, generally consisting of absorbent circulation pump, absorbent filter, lean/rich solution heat exchanger, lean solution cooling unit, circulation chamber, pipeline, etc.

(15) Decarbonization agent supply system means the supply system for refueling, storing, and transporting decarbonization agents to the absorbent circulation system, generally consisting of decarbonization agent storage tanks, pumps, valves, decarbonization agent concentration control system, refueling and transportation pipelines, etc.

(16) CO_2 storage and unloading system means the system for storing and unloading liquid CO_2 on board the ship, generally consisting of CO_2 storage tanks and their containment system, CO_2 unloading devices, associated pipelines and control system, etc.

(17) Gas and liquid separator means the equipment used to separate and remove liquid from CO_2 gas.

(18) Triple point means the points at which temperature and pressure are at a thermodunamic equilibrium in which three phases of gas, liquid and solid CO2 exist together.

(19) OISC control station means the space where control, monitoring, alarm, display, safety protection and other devices related to OISC are centrally arranged.

1.3.2 The abbreviations and symbols are explained as follows:

(1) OISC means the onboard carbon capture system.

(2) SCR means the selective catalytic reduction.

(3) EGCS means the exhaust gas cleaning system.

1.4 Class notations

1.4.1 Ships installed with onboard carbon capture system and in compliance with the relevant requirements of Chapters 1 to 8 of this Guidelines are to be assigned with the class notation OISC upon the application and satisfaction survey.

1.4.2 OISC ready ships are to be assigned with class notations OISC Ready 1, OISC Ready 2 or OISC Ready 2 (X) after confirming that the ships are in compliance with the relevant requirements of Chapter 9 of this Guidelines, with the following specific meanings:

(1) OISC Ready 1: design and approval of principle drawings are carried out for OISC ready ship to ensure that the ship is in compliance with the basic requirements for future installation of OISC, and that no equipment or systems related to carbon capture systems have actually been installed on board;

(2) OISC Ready 2: design and approval of detailed drawings are carried out for OISC ready ship to ensure that the OISC ready is in compliance with the relevant requirements of this Guidelines, and that no equipment or systems related to carbon capture systems have actually been installed on board;

(3) OISC Ready 2 (X): on the basis of meeting the requirements of OISC Ready 2, the OISC related equipment and systems have actually been installed on board the ship. The symbol X represents one or more suffixes of class notation, with the following specific meanings:

① The hull structures and related supporting structures have been strengthened, represented by the capital letter S;

② The absorption tower, desorption tower and absorbent circulation system have been installed, represented by the capital letter A;

③ The CO_2 compression and liquefaction system has been installed, represented by the capital letter L;

④ The CO_2 storage tanks have been installed, represented by the capital letter T.

1.5 Plans and information

1.5.1 For ships installed with OISC, in addition to the plans and information required in the relevant requirements of ISC rules and guidelines, the followings are also to be submitted to ISC for approval:

(1) Piping system related to OISC, mainly including:

①Exhaust piping system;

②Cooling water piping system;

③ Absorbent circulation system pipeline;

④ Absorbent purification pipeline (if application);

⑤Steam piping system (if application);

⑥Tank ventilation pipes;

⑦CO_2 compression and liquefaction storage pipeline;

⑧Decarbonization agent supply system pipeline.

(2) Hazardous area divisions (if applicable);

(3) Arrangement of electrical equipment in hazardous areas (if applicable);

(4) Power load calculation sheet;

(5) Arrangement of ventilation;

(6) Detailed list of monitoring, alarms and safety protection;

(7) OISC electrical system;

(8) Gas detection system and arrangement.

1.5.2 For ships installed with OISC, in addition to the plans and information required in the relevant requirements of ISC rules and guidelines, the followings are also to be submitted to ISC for information:

(1) OISC technical description and installation plan, mainly including system design parameters, compatibility with combustion unit, list of systems and equipment, system arrangement plan, CO_2 capture capacity calculation sheet for the system, etc.;

(2) Explanation on the working principle and flowchart of OISC;

(3) Arrangement of OISC system and equipment;

(4) Risk assessment report;

(5) Arrangement of CO_2 storage tanks;

(6) Arrangement of CO_2 unloading system;

(7) OISC operation and maintenance manual;

(8) Decarbonization agent safety data sheet (MSDS), including but not limited to physical and chemical characteristics, first aid measures, fire protection measures, leakage emergency response, operational disposal and storage, personal protective measures, stability and reactivity, toxicological information, etc;

(9) OISC steam consumption calculation sheet (if applicable).

1.5.3 Additional drawings and data are to be required to submit if ISC deems necessary.

1.6 Risk assessment

1.6.1 A necessary risk assessment intends to conduct for eliminating or mitigating all adverse effects arising from the installation of OISC on persons on board, the environment, and the structural strength and integrity of the ship.

1.6.2 The risks are to be analyzed using acceptable and recognized risk analysis techniques, and the followings are to be taken into account:

(1) Adaptability to environmental and working conditions;

(2) Impact on the safe operation of combustion unit and power plant;

(3) Accidental accumulation or diffusion of flammable, explosive, and toxic gases;

(4) Leakage and diffusion of chemical substances;
(5) Possible injuries to crew members or other equipment caused by high/low temperature, high pressure, and operating equipment;
(6) Potential fire risks;
(7) The CO_2 suffocation risk.
1.6.3 In general, the risk assessment report is to address the following contents:
(1) Standards and methods used for risk analysis;
(2) Various assumptions and prerequisites provided during analysis;
(3) Analyzing objects such as system, equipment, operation, etc;
(4) Possible risks;
(5) Causes for risks;
(6) Potential impact of risks;
(7) Measures taken to prevent or mitigate risks and hazards and the implementation.

1.7 Operation and maintenance manual

1.7.1 OISC operation and maintenance manual that has been reviewed by ISC is to be available on board the ship. The manual is to address operation, safety, maintenance requirements, and occupational health risks related to the system.
1.7.2 The manual is to include the followings, as a minimum:
(1) Procedures and plans related to OISC operation, survey, testing and maintenance;
(2) Procedures and plans related to regular testing and maintenance of detection system and safety shutdown system;
(3) Special instructions on refueling, storage, and use of hazardous and non-hazardous chemicals intended for system operation;
(4) Various conditions related to system operation, etc;
(5) Emergency handling procedures, such as operating procedures for emergency shutdown, exhaust bypass and isolation, absorbent leakage, CO_2 leakage, emergency cleaning, ventilation and protection, as well as the arrangement for responsible personnel, etc.;
(6) Training and routine maintenance records, etc.

Chapter 2 Design and Arrangement

2.1 General provisions

2.1.1 The OISC is to be designed and arranged to meet the followings:

(1) The system design is to be applicable to the operating environment onboard the ship;

(2) The strength and tightness design of the system are to meet the required fluid characteristics for processing;

(3) The system is to have redundant safety and protection measures and the capability to prevent and handle unexpected events.

2.1.2 Ductility, corrosion resistance and possibility of hazardous reactions under working temperature and pressure are to be taken into account for the main equipment and associated piping materials of OISC. Material that directly contact with absorbent is to be compatible with it, or appropriate anti-corrosion coating is to be used. The materials (including coatings) used for equipment, pipelines and components in contact with seawater are to be harmless to marine organisms.

2.1.3 The CO_2 storage, pressure release, control and monitoring system are to be designed to take into account the composition, moisture content, expected impurities of liquid CO_2 and respective impact on the triple point of CO_2 .

2.1.4 Where other exhaust gas post-treatment units (such as EGCS, SCR) are installed, their compatibility with OISC are to be considered.

2.1.5 The structural design and arrangement of OISC are to facilitate for installation, operation and maintenance.

2.2 Ship arrangement

2.2.1 The CO_2 storage tank space is to be isolated from the machinery space, accommodation spaces, service space, control station, cable locker, domestic water tank and storage tank by means of cofferdam tank, oil fuel tank or bulkhead meeting with the airtightness requirement of A-0 class division.

2.2.2 Sealing device is to be provided in way of the openings for CO_2 cargo containment system on the open deck.

2.2.3 In order to prevent CO_2 from entering accommodation space, service space, machinery space, control station, etc., the impacts of CO_2 pipeline, CO_2 storage tank ventilation system and exhaust gas emitted by gas combustion unit in the machinery space on the aforementioned spaces are to be considered when determining the positions of air inlet/outlet and openings in these spaces.

2.2.4 All air inlets, outlets, and other openings in accommodation space, service space and control station (excluding CO_2 storage areas) are to be provided with shut-off devices. The devices are to be capable of operating both externally and internally in these spaces that are frequently accessed with a risk of CO_2 entry.

2.2.5 Proper ventilation is to be provided in the space where the CO_2 compression and liquefaction equipment is located. Where the equipment is arranged in a separate compartment, the common bulkheads between the compartment and other enclosed spaces such as machinery space, accommodation space, service space and control station are to be kept airtight and are not to be directly entered from the aforementioned spaces.

2.2.6 The machinery space serving for CO_2 storage and unloading is to be so arranged to allow personnel wearing protective clothing and respirators to enter and exit safely and unobstructed, and to promptly rescue injured personnel in the event of injury. At least two escape routes and doors away from each other are to be provided within the machinery space. Single escape route is not acceptable unless the maximum distance from any point to the door within the space is less than or equal to 5 m.

2.2.7 All valves required for CO_2 unloading are to be accessible and operated by personnel wearing protective clothing. Drainage devices that are not directly connected to other spaces are to be provided in the spaces where CO_2 compression and liquefaction equipment and storage tanks are located.

2.2.8 Access is to be provided for inspecting the insulation of CO_2 storage tanks.

2.2.9 The CO_2 storage spaces and void compartments are to be arranged to allow personnel wearing breathing apparatus to enter these spaces for inspection, and allow the injured and/or unconscious personnel to evacuate.

2.2.10 Requirements for arrangement of CO_2 storage tanks:

(1) Where the CO_2 storage tanks are arranged on the open deck, the impacts on the bridge room visibility and the safety access for crew members are to be considered;

(2) Where the CO_2 storage tanks are arranged below the open deck, suitable drainage devices that are not connected to the machinery space are to be provided in the storage space and leakage detectors are to be provided;

(3) The location of CO_2 storage tanks is to be so arranged to reduce the probability of damage of the tanks in the event of minor ship collision damage to the minimum level.

2.2.11 Drip trays are to be provided at locations where liquid CO_2 may leak, and monitoring and alarms are also to be provided.

2.3 Strength and stability

2.3.1 Ships installed with OISC are to meet the applicable requirements of longitudinal strength and local strength specified in the ISC Rules.

2.3.2 The structural strength evaluation of CO_2 storage tanks and their supporting structures is to meet the applicable requirements of Appendix 2, Chapter A4, PART TWO in the Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (the ISC Rules for Liquefied Gases in Bulk). For independent C-type twin and/or triple tanks, the applicable requirements of Appendix 3, Section 5 of the ISC Rules for Liquefied Gases in Bulk are also to be met.

2.3.3 Impacts of wind area, empty ship center of gravity, heel and trim on hull stability and number of outfittings, as well as the potential impacts of changes in tonnage on the applicable statutory standards are to be taken into consideration for the ships installed with OISC.

2.3.4 The impact of the weight and center of gravity changes of CO_2 captured during the navigation on hull stability is to be taken into account.

2.4 Compatibility with combustion unit

2.4.1 OISC is to be applicable to the flow volume, temperature, back pressure, SO_x concentration, particle size, etc. of the exhaust gas from combustion unit connected, and treatment of partial

volume of the exhaust gas is permitted. The relevant operation conditions, restrictions, exhaust gas treatment capacity, etc. are to be clearly specified in the operation manual.

2.4.2 OISC is to be compatible with the connected combustion unit, and the relevant technical specifications are to be submitted for review.

2.5 Exhaust gas back pressure

2.5.1 After OISC is installed onboard a ship, the exhaust gas back pressure is always to be maintained within the range specified by the combustion unit manufacturer under various operating conditions.

2.5.2 Where a fan is installed to maintain the required back pressure, measures are to be taken to ensure that even if the fan fails, the connected combustion unit can still normally operate. In the case of multiple combustion units sharing a common OISC, the fan is to be provided by the consideration of back pressure requirements of all connected combustion units.

2.5.3 Appropriate measures are to be taken to reduce the risk of corrosion and blockage affecting the normal operation of fans (if provided).

2.6 Exhaust bypass or equivalent measures

2.6.1 The OISC system is to be designed and arranged to ensure that the combustion units can still operate normally in the event of its failure or normal shutdown.

2.6.2 For the purpose of the achievement of the objective specified in 2.6.1 of this Guidelines, the bypass device are provided to meet the following requirements:

(1) Means are provided in local and remote control position to correctly indicate the working conditions;

(2) Reliable operation, ensuring the safe operation of the combustion unit under any circumstances;

(3) A safety interlock device is to be provided between the bypass valve and the relevant inlet valve of the OISC absorber unit to ensure that the exhaust gas of combustion unit can be smoothly emitted under any circumstances;

(4) The actions are to be automatically initiated according to the requirements of Table 7.2.4 in Chapter 7 of this Guidelines.

2.6.3 Where a bypass is not provided for the OISC system, it is to be ensured that even washwater sprinkling is stopped within the OISC absorber unit, high temperature exhaust gas generated by the FOCU can also be emitted smoothly without causing damages to the OISC system and its components or affecting the continuous safe operation of the FOCU. Under such circumstance, the design of the OISC system is to fully consider risks such as the fire, soot accumulation and carbonization due to direct erosion of the high temperature exhaust gas and appropriate measures are to be taken to control such risks.

2.7 Interconnections of exhaust gas piping

2.7.1 Normally, exhaust pipes from FOCUs are to be routed separately and not interconnected. However, interconnected exhaust piping systems to a common OISC unit may be accepted subject to the agreement of ISC if the designer takes full consideration of the potential risks and makes effective isolation arrangements preventing the exhaust gas from flowing back or leaking to the stopped FOCU(s) or other spaces.

2.7.2 A safety interlock device is to be provided between the starting device and the isolation device for remotely controlled or automatically started FOCU(s) to prevent the isolated FOCU(s) from being started when the isolation device is in the closed condition.

2.7.3 The isolation device is to work reliably and failure of the isolation device under any circumstances is to ensure the safe operation of the FOCU(s).

2.8 Electrical installations

2.8.1 The electrical load of OISC is to be included in the global ship electrical load estimation, which can be included in the "Electrical Load Estimation of Main and Emergency Power Supply" required to be submitted for approval in 1.1.3.1, Chapter 1 of PART FOUR in the ISC Rules. The capacity of the main power supply on board the ship is to enable the continuous operation of the OISC system during normal navigation, and is also to meet the requirements of 2.1.1.1, Chapter 2 of PART FOUR in the ISC Rules.

2.8.2 The selection of enclosure protection type for electrical equipment related to OISC is to be suitable for the installation location, and its minimum protection grade is to meet the requirements of Table 1.3.2.2, Chapter 1 of PART FOUR in the ISC Rules.

2.8.3 All feeder circuits are to be protected against overload and short circuits by a multi-pole circuit breaker arranged to interrupt simultaneously all insulated poles, or a multi-pole switch with fuses, and are also to meet the requirements of 2.5.9, Chapter 2 of PART FOUR in the ISC Rules.

2.8.4 In addition to the provisions of 2.8.1 ~ 2.8.3 in this Guidelines, the OISC electrical equipment is to comply with the applicable requirements of Chapter 2 of PART FOUR in the ISC Rules.

2.9 Explosion protection

2.9.1 A safety data sheet for decarbonization agents are to be provided. Where the decarbonization agents emit flammable and explosive gases, hazardous areas are to be classified in accordance with the requirements of IEC6007-10-1 "Explosive atmospheres - Classification of areas - Explosive gas atmospheres" and IEC60079-502 "Electrical installations in ships - Tankers - Special features".

2.9.2 For electrical equipment installed in hazardous areas, the appropriate certified explosion-proof equipment is to be selected in accordance with the category of hazardous areas, and the explosion group and temperature class are to meet the safety data sheet of CO_2 absorbents.

Chapter 3 CO_2 Absorption and Desorption

3.1 General provisions

3.1.1 This Chapter applies to the design and application of systems and equipment related to CO_2 absorption and desorption (the systems and equipment) onboard the ships.

3.1.2 The operation conditions of the system and equipment are to meet the applicable requirements of Section 2, Chapter1 of PART THREE, Section 2, Chapter 1 of PART FOUR and Section 1, Chapter 2 of PART SEVEN in the ISC Rules.

3.1.3 The materials of the system and equipment are to meet the applicable requirements of the ISC Material Rules, and directly or indirectly (through appropriate protective measures such as coatings and linings) applicable to the characteristics of the working medium under predictable temperature and/or pressure conditions.

3.1.4 The pressure vessels and heat exchangers inside the system and equipment are to meet the applicable requirements of Chapter 6 of PART THREE in the ISC Rules.

3.1.5 The system and equipment are to be provided with protective measures in accordance with the applicable requirements of 1.3.6, Chapter 1 or PART THREE in the ISC Rules.

3.1.6 Absorbent leakage monitoring and alarm are to be provided.

3.1.7 In case there is significant risk of fire and/or toxicity after the leakage of absorbent, special consideration is to be given to on the system and equipment arrangement on board the ship, ventilation of spaces and safety measures.

3.2 Absorber unit

3.2.1 The absober unit is to be considered as a constituent part of the combustion unit exhaust gas system.

3.2.2 Unless effective measure, such as bypass device, is provided to prevent overheating, all components, that may contact with exhaust gas, are to enable withstanding all possible exhaust gas high temperatures.

3.2.3 The components in contact with lean solution or rich solution are to be made of corrosion-resistant stainless steel or other corrosion-resistant materials, and are to enable withstanding the pH and temperature changes of lean solution or lean solution and other media that may contact with.

3.2.4 Exhaust cooling units

(1) Capable of meeting the exhaust gas cooling capacity requirements under the maximum working load of CO_2 absorption tower, and adjusting the exhaust output temperatures to meet the settings of CO_2 absorption tower;

(2) Pressure and temperature monitoring and alarms are to be provided on its exhaust gas inlets and outlets according to Table 7.2.4 of this Guidelines;

(3) Where the exhaust gas outlet temperature exceeds the setting, the associated safety action is to be activated according to the requirements of Table 7.2.4 of this Guidelines, unless the absorption tower can withstand the expected high temperature effect of the exhaust gas;

(4) The cooling water discharge of cleaning type exhaust gas cooling unit is to meet the relevant requirements of 2.6, Chapter 2 in the Guidelines for Application of Exhaust Gas Recirculation (EGR) Systems Onboard Ships.

3.2.5 Absorption tower

(1) The absorption tower and its internal structures are to be designed by taking consideration of corrosion, flushing, backflow, leakage, etc;

(2) The exhaust gas inlet or its pipeline is to be so designed to prevent liquid backflow from the tower into external exhaust gas inlet pipeline, and the appropriate liquid level monitoring may be provided for this purpose;

(3) Pressure and temperature monitoring and alarms are to be provided according to Table 7.2.4 of this Guidelines, and if necessary, associated safety actions are to be activated;

(4) Necessary measures are to be taken to separate the gas and liquid;

(5) Measures are to be taken to monitor the absorption effect, such as monitoring the difference of CO_2 concentrations of the exhaust gas before and after passing through the absorption tower;

(6) Liquid level monitoring and alarm are to be provided according to Table 7.2.4 of this Guidelines, and the alarm points are to be provided by taking the consideration of the angles of heeling, trim, rolling and pitch during the ship operation; If necessary, associated safety actions are to be activated;

(7) The absorbent nozzles are to be designed and arranged to take account of the risks of scaling and blockage, and if necessary, appropriate flushing measures are to be taken;

(8) Suitable manholes/inspection holes, accesses or platforms are to be provided, and spaces are to be left around the absorption tower for parts and components renewal, maintenance, and cleaning.

3.2.6 The absorption tower and its hull support structures are to enable withstanding various loads under normal ship operating conditions.

3.3 Absorbent circulation system

3.3.1 An absorbent circulation tank with appropriate capacity or other equivalent measures is to be provided, and it is to meet the following requirements:

(1) The tank capacity is at least to meet the expected longest continuous operating duration of OISC;

(2) Temperature and liquid level monitoring and alarms are to be provided according to Table 7.2.4 of this Guidelines;

(3) The lean solution circulation tank is to be provided with absorbent condition monitoring (such as pH value).

3.3.2 An absorbent circulation pump with a capacity meeting the absorbent circulation requirements under the maximum load of the OISC system is to be provided.

3.3.3 Where a gravity type is used, the absorbent pipeline from absorption tower/desorption tower to absorbent circulation tank is to be so arranged to facilitate for gravity discharge, taking the consideration of the alarming liquid level of the absorption tower/desorption tower, gas escape and siphon effect.

3.3.4 Absorbent filters or equivalent measures are to be provided for the rich solution circulation or treatment pipelines, and the filtered residues are to be discharged into the OISC residue tank.

3.3.5 OISC residue tank：

(1) The tank capacity is to meet the maximum residue generated by the absorbent filters during the expected longest operating duration of OISC;

(2) High liquid level alarms are to be provided;

(3) Residue discharge pumps and shore pipelines are to be provided.

3.3.6 Both the absorbent circulation tank and OISC residue tank are to be provided with appropriate cleaning and discharging measures.

3.3.7 The air pipes of the absorbent circulation tank and OISC residue tank are to meet the requirements of 4.2.5 and 4.2.6 of this Guidelines.

3.3.8 Necessary degassing and ventilation are to be provided for absorbent circulation tanks and OISC residue tanks that need internal maintenance.

3.3.9 Drip tray is to be provided at the possible leakage location in the absorbent circulation system. Discharging device is to be provided for drip tray so that the absorbents can be discharged to OISC residue tank, and check valve is to be fitted on the discharge pipeline.

3.3.10 Check devices are to be provided on the fresh water supply pipelines leading to tanks and processing equipment containing absorbents.

3.3.11 The lean/rich solution heat exchanger and lean solution cooling unit are to be provided with temperature and pressure monitoring and alarms according to Table 7.2.4 of this Guidelines.

3.4 Desorber unit

3.4.1 All components of the desorber unit are to unable withstanding all possible high temperatures.

3.4.2 The components in contact with lean or Rich solutions are to be made of corrosion-resistant stainless steel or other corrosion-resistant materials, and are to enable withstanding the pH and temperature changes of lean or rich solution and other media that may contact with.

3.4.3 Desorption tower

(1) The desorption tower and its internal structures are to be designed by taking consideration of corrosion, flushing, backflow, leakage, etc;

(2) Temperature, liquid level and pressure monitoring and alarms are to be provided according to Table 7.2.4 of this Guidelines, and the alarm points for liquid level are to be provided by taking the consideration of the angles of heeling, trim, rolling and pitch during the ship operation;

(3) The absorbent nozzles are to be designed and arranged to take account of the risks of scaling and blockage, and if necessary, appropriate flushing measures are to be taken;

(4) Suitable manholes/inspection holes, accesses or platforms are to be provided, and spaces are to be left around the desorption tower for parts and components renewal, maintenance, and cleaning.

3.4.4 Reboiler

(1) Temperature and pressure monitoring is to be provided for the absorbent and heating medium pipelines between the reboiler and desorption tower according to Table 7.2.4 of this Guidelines;

(2) The effect of heating temperature on the volatility of the absorbent is to be taken into consideration.

3.4.5 CO_2 cooling unit and gas-liquid separator are generally to be provided on the gas treatment pipeline after the desorption tower.

3.5 Cooling water system

3.5.1 The cooling water system (used for exhaust gas cooling unit, lean solution cooling unit, CO_2 cooling unit, etc.) are to meet the applicable requirements of PART THREE in the ISC Rules.

3.5.2 The capacity of cooling water pump is to meet the cooling water demand of OISC at maximum working load, and not to affect the cooling water demand of critical systems such as propulsion.

3.6 Piping system

3.6.1 The piping system is to be designed to meet the applicable requirements of PART THREE in the ISC Rules.

3.6.2 Unless a clear difference between the absorbent and decarbonization agent is provided, the design of piping system related to absorbent is also to meet the applicable requirements of that related to decarbonizaiton agent specified in Chapter 4 of this Guidelines.

Chapter 4 Decarbonization Agent Supply System

4.1 General provisions

4.1.1 The material, design, installation and arrangement, etc. of the decarbonization agent supply system (including pipelines, valves, joints) are to meet the applicable requirements of Chapters 1 and 2 of PART THREE in the ISC Rules.

4.1.2 Pipelines and tanks related to filling, storage, transportation and treatment of decarbonization agents, as well as any other components that may contact with decarbonization agents, are to be made of corrosion-resistant stainless steel materials or other corrosion-resistant materials that can withstand acid and alkali corrosion of the medium which may be contacted with.

4.1.3 The decarbonization agent supply pipelines are to be independent of other piping systems on board and not to be provided in or pass through the accommodation spaces, service spaces, and control stations.

4.1.4 The decarbonization agent supply pipelines are not to be arranged above the boiler or near steam piping, exhaust piping or hot surfaces requiring insulation.

4.1.5 Drip trays are to be provided for decarbonization agent storage and supply pipeline at the possible leakage locations to accommodate the leaked agent.

4.1.6 Discharge device is to be provided for the drip tray to discharge the decarbonization agent in the tray to the overflow tank or other suitable tanks (such as OISC residue tank), and a check valve is to be fitted on the discharge pipeline. Alternatively, a leakage monitoring device and a quick-closing valve are to be provided to quickly and automatically cut off the decarbonization agent transportation in the case of leakage. When this arrangement is used, the capacity of the drip tray is to be sufficient to accommodate the possible leakage.

4.1.7 Appropriate protective measures are to be taken in accordance with the requirements of 1.3.6, Chapter 1 of PART THREE in the ISC Rules to prevent potential harm to personnel onboard during the filling and maintenance of decarbonization agent storage tanks.

4.2 Storage of decarbonization agent

4.2.1 The capacity of decarbonization agent storage tank is to be so designed to at least meet the decarbonization agent consumption required for the maximum navigation duration between ports where the decarbonization agent may be filled by taking the consideration of the factors such as intended ship route, CO_2 capture capacity per time unit, decarbonization agent consumption rate, etc. If no accurate data of navigation duration are provided, it may be calculated as 30 days.

4.2.2 The decarbonization agent storage tanks are to be far away from heat sources, arranged in a well ventilated area, and not to be directly adjacent to the fuel tanks and fresh water tanks.

4.2.3 Where a decarbonization agent storage tank is arranged in an independent enclosed compartment, airtight bulkheads are to be used for isolation to prevent leaked decarbonization agents from entering other compartments. The bulkheads of the tank can be used for penetrating cables and piping systems, and are also to meet the requirements of airtightness structure. The distance between the bulkhead and the shell plating of hull is not to be less than 760mm.

4.2.4 The compartment where the decarbonization agent storage tank is located is to be provided with a negative pressure mechanical ventilation system independent of other spaces onboard the ship, with the air changes not less than 30 times per hour. The outlet of ventilation system is to be

generally arranged in accordance with the decarbonization agent safety data sheet (MSDS).

4.2.5 Air pipes are to be fitted with for decarbonization agent storage tank in accordance with the requirements of Section 10, Chapter 3 of PART THREE in the ISC Rules. The outlets of air pipes are to be located in a safe area on the open deck and not easily accessible to personnel, and effective measures are to be taken to prevent water from entering the tank. The air pipes are to be independent of other piping or systems onboard the ship.

4.2.6 The air pipe outlet positions in the decarbonization agent storage tank are to meet the following requirements:

(1) At least 6 m above the open deck;

(2) 10 m distanced from the inlets and openings of the nearest accommodation spaces, service spaces and control stations.

4.2.7 The decarbonization agent tank, pipeline/piping system are to be made of steel or other equivalent materials with a melting point higher than 925 ℃.

4.2.8 The ventilation requirements in 4.2.4 of this Guidelines are also applicable to the adjacent enclosed compartments that are usually manned:

(1) Where it is adjacent to the compartment where the decarbonization agent tank is located, with potential leakage points from that compartment (such as manholes, connectors); or

(2) Where the decarbonization agent transporting system passes through these compartments, the ventilation system specified in 4.2.4 of this Guidelines is not to be provided, unless the transporting system is made of steel or other equivalent materials with a melting point higher than 925 ℃ and has fully welded joints.

4.2.9 Excessively high or low temperatures may affect the performance of decarbonization agent. Necessary heating and/or cooling systems are to be provided to decarbonization agent storage tanks based on the ship navigation routes or operating areas, as well as the storage temperature range of decarbonization agent.

4.2.10 Where the pipeline leading from the decarbonization agent storage tank is damaged and causes the decarbonization agent to flow out, a quick closing valve is to be provided to the rigid duct on the bulkhead of storage tank, and the length of the rigid duct is to meet the applicable requirements of 4.2.5.2 of PART THREE in the ISC Rules. In addition to being capable of closing locally, the quick closing valve is also to be remotely closed in a safe location that is easily accessible outside the storage tank.

4.2.11 The decarbonization agent storage tank is to be so arranged to empty the decarbonization agent inside the tank and degassing the tank through a portable or fixed system.

4.2.12 The entrance/access of the compartment where the decarbonization agent storage tank is located is to meet the following requirements:

(1) At least two entrance/access doors are to be provided and arranged as far apart as possible. At least one entrance/access door is directly to lead to the open deck; Access doors that do not directly lead to the open deck is to be airtight and self closing;

(2) The access doors are to be easy to operate and open outward;

(3) The access is not to be directly connected to that of the accommodation space.

4.2.13 The compartment where the decarbonization agent storage tank is located is to be provided with an independent bilge water discharge system to ensure that these bilge water does not flow into the open bilge well or the bilge water system of other compartments.

4.2.14 The air pipes, filling pipes, measuring pipes and transportation pipelines of the

decarbonization agent storage tank are not to pass through accommodation spaces, service spaces and control stations, unless reliable leak prevention measures are taken, such as double-wall pipes are used for protection.

4.2.15 According to the parameters of decarbonization agent safety data sheet (MSDS), a set of fixed combustible and/or toxic gas detection system (if applicable) is to be provided in each compartment where decarbonization agent storage tank is located.

4.2.16 In addition to emergency lighting, the lighting in the compartment where the decarbonization agent storage tank is located is to be interlocked with ventilation, and the ventilation system is to start when the lighting is turned on. The failure of the ventilation system is not to turn off the lighting.

4.3 Filling of decarbonization agent

4.3.1 The filling open ends of decarbonization agent is to be located on the open deck and provided with relevant closing valves and blind flanges. The filling open ends and filling pipelines located on the open deck are to be identified. Drip trays are to be provided at the filling open ends or other possible leakage locations.

4.3.2 The filling pipeline of decarbonization agent is to be arranged above the decarbonization agent storage tank and as close as possible to the decarbonization agent storage tank. The decarbonization agent filling pipeline and its arrangements are to be reasonably designed to prevent the decarbornization agent from staying in the filling pipeline after use or when not in use.

4.4 Filter

4.4.1 To reduce the damage of impurities to valves and other critical components of the decarbonization agent supply system, filters are to be installed in the decarbonization agent supply system.

4.4.2 The design pressure of the filter is to be greater than the maximum working pressure of the decarbonization agent supply system.

4.5 Decarbonization agent overflow tank

4.5.1 The decarbonization agent overflow tank is to be arranged below the decarbonization agent storage tank to collect the overflow decarbonization agent after filling.

4.5.2 The decarbonization agent in the overflow tank is not to be discharged overboard without treatment.

4.5.3 The air pipes of the overflow tank can be connected to the air pipeline of the decarbonization agent storage tank.

4.5.4 For the convenience of maintenance, it is necessary to temporarily remove the decarbonization agent from the decarbonization agent supply piping system. A decarbonization agent discharge pipeline is to be provided between the bottom of decarbonization agent transportation pipeline and the decarbonization agent overflow tank, and a shut-off valve is to be installed. The capacity of the decarbonization agent overflow tank is to be sufficient to accommodate the maximum decarbonization agent stored in the transportation pipeline between the main valve of the decarbonization agent storage tank and absorbent circulation system.

4.6 Protection measures

4.6.1 Relevant safety instructions, including MSDS for decarbonization agents, is to be posted near to the entrance of the compartment where the decarbonization agent storage tank is located.

4.6.2 To protect crew members, appropriate protective equipment (including aprons, long sleeved rubber gloves, rubber boots, overall made of chemical-resistant materials, masks, chemical-resistant goggles or masks) are to be equipped onboard the ship. At least three sets of protective equipment are to be provided onboard the ship, and these equipment are to be stored in the dedicated storage tanks that is easily accessible outside the accommodation space.

4.6.3 At least the following emergency equipment are to be provided inside the dedicated storage tanks that is easily accessible outside the decarbonization agent storage tank:

(1) Self-contained breathing apparatus (capable of supplying for at least 30 minutes), 3 sets;

(2) Eye wash solution, 3 boxes;

(3) Boric acid, 250ml/bottle, 3 bottles;

(4) Stretcher, 1 pair.

4.6.4 Eye flushing device and shower facilities are to be provided near the main filling decarbonization agent pipes and pumps.

Chapter 5 CO_2 Compression and Liquefaction

5.1 General provisions

5.1.1 This Chapter applies to the arrangement and design of CO_2 compression and liquefaction systems onboard the ships.

5.1.2 CO_2 pressure vessels are to meet the requirements of Chapter 6 of PART THREE in the ISC Rules. The CO_2 pressure vessels mentioned in this Chapter include surge tanks, heat exchangers and pressure accumulators for processing liquid or gaseous CO_2.

5.1.3 The requirements for C-type independent liquid cargo tanks in Chapter 4 of PART THREE in the ISC Rules for Liquefied Gases in Bulk can be applied to liquid CO_2 pressure vessels.

5.1.4 The CO_2 pipeline is to meet the applicable requirements of Chapter 5 of the ISC Rules for Liquefied Gases in Bulk, and the liquid and gaseous CO_2 pipeline is also to meet the Grade I pipeline requirements of Chapter 2 of PART THREE in the ISC Rules.

5.1.5 The CO_2 compression and liquefaction system and equipment are to be arranged to meet the requirements of 2.2.5 in this Guidelines. Where a liquid CO_2 storage tank is provided in the liquefaction unit, the unit is also to be arranged in accordance with the relevant CO_2 storage tank requirements of 2.2 of this Guidelines.

5.1.6 Drip trays are to be provided at possible liquid CO_2 leakage locations and leakage monitoring and alarm are to be provided.

5.1.7 The CO_2 compression and liquefaction systems are to be designed to take into consideration the following factors:

(1) Preventing the leakage of gaseous and liquid CO_2 caused by abnormal conditions;

(2) Suffocation risk for personnel exposed to high CO_2 concentration environments;

(3) Low-temperature impact of liquid CO_2 leakage on the hull, equipment and personnel.

5.2 Compression and liquefaction

5.2.1 The processing capacity of the compression and liquefaction systems are to meet the CO_2 compression and liquefaction requirements under the maximum working load of OISC.

5.2.2 Necessary gas-liquid separators (such as separating absorbents, water, oil, etc.) are to be provided.

5.2.3 In general, surge tank is to be provided in front of the compressors. Where a two-stage process of compression and heat-exchanging liquefaction is used, surge tank is generally also to be provided between the compressors and the liquefaction unit.

5.2.4 The surge tank is to be provided with temperature and pressure monitoring and alarm in accordance with Table 7.2.4 of this Guidelines.

5.2.5 The enclosed space where compression and liquefaction equipment are located is to be equipped with CO_2 and O_2 concentration monitoring and alarm in accordance with Table 7.2.4 of this Guidelines for the space where CO_2 storage tanks are located.

5.3 Piping system

5.3.1 The CO_2 pipelines are not to pass through the accommodation spaces, service spaces and control stations.

5.3.2 Except for the connections of equipment, valves, and instrument accessories, CO_2 pipelines are to be connected by welding as much as possible.

5.3.3 The effects of temperature stress are to be taken into consideration for the liquid CO_2 pipeline and its supporting.

5.3.4 The liquid CO_2 pipelines are to be provided with necessary safety relief devices with its outlet led to the areas on open deck.

5.3.5 The liquid CO_2 pipelines are to be be wrapped with thermal insulation.

5.4 Ventilation

5.4.1 The ventilation of the enclosed space, where the CO_2 compression and liquefaction equipment is located, is to meet the relevant requirements of 6.3.2 of this Guidelines.

Chapter 6 CO_2 Storage and Unloading

6.1 General provisions

6.1.1 In addition to the provisions of this Chapter, CO_2 storage and unloading are to meet the relevant requirements of ports and competent authorities.

6.1.2 The pressure and temperature of CO_2 storage tanks are to be maintained during the CO_2 storage and unloading to prevent the impact of pressure-loss solidification on the hull structures and the harm of overpressure gasification leakage to personnel.

6.2 Containment system of CO_2 storage tanks

6.2.1 The integral cargo tanks, membrane/semi-membrane cargo tanks, or Type A/Tape B diamond-shaped independent cargo tanks are not to be used as CO_2 storage tanks.

6.2.2 The containment system of CO_2 storage tanks is to meet the requirements of Section 6, Appendix 4 of PART TWO in the ISC Rules for Liquefied Gases in Bulk.

6.2.3 The triple point is to be determined based on the captured CO_2 purity. The design temperature and pressure of CO_2 storage tanks is to be fully considered the triple points with sufficient operation margins.

6.3 Ventilation system

6.3.1 Spaces that frequently access during the CO_2 unloading are to meet the following requirements:

(1) The electric engine room, CO_2 compressor room and pump room, spaces equipped with CO_2 handling devices and other enclosed spaces where CO_2 may accumulate, are to be provided with fixed mechanical systems that can be controlled outside the aforementioned spaces. A warning notice requiring the use of such ventilation before entering the compartment is to be provided outside these spaces.Failure of the ventilation system[①] is to give an audible and visual alarm in the manned spaces during the CO_2 handling operations and the aforementioned compartments requiring ventilation;

(2) The inlets and outlets of mechanical ventilation are to be arranged to ensure sufficient air flow through the areas to avoid the CO_2 accumulation. The ventilation inlets are to be located at the bottom and the outlets are to be located at the top, taking the consideration of the CO_2 density;

(3) The ventilation systems are to provide not less than 30 air changes per hour, and 8 air changes per hour for the CO_2 control room that is not located in the hazardous area;

(4) In the case of failure of any fans for the ventilation system, full ventilation flow rate as required in 6.3.1(3) is still to be provided in each space, or spare parts consisting of electric motor, starting parts and complete rotating components (including various bearings) are to be provided.

6.3.2 Spaces that not frequently access are to meet the following requirements:

(1) Enclosed spaces that may accumulate CO_2 are to be capable of ventilation to ensure a safe environment for entering;

(2) The ventilation systems are to be capable of using before and during entry;

(3) The fixed ventilation systems are to provide 8 air changes per hour and the portable ventilation

[①] Ventilation failure alarm can be given by the means of fan operation monitoring or the ventilation flow rate of the space.

systems are to provide 16 air changes per hour. Details of type, quantity, arrangement and accessories of the portable mechanical ventilation fans are to be provided.

6.4 CO_2 unloading

6.4.1 For crew members engaged in CO_2 unloading operations, personnel protection is to meet the requirements of 4.4.2, Section 4, Appendix 4 of PART TWO in the ISC Rules for Liquefied Gases in Bulk.

6.4.2 Where the CO_2 unloading devices are located at the stem or stern of the ship, the ship is to be arranged to meet the requirements of 4.1.4 (8), Section 4, Appendix 4 of PART TWO in the ISC Rules for Liquefied Gases in Bulk. Windows and side scuttles on the end bulkheads of the superstructure or deck room within the aforementioned areas are to be rapid closed and effective airtightness.

6.5 Monitoring and alarm of CO_2 storage tanks

6.5.1 Each CO_2 storage tank is to be provided with a device showing the CO_2 level, pressure and temperature. Pressure gauges and temperature indicators are to be installed in liquid and gas piping systems as well as refrigeration devices.

6.5.2 All remote control devices and indicators related to CO_2 storage tanks are to be centralized at the OISC control station.

6.5.3 Level measurement

(1) Each CO_2 storage tank is to be fitted with liquid level gauging device, arranged to ensure that a level reading is always obtainable whenever the CO_2 storage tank is operational. The device is to be so designed to operate throughout the design pressure range of the CO_2 storage tank and at temperatures within the CO_2 operating temperature range.

(2) Where only one level gauge is installed, it is to be so arranged to maintain in operation without the need to empty or degass the storage tank. When the storage tank is in operation, any components of the level gauge (excluding passive components) can be maintained and repaired. Passive components are those assumed without failure under normal working conditions;

(3) The liquid level gauge can be an indirect, enclosed or restricted device, as shown in 13.2.3, Chapter 13, of PART THREE in the ISC Rules for Liquefied Gases in Bulk;

(4) The level gauge containing CO_2 installed outside the CO_2 storage tank is to be so arranged to provide isolation in case of failure.

6.5.4 Overflow control

(1) Each CO_2 storage tank is to be fitted with a high liquid level alarm device operating independently of other liquid level indicators and giving an audible and visual warning when activated;

(2) Another sensor operating independently of high liquid level alarm is to automatically actuate a shutoff valve in a manner which will both avoid excessive liquid pressure in the CO_2 supply line and prevent the CO_2 storage tank from becoming liquid full. The closing time of the shutoff valve is to be adjustable;

(3) In one of the following cases, the device specified in aforementioned (1) and (2) may not be required to install in the storage tank:

① the storage tank with a volume not more than 200m^3; or

② the storage tank is designed to withstand the maximum possible pressure during the

loading operation and such pressure is below that of the setting of the storage tank relief valve.

(4) Where an override device is provided for the overflow control system, it is to be capable of preventing improper operations. If conducting overriding, continuous visual indications are to be given at the OISC control station and bridge room.

6.5.5 Pressure monitoring (included in 6.2.2 of containment system of CO_2 storage tanks)

(1) Each gas space in CO_2 storage tank is to be provided with a direct reading pressure gauge and an indirect indicator at the OISC control station, which can clearly indicate the maximum and minimum allowable pressures;

(2) A high pressure alarm device is to be provided in bridge room. Where a vacuum protection is required, a low pressure alarm device is also to be provided in bridge room and OISC control station. Before reaching the setting, an alarm is to be initiated;

(3) Where the storage tank is provided with a pressure relief valve that can adjust more than one pressure, a high pressure alarm is to be set for each pressure;

(4) At least one pressure indicator is to be installed on each CO_2 unloading pipeline;

(5) All pressure indicators are to be capable of providing indications within the operating pressure range.

6.5.6 Temperature indicating device

(1) Each CO_2 storage tank is to be provided with at least two devices for indicating cargo temperatures, one placed at the bottom of the CO_2 storage tank and the another near the top of the tank, below the highest allowable liquid level. The lowest temperature of CO_2 storage tank is to be clearly indicated by means of a sign on or near the temperature indicating devices.

(2) The temperature indicating devices are to be capable of providing temperature indication across the expected CO_2 operating temperature range of the CO_2 storage tanks.

Chapter 7 Control, Monitoring , Alarm and Safety System

7.1 General provisions

7.1.1 In addition to the provisions of this Chapter, the control, monitoring, alarm and safety system of OISC are to meet the applicable requirements of Chapters 1 and 2 of PART SEVEN in the ISC Rules. Ships assigned with class notation of Automation are to meet the applicable requirements of Section 8, Chapter 3 of PART SEVEN in the ISC Rules.

7.1.2 The computer system used for OISC control, monitoring, alarm and safety protection is to meet the applicable requirements of Category II computer systems of Section 6, Chapter 2 of PART SEVEN in the ISC Rules.

7.2 Control, monitoring and alarm system

7.2.1 To ensure that the operating parameters of OISC and its connected engines are always within the specified range, OISC system is to have automatic control, monitoring, alarm and safety protection functions, and be provided with manual operating devices.

7.2.2 The OISC control system can be designed as an independent system or integrated into ship automation systems. The system design is to ensure that a single failure of a component does not lead to potential danger for the safety of ships and personnel. When integrating the OISC control system with the ship automation system, a risk analysis is to be carried out, and the risk analysis report is to be submitted to ISC for information.

7.2.3 For ships with periodic unmanned machinery spaces, the OISC monitoring and alarm system can be integrated with the centralized monitoring and alarm system of the ship.

7.2.4 The OISC monitoring, alarm and safety protection is to be determined based on the results of risk analysis. In general, monitoring, alarm and indication can be provided at the OISC remote control (if equipped) and local control positions according to the requirements of Table 7.2.4. At the meanwhile, all alarms are to be extended to continuously manned positions in the form of single or combined alarms.

7.2.5 In the case of failure of remote control system (if provided) or in emergency, OISC system is to be locally controlled and monitored. Key parameters required for system safe operation and working conditions of equipment are to be indicated at the local control position.

7.3 Safety system

7.3.1 Emergency shutdown device is to be provided at the OISC remote control (if equipped) and local control stations to stop system operation and automatically initiate the waste gas bypass device (if equipped). The shutdown of OISC is not to affect the reliable operation of the engine.

7.3.2 A safety system is to be provided and meet the following requirements:

(1) Upon activation of the safety shutdown system, an audible and visual alarm is to be given at the remote control position and at the local control station.In the event where shutdown by the safety shutdown system is activated the restart is not to occur automatically, until the system has been manually reset.

(2) Safety shutdowns are to be automatically activated according to the requirements of Table 7.2.4.

7.4 Gas detection system

7.4.1 Gas detection system is to be provided in spaces where CO_2 possibly leaks and accumulates during the OISC operation.

7.4.2 CO_2 gas detection systems and O_2 sensors are to be provided in CO_2 machinery spaces, CO_2 storage tank spaces, enclosed spaces where absorption and desorption towers are installed and other enclosed spaces where CO_2 may accumulate. Where the CO_2 concentration in the spaces exceeds 5000ppm (0.5%) and/or the O_2 concentration is below 19%, an audible and visual alarm is to be given at the following locations:

(1) OISC remote control station (if provided);

(2) OISC local control station；

(3) Bridge room;

(4) Position where gas detector is located.

7.4.3 Gas detection system is to be continuous without delay and of the self-monitoring type. In the event that a system fault is detected by the self-monitoring functions, the output of the detection system is to be automatically disconnected such that the detector fault will not cause false emergency shutdown.

7.4.4 Gas detectors are to be designed and tested according to the standards accepted by ISC.

7.4.5 The number of gas detectors in each space is to be considered taking into account the size, layout and ventilation of the space. Gas detectors are to be located where gas/vapor may accumulate and/or in ventilation outlets. Gas dispersal analysis or physical smoke test is to be used to find the best arrangement.

7.4.6 The gas detection equipment is to be designed so that it may be readily tested.

7.4.7 In addition to the fixed gas detection system, at least two portable gas detectors are to be provided onboard the ship.

Monitoring , Alarm and Safety Protection for OISC Systems **Table 7.2.4**

Item	Monitored parameter	Display	Alarm	Automatic shutdown or bybass①	Remark
CO_2 absorber unit	Inlet pressure of exhaust cooling unit	Pressure	--	--	
	Outlet pressure of exhaust cooling unit	Pressure	--	--	
	Outlet temperature of exhaust cooling unit	Temperature	High	Excessively high	
	Level of absorption tower	Level	High/low	Excessively high/excessively low	
	Pressure of absorption tower	Pressure	High	Excessively high	
	Temperature of absorption tower	Temperature	High	--	

Item	Monitored parameter	Display	Alarm	Automatic shutdown or bybass①	Remark
	Outlet pressure of absorbent nozzle	Pressure	Low	--	
	CO_2 concentration in decarbonized exhaust gas	concentration	High	--	
Decarbonization agent supply system, absorbent circulation system	Outlet pressure of decarbonizaiton agent supply pump*	Pressure	Low	--	
	Condition of decarbonizaiton agent supply pump*	Running	Failed	--	
	Level of decarbonization agent storage tank	Level	High/low	--	
	Lean solution level of absorbent circulation tank	Level	High/low	--	
	Rich solution level of absorbent circulation tank	Level	High/low	--	
	Temperature of absorbent circulation tank	Temperature	--	--	
	Lean solution pH of absorbent circulation tank	pH	--	--	If applicable
	Outlet pressure of absorbent circulation tank (lean solution)	Pressure	low	--	
	OISC residue tank discharging pipeline pressure	Pressure	--	--	
	OISC residue tank level	Level	High	--	
CO_2 desorber unit	Outlet pressure of absorbent circulation tank (rich solution)	Pressure	Low	--	
	Rich solution inlet/outlet temperature of lean/rich solution heat exchanger *	Temperature	--	--	
	Lean solution inlet/outlet temperature of lean/rich solution heat exchanger *	Temperature	--	--	
	Lean solution inlet/outlet temperature of Lean solution cooling unit	Temperature	High	--	
	Cooling water inlet/outlet temperature of Lean solution	Temperature	--	--	

Item	Monitored parameter	Display	Alarm	Automatic shutdown or bybass①	Remark
	cooling unit				
	Cooling water pump outlet pressure of Lean solution cooling unit	Pressure	Low	--	
	Level of desorption tower	Level	High	--	
	Temperature of desorption tower	Temperature	Low	--	
	Rich solution nozzle outlet pressure of desorption tower	Pressure	High/low	--	
	Heat steam inlet/outlet pressure of reboiler	Pressure	--	--	
	Heat steam inlet/outlet temperature of reboiler	Temperature	--	--	
	Rich solution pump outlet pressure from desorption tower to reboiler	Pressure	Low	--	
	Rich solution inlet pressure from reboiler to desorption tower	Temperature	Low	--	
	Heat Lean solution pump outlet pressure of desorption tower	Pressure	Low	--	
	Cooling water pump outlet pressure of CO_2 gas	Pressure	Low	--	
	Cooling water inlet/outlet temperature of CO_2 gas heat exchanger	Temperature	--	--	
CO_2 compression/ liquefaction/ storage unit	Cooling water inlet/outlet temperature of compression unit	Temperature	High	--	
	CO_2 inlet pipeline water content of surge tank*	Moisture	High	--	
	CO_2 inlet pipeline pressure of surge tank*	Pressure	High	--	
	Surge tank* temperature	Temperature	--	--	
	Surge tank* pressure	Pressure	High	--	
	CO_2 inlet temperature of liquefaction unit	Temperature	High	--	
	CO_2 inlet pressure of liquefaction unit	Pressure	High	--	
	Level of CO_2 storage tank	Level	High	Excessively	

Item	Monitored parameter	Display	Alarm	Automatic shutdown or bybass[①]	Remark
				high	
	Temperature of CO_2 storage tank	Temperature	High	--	
	Pressure of CO_2 storage tank	Pressure	High/low	--	If vacuum protection is required, a low pressure alarm is to be provided
	CO_2 concentration of CO_2 storage tank spaces (see 7.4.2)	CO_2 content	High	--	
	O_2 concentration of CO_2 storage tank spaces (see 7.4.2)	O_2 content	low	--	
Miscellaneous	Power source of control, monitoring, alarm and safety system	Voltage	Failed	--	May be replaced by indicating light
	Sensor condition	--	Failed	Failed	Sensors suitable for activating automatic shutdown and bypass functions
	Pump operation	Running	Failed	--	
	Fan required in 6.3.1	Running	Failed	--	
	Pressure of control air pipe	--	Low	--	
	OISC shutdown	--	Operating	Operating	
	Exhaust gas booster fan*	Running	Failed	--	
	Exhaust gas bybass device*	Working condition	Failed	--	
	Exhaust back pressure of combustion unit	--	High	Excessively high	

The symbols and their meanings in the Table are as follows:

--: Not required

*: If provided

①: Applicable to the bypass device provided according to 2.6.2 of this Guidelines

Chapter 8 Surveys

8.1 General provisions

8.1.1 In addition to the provisions of this Guidelines, the OISC system is to meet the relevant requirements of applicable rules and standards.

8.1.2 The OISC survey categories are to include product survey, survey during construction and survey after construction.

8.2 Drawings examination

8.2.1 Before the commencement of construction, the applicant is to submit triplicated or electronic drawings and information specified in 1.5 of Chapter 1 in this Guidelines to ISC for approval.

8.2.2 Technical documents, system commissioning and functional and effectiveness testing programs are to be submitted to the ISC field surveyors for approval.

8.3 Product surveys

8.3.1 The product survey and approval of OISC are to meet the applicable requirements of ISC rules and product inspection guidelines.

8.3.2 Equipment, piping and valves related to OISC are to be approved by ISC with relevant certification documents before installation on board the ships.

8.3.3 The welding, heat treatment and non-destructive testing of pressure vessels are to be carried out in accordance with the relevant documents approved by ISC.

8.4 Surveys during construction

8.4.1 Before the construction of OISC, the applicant is to submit a written application for construction surveys to ISC or sign a survey contract.

8.4.2 Design review and survey are to be carried out for the manufacturer's self-made equipment in accordance with the requirements of product surveys in 8.3 of this Guidelines. When the equipment is assembled, the ISC field surveyors are to inspect the equipment assembly, pipelines, and electrical installations according to the approved drawings and test procedures, and witness the pressure and functional tests of the relevant equipment or pipelines.

8.4.3 Before the commencement of construction, ISC field surveyors are to inspect and confirm the relevant construction and inspection preparations made by the manufactures, e.g.: construction preparation work plan, construction/welding processes, welder/non-destructive testing personnel qualifications, list of marine product certificates, welding specifications, non-destructive testing plan, tightness test plan, inspection/test items, relevant materials (steel plating, welding materials, etc.), construction tolerance standards, subcontractors (if applicable) and necessary technical information, i.e. drawings and data before commencement of construction. For individual projects that do not affect the commencement of construction, ISC field surveyors may carry out inspection and confirmation case by case before the relevant construction stage.

8.4.4 ISC field surveyors are to approve the construction processes and test programs to confirm that they are in compliance with the approved drawings and data (including plan approval comments) and relevant rules, and carry out surveys according to the approved drawings, data,

processes and test programs.

8.4.5 The as-built documents are to include installation reports, test reports and equipment delivery certificates.

8.4.6 The installation of the system and equipment are to be checked whether it is in compliance with the drawings so as to verify the performance and operation meet the design requirements.

(1) Pumps

① Visual inspection;

② The safety device alarm and shutdown functional test is satisfactory;

③ Starting and shutdown test;

④ Check the parameters of pumps.

(2) Compressors

① Visual inspection;

② Testing the alarm and shutdown protection by means of simulation;

③ Starting and shutdown test;

④ During the operation test, checking the automatic unloading and loading functions of the compressor, and test the parameters of the compressors, motors and associated equipment.

(3) Heat exchangers

① Visual inspection;

② Inlet and outlet pressure and temperature of heat exchanges are in compliance with the design requirements;

③ The safety device alarm and shutdown functional test is satisfactory;

(4) Pressure vessels

① Visual inspection and internal inspection;

② The following alarm and shutdown protection is carried out by means of simulation, generally including:

a. High or low pressure alarm and shutdown protection;

b. High or low level alarm and shutdown protection;

c. Low temperature alarm and protection.

(5) Gas detection system

①Confirm the installation of gas detection system meeting the relevant requirements of 7.4 in this Guidelines;

② Confirm that the gas detectors have been calibrated by the qualified firms;

③ Confirm that the gas detection system has been commissioned and meet the requirements.

(6) CO_2 piping system

① Visual inspection;

② Check for leaks and looseness at the connections of flanges, valves, and accessories;

③ Hydraulic test;

④ Safety alarm and shutdown functional test are satisfactory.

8.4.7 Visual inspection is to be carried out for OISC arrangements required in Chapter 2 of this Guidelines.

8.5 Surveys after construction

8.5.1 Annual survey is to be carried out for OISC system. The survey items are the same as the requirements of 8.4.6 and 8.4.7 in this Guidelines, except for the internal inspection of pressure

vessels and hydraulic testing of CO_2 piping systems.

8.5.2 Intermediate survey is to be carried out for OISC system, with the survey items as the same as the annual survey.

8.5.3 Special survey is to be carried out for OISC system, with the survey items as the same as the requirements of 8.4.6 and 8.4.7 in this Guidelines.

8.5.4 Where an OISC is modified, renewed, damaged or repaired that may affect system safety, or where the system delivery condition changes, an application for occasional survey is to be submitted to ISC in a timely manner.

Chapter 9 Ready Technology Requirements for OISC

9.1 General provisions

9.1.1 This Chapter applies to OISC Ready ships which intend for OISC installation and modification in future. Such ships are also to meet the requirements of competent authorities (if any).

9.1.2 This Chapter provides the requirements of design, arrangement, space reservation, structural strengthening and surveys for the OISC Ready ships.

9.1.3 This Chapter intends to clarify the OISC Ready requirements and provides technical guidance for the subsequent installation and modification of OISC onboard the ships.

9.2 Requirements of ready

9.2.1 The OISC Ready is to meet the following functional requirements:

(1) The layout and design of OISC Ready are to reduce the probability and consequences of risks related to OISC to a minimum level;

(2) In the event of failure of OISC, necessary safety measures are to be initiated, taking the consideration that these safety measures will not cause unacceptable power loss to the ship;

(3) The OISC Ready is to be arranged by taking the consideration to reduce the hazardous areas as much as possible to minimize the potential risks that may affect the safety of ships, personnel, and equipment on board the ships.

9.2.2 Ships applying for the class notation OISC Ready 1 are to comprehensively consider the space required for installation and maintenance, as well as the potential impact on ship layout, equipment, electrical load, structural strength, stability, tonnage, and load capacity.

9.2.3 Ships applying for the class notation OISC Ready 2 are to meet the relevant requirements of class notation OISC in this Guidelines, in addition to the requirements of 9.2.2 of this Guidelines.

9.2.4 Ships applying for the class notation OISC Ready 2 (X) are to meet the relevant survey requirements related to the suffix "X", in addition to the requirements of 9.2.2 and 9.2.3 of this Guidelines.

9.3 Plans and information

9.3.1 In addition to submit the drawings and information in accordance with the relevant requirements of ISC rules and guidelines, ships applying for the class notation OISC Ready 1 are also to provide:

(1) The followings are to be submitted for approval, as a minimum:

① General arrangement, including the reserved layout of OISC;

② Power load calculation sheet.

(2) The followings are to be submitted for information, as a minimum:

① OISC Ready and layout instructions;

② OISC steam consumption calculation sheet (if applicable);

③Longitudinal strength calculation sheet (taking into account the impacts of OISC on ship weight distribution)

9.3.2 Ships applying for class notations OISC Ready 2 or OISC Ready 2 (X) are to submit the drawings and information in accordance to the requirements of 1.5 in this Guidelines.

9.4 Surveys

9.4.1 Ships applying for class notation OISC Ready 2 (X) are to surveyed in accordance with the applicable requirements of Chapter 8 in this Guidelines.

9.4.2 The equipment related to OISC installed at the Ready stage is to be surveyed in accordance with the relevant requirements of the Onboard Carbon Capture and Storage System (No. K-08) in ISC Guidelines for Product Surveys.