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船舶废气清洗系统设计与安装指南

GUIDELINES FOR DESIGN AND INSTALLATION OF EXHAUST GAS CLEANING SYSTEMS

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出 版 说 明

《船舶废气清洗系统设计与安装指南》适用于船舶为减少船上燃油燃烧装置SO_x排放而安装的湿式废气清洗系统（以下简称EGC系统）。

指南中全面考虑了船舶安装和使用EGC系统可能的安全问题，从船舶安全角度出发，规定了废气清洗系统设计、制造、安装布置、控制监测、试验等方面的要求，作为规范的补充，旨在为船舶设计、建造/改造、检验、试验等提供指导。

指南第1章规定了适用范围、附加标志、图纸资料、风险分析、定义与缩写、船上试验、产品持证等一般要求；第2章规定了EGC系统的设计、布置、安装等方面的要求；第3章规定了脱硫塔、泵和风机、压力容器、旁通与隔离装置、洗涤水处理装置等设备的设计要求；第4章规定了系统控制、监测与安全保护要求；第5章规定了操作手册的基本要求。

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Contents

Foreword

The international conventions, relevant regions and countries have laid more and more requirements on shipboard SO_x emission control. For the requirements of conventions and relevant regional/national regulations for the limit of the sulphur content of fuel oils used by ships, see Table 0.

Note: For users' easy reference, Table 0 only gives part of the requirements for the limit of sulphur content of fuel oils used by ships, the date of implementation and implementation areas as specified in MARPOL Annex VI, EU Low Sulphur Directive 2005/33/EC, Titles 13 and 17 of California Code of Regulations, and Hong Kong Air Pollution Control (Ocean going Vessels) (Fuel at Berth) Regulation. Detailed requirements are to be referred to the above-mentioned convention, directive/regulations.

List of Requirements for the Limit of Sulphur Content of Fuel Oils Table 0

Convention/Regulations	Sulphur content of fuel oils (% m/m)	Date of implementation	Implementation area
MARPOL Annex VI	3.50	1 January 2012	Outside SO_x emission control area
	0.50[1]	1 January 2020	
	1.00	1 July 2010	Inside SO_x emission control area[2]
	0.10	1 January 2015	
EU Directive	0.10	1 January 2010	EU ports[3]
CARB Regulations	1.50[4] 0.50[5]	1 July 2009	California waters[6]
	1.00[4] 0.50[5]	1 August 2012	
	0.10[4] 0.10[5]	1 January 2014	
Hong Kong Regulation	0.50	1 July 2015	Hong Kong ports[7]

Notes:1. A group of experts has been established by IMO to analyze and evaluate the global fuel oil supply and demand and the trends in fuel oil markets so as to determine the availability of such fuel oils. If IMO determines that it is not possible for ships to comply with this limit, then the criterion for fuel oils having a sulphur content up to 0.50% m/m will be implemented on 1 January 2025.

2. The emission control areas as specified in regulation 14 of MARPOL Annex VI include at present: Baltic Sea area, North Sea area, North American area and United States Caribbean Sea area (to be implemented on 1 January 2014).

3. Ships berthing at EU ports (including anchoring, mooring on buoy, alongside dock) for more than 2 hours are not allowed to use fuel oils with a sulphur content exceeding 0.10%.

4. Marine gas oil, corresponding to DMA grade "Distillate Fuel" as specified in ISO 8217 standard.

5. Marine diesel oil, corresponding to DMB grade "Distillate Fuel" as specified in ISO 8217 standard.

6. 24 n miles from California coast and its ports.

7. Ships berthing at Hong Kong ports are not allowed to use fuel oils with a sulphur content exceeding 0.50%.

SO_x in the shipboard exhaust gas is the pollutant generated after the combustion of sulphur in the fuel oil. It is very difficult to achieve the objective of controlling SO_x emission by self-improvement of fuel combustion units (such as diesel engines, boilers, etc.). Control is only possible through pre-treatment of fuel oils, after-treatment of exhaust gas or alternative fuels, i.e.:

— pre-treatment of fuel oils: using specialized process to desulfurize fuel oil so that the ship uses low-sulphur oil complying with the requirements;

— after-treatment of exhaust gas: removing SO_x in the exhaust gas by installing exhaust gas treatment unit so as to achieve emission reduction equivalent to that of using low-sulphur fuel oil;

— alternative fuels: ships use clean fuels such as natural gas; as natural gas is low in sulphur, SO_x emission is low after combustion.

As the number of global emission control areas is ever on the increase, and in particular since 2020 ships engaged on international voyages can only use fuel oils with a sulphur content not greater than 0.5%, resulting in supply shortage of low-sulphur oil and sharp increase in the fuel cost of ship operation, after-treatment of exhaust gas or alternative fuels become the main alternative solution chosen by shipowners and designers.

Exhaust gas cleaning systems are frequently applied post-treatment technology in marine transportation section. IMO specifically developed the Guidelines for Exhaust Gas Cleaning Systems, 2009 (resolution MEPC.184(59)) (hereinafter referred to as the Guidelines, and the amendments to the Guidelines was approved and adopted in 2015 (resolution MEPC.259(68))). The Guidelines specifies testing methods and survey procedures of the exhaust gas cleaning system compliance verification (including exhaust gas emission and washwater discharge) and serves as the main basis for the statutory survey of the EGC systems. CCS developed the Guidelines for Testing and Survey of Exhaust Gas Cleaning Systems (2011) (hereinafter referred to as the Guidelines for Survey of EGC systems) on the basis of the Guidelines.

The EGC systems, as one of the major pollution prevention equipment on board, need to take into account issues related to the system operational safety in addition to meeting requirements of statutory emission criteria and compliance verification, i.e. the operation and usage of the system will not cause unacceptable hazards to the ship, essential equipment and personnel. The Guidelines specifies the requirements for the design, manufacturing, arrangement, control and monitoring, installation and testing of the EGC systems from the perspective of ship safety and serves as a supplement to CCS rules, with an aim to provide guidance on the ship design, construction/conversion, survey, testing, etc.

Chapter 1 General

1.1 Application

1.1.1 The Guidelines is applicable to wet exhaust gas cleaning systems (hereinafter referred to as the EGC systems) installed to reduce SO_x emission of fuel oil combustion units onboard. Dry desulfurization systems are subject to special consideration.

1.1.2 The Guidelines specifies the requirements for the design, manufacturing, installation and arrangement, control and monitoring, and testing of the EGC systems.

1.1.3 The requirements of the Guidelines are only supplementary to CCS rules. The EGC systems, in addition to satisfying the requirements of the Guidelines, are also to comply with the relevant requirements of CCS Rules for Classification of Sea-going Steel Ships or Rules for Construction of Sea-going Ships Engaged on Domestic Voyages or Rules for Construction of Inland River Steel Ships (hereinafter referred to as CCS Rules), CCS Rules for Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (hereinafter referred to CCS Rules for Chemicals in Bulk). Those ships installing the EGC system need to pay attention to the relevant provisions, if any, of the Administration of the flag States.

1.1.4 Where CCS is authorized by the Administration to issue the IAPP certificate specified by MARPOL Annex VI, the compliance verification of the EGC systems in accordance with the Guidelines for Survey of EGC systems is also within the jurisdiction of the classification society.

1.2 Class notation

1.2.1 Ships installed with the EGC systems for reduction of SO_x emission can be assigned with SEC (EGCS) notation upon satisfactory survey provided that the EGC systems are designed, manufactured, tested according to the requirements of the Guidelines and verified for emission compliance according to the Guidelines for Survey of EGC systems.

1.3 Definitions and abbreviations

1.3.1 Definitions

(1) *Fuel Oil Combustion Unit* means any engine, boiler or other fuel oil fired equipment, excluding shipboard incinerators.

(2) *Desulfurization System* is the generic term for scrubbers installed for SO_x removal in the exhaust gas of the fuel oil combustion units as well as auxiliary equipment, instrument, pipelines, etc.

(3) *Scrubber* means the reaction unit for getting rid of hazardous substances such as SO_x in the desulfurization process.

(4) *Desulfurization Agent* means absorbent used to neutralize hazardous substances such as SO_x, e.g. NaOH, $Mg(OH)_2$, MgO, etc.

(5) *Residue* means the mixture of by-product generated after the reaction of desulfurization agent and hazardous substances such as SO_x, unreacted desulfurization agent and impurities, soot and dust particles captured by the system.

(6) *Alkali Solution/Serous Fluid* means the alkali solution produced after the desulfurization agent is dissolved in water. In the Guidelines, the alkali solution refers generally to NaOH solution and serous fluid to $Mg(OH)_2$ solution.

(7) *Pressure Resistance of the Scrubber* means the total pressure difference of exhaust gas between the inlet and outlet of the scrubber, in Pa.

(8) *Wet Desulfurization System* means the desulfurization agent coming into direct contact with the exhaust gas of the fuel oil combustion unit in the form of water solution or serous fluid to get rid of SO_x in the exhaust gas.

(9) *Dry Desulfurization System* means the desulfurization agent coming into direct contact with the exhaust gas of the fuel oil combustion unit in the form of particles to get rid of SO_x in the exhaust gas.

(10) *Booster Fan* means fan added to overcome the resistance of the flue gas in the desulfurization system.

1.3.2 Abbreviations and symbols

(1) EGC: Exhaust Gas Cleaning.

(2) SCR: Selective Catalytic Reduction.

(3) MCR: Maximum Continuous Rating.

(4) FOCU: Fuel Oil Combustion Unit.

(5) SO_x: Sulphur oxides.

(6) SO_2: Sulphur dioxide.

(7) CO_2: Carbon dioxide.

(8) NaOH: sodium hydroxide.

(9) $Mg(OH)_2$: magnesium hydroxide.

(10) MgO: magnesium oxide.

(11) CARB: California Air Resources Board.

(12) EU: European Union.

1.4 Goals and functional requirements

1.4.1 The Guidelines is intended to provide standards for the design, manufacturing, installation and arrangement onboard, operational safety of the EGC system, so as to avoid or reduce in so far as practicable the hazards caused by the installation and usage of the EGC system to the ship, essential equipment and personnel.

1.4.2 To achieve the above mentioned goals, the design, manufacturing, installation and arrangement of the EGC system is to comply with the following functional requirements:

(1) adapting to the environmental and working conditions of ship operation;

(2) effectively treating SO_x in the exhaust gas emitted by the fuel oil combustion unit connected with the system;

(3) reducing in so far as practicable the impacts of the installation and operation of the EGC system on the fuel oil combustion unit to ensure that the latter can operate continuously and that the operation parameters and power output are maintained within the design limits;

(4) avoiding the accidental accumulation or spread of inflammable, explosive, toxic gases;

(5) avoiding damages to the ship structure or other equipment and systems due to the leakage and spread of chemical substances (such as desulfurization agent);

(6) avoiding harms to the crew or other equipment due to low temperature, high temperature, running equipment, etc.;

(7) fire detection, fire protection and fire extinguishing measures are to be taken for potential fire risks;

(8) the installation and arrangement of the EGC system are to take into account the impacts on the ship structure, ship stability and loadlines;

(9) appropriate control, monitoring, safe protection systems are to be adopted to ensure the safe and reliable operation of the system.

1.5 Risk analysis

1.5.1 A recognized method for risk analysis/assessment (such as IEC/ISO 31010) is to be used to analyze and evaluate the safety issues in relation to the design, arrangement, operation of the EGC system and appropriate measures are to be taken to control the identified risks.

1.5.2 Risk analysis is generally to take into account the following possible risks:

(1) adaptability to the environmental and working conditions;

(2) impacts on the safe operation of the fuel oil combustion unit;

(3) accidental accumulation or spread of inflammable, explosive, toxic gases;

(4) leakage and spread of chemical substances;

(5) harms to the crew or other equipment due to low temperature, high temperature, running equipment, etc.;

(6) potential fire risks.

1.5.3 The risk analysis report is generally to include the following aspects:

(1) standards and methodology for risk analysis;

(2) assumptions and prerequisites of the analysis;

(3) analysis objects, such as the system, equipment, operation, etc.;

(4) potential risks;

(5) causes for the risks;

(6) possible effects of the risks;

(7) measures taken to prevent or reduce the impacts of risks and implementation.

1.6 Plans and documents

1.6.1 For application of type approval of the EGC system, the following plans and documents are to be submitted to CCS for approval or information:

(1) product performance specifications, mainly including but not limited to:

- design treatment capability, such as the maximum mass flow rate of exhaust gas and washwater that can be treated by the EGC system;
- working conditions and limitations, such as inlet exhaust gas temperature range and pressure range, outlet exhaust gas temperature range, pressure loss, washwater inlet pressure and alkalinity, type of neutralization agents, operation and control parameters of the system and setup, applicable maximum sulphur content of the fuel oil of the EGC system;
- main performance and emission indicators, such as consumption rate of neutralization agents, fresh water/sea water consumption rate, SO_2 (ppm)/CO_2 (%v/v) ratios in the treated exhaust gas, washwater discharge indicators, etc.

(2) the general arrangement plan;

(3) structural diagrams and details of the scrubber, including arrangements such as the connection structure, openings, nozzles, fillers, dehumidifying structure;

(4) working principles and diagram showing the process flow as well as the instructions;

(5) material details of main components and parts (including corrosion analysis of the contact medium to the materials used);

(6) detailed information on the added chemical substances, including their corrosion, toxicity, flammability, chemical reaction, etc. as well as the relevant limitation conditions for their storage, transfer, disposal and usage;

(7) diagrams of the control, monitoring and safe protection systems, including basic control strategy, setup, monitoring locations for exhaust gas and washwater, etc.;

(8) diagram of the electrical system;

(9) type test program (when applying for type approval);

(10) risk analysis report (for information, according to the provisions of 1.5);

(11) operation manual (for information, according to the provisions of Chapter 5);

(12) calculations (such as calculation of the treatment capability of the EGC system, for information);

(13) list, models and technical parameters of main spares (if any) (for information);

(14) name plate (for information).

1.6.2 For ships intended to be installed with the EGC system, the following plans and documents are to be submitted to CCS for approval or information:

(1) installation and arrangement of the scrubber, including exhaust gas collection device (if applicable), bypass and isolation devices (if installed);

(2) diagram of the installation foundation of the scrubber and diagrams related to ship structural connection;

(3) documentation detailing the effect on loadline and stability of EGC system;

(4) arrangement details of bunkering, storage, transfer, preparation of the desulfurization agent, including capacity calculation of the storage tank;

(5) capacity and arrangement of tanks related to the treatment of the washwater and residue;

(6) arrangement of air pipes, sounding pipes and overflow pipes in tanks related to the system;

(7) diagram of the main piping systems;

(8) control, monitoring and safeguard systems;

(9) list of alarm and indication points;

(10) EGC system emergency shut-down device;

(11) on-board test program;

(12) detailed information demonstrating compatibility of the EGC system with the fuel oil combustion units onboard (for information, according to the provisions of 2.2).

1.7 On-board tests and surveys

1.7.1 An integration test is to be carried out after the installation of the EGC system onboard to confirm that the relevant systems and equipment function normally and work stably, that major working parameters are controlled in the design limits. During the test, various working and loading conditions are to be considered.

1.7.2 The test items are to be determined according to the results of the risk analysis. Control, alarm and safe protection related to the system operation are to be verified.

1.7.3 The EGC system is also to be surveyed and tested in accordance with the Guidelines for Survey of EGC systems.

Note: Verification of the emission compliance of EGC systems is statutory requirement. Where CCS is authorized by the Administration to issue the IAPP certificate, emission performance of EGC systems is to be verified in accordance with the Guidelines for Survey of EGC systems.

1.8 Certification

1.8.1 The EGC system is to be approved. The system and components are to be surveyed and certified in accordance with the provisions of Chapter 3, PART ONE of CCS Rules for Classification of Sea-going Steel Ships.

Chapter 2 System design and arrangement

2.1 General requirements

2.1.1 The machinery, electrical equipment and controls system comprising the EGC system are to be designed, type selected, arranged in accordance with the environmental/working conditions specified by PART THREE, FOUR, SEVEN of CCS Rules for Classification of Sea-going Steel Ships respectively.

2.1.2 The materials of the relevant pipings and equipment of the EGC system is to be suitable to the characteristics of the medium coming into contact with them and working conditions. The following principles are generally to be followed when selecting metallic and non-metallic materials:

(1) carbon steel is the preferable metallic material. Where the surface of the metallic material is likely to come into contact with corrosive medium, corrosion-resistant and abrasion-resistant non-metallic materials are to be used as lining according to the actual conditions of desulfurization process in different parts;

(2) where the metallic material is used as pressure-bearing components, and the non-metallic material is used as corrosion-resistant lining, due consideration is to be given to the bonding strength between the metallic material and the non-metallic material. Also, the design of the pressure-bearing components is to ensure that the non-metallic material can be bonded to the pressure-bearing components for a long time and in a stable manner;

(3) for some parts coming into contact with corrosive medium, where carbon steel lined with non-metallic material cannot reach the engineering application requirements, stainless steel based mainly on nickel is to be used according to the corrosiveness and abrasiveness of the medium. After sufficient justification, corrosion-resistant low alloy steel may be used for some areas. See Table 2-1 for the applicable medium conditions.

Applicable Medium Conditions for Nickel-Based Stainless Steel Table 2-1

No.	Material composition	Applicable medium	Remarks
1	Iron-nickel-chromium alloy	Clean flue gas, low-temperature raw flue gas	
2	Iron-nickel-chromium alloy Iron-molybdenum-nickel-chromium alloy	Serous fluid with pH between 3 to 6 and chloride ion concentration≤60000 mg/L	The usage conditions of these two are different and attention is to be paid to the difference during application

(4) For non-metallic materials, glass flake resin, fiber reinforced plastics, plastics, rubber, ceramics are to be used to protect the system against corrosion and abrasion. The parts for which such materials are suitable are given in Table 2-2. For flue gas with high concentration of fluorine, the corrosion-resistant materials are not to contain glass.

Main Non-metallic Materials and Their Applied Parts Table 2-2

No.	Material name	Major composition of the material	The applied part
1	glass flake resin	glass flake, vinyl ester resin, phenolic resin, epoxy resin	inner lining of pipe for clean flue gas after desulfurization, pipe for low-temperature raw flue gas, scrubber, tank of desulfurization serous fluid
2	granite	silicon dioxide	inner lining of scrubber, side-scrubber, flues, sedimentation tanks, serous fluid tanks, filter discharge tanks
3	plastics	polypropylene, polyethylene, polyurethane, polyvinyl chloride	inner lining of pipes for desulfurization agent, dehumidifier, pump impeller, pump body
4	fiber reinforced plastics	glass fiber vinyl ester resin phenolic resin	scrubber spray layer, pipelines, tanks scrubber outlet flues scrubber
5	ceramics	silicon carbide, silicon nitride	desulfurization nozzles, cooling nozzles
6	rubber	chlorobutyl rubber, chlorinated rubber, styrene-butadiene rubber	inner lining of scrubber, pipelines, tanks, hydroclone vacuum belt conveyor, belt conveyor

2.1.3 Spaces where inflammable or toxic vapour may accumulate are to comply with the ventilation requirements of 1.3.4 of PART THREE.

2.1.4 Components and pipings exposed to corrosive environment are to comply with the corrosion-resistant requirements of 1.3.5 of PART THREE.

2.1.5 Appropriate protective measures are to be provided in accordance with 1.3.6, Chapter 1, PART THREE of the Rules for Classification of Sea-going Steel Ships to prevent damages to the personnel onboard that might be caused by the operation and maintenance of the EGC system.

2.1.6 The impacts of the EGC system on ship stability and loadlines are to be evaluated. During evaluation, the working condition of the EGC system is to be taken into account and detailed information related to calculation and evaluation is to be submitted to the classification society for approval.

2.1.7 The EGC system is to be able to put into work in hot condition and not cause any damage due to thermal shock.

2.1.8 Where soot sediment and deposit occur during the operation of the system, appropriate measures are to be taken to clean the sediment and deposit.

2.1.9 The installation and operation of the EGC system are not to lead to the NO_x emission of the diesel engine exceeding the specified value in the EIAPP certificate of the diesel engine.

2.1.10 The structural design and arrangement of the EGC system are to facilitate installation, operation and maintenance.

2.1.11 Where the exhaust gas system is installed with other post-treatment device (such as SCR) in addition to the EGC system, the compatibility of those post-treatment systems is to be considered during onboard installation.

2.2 Compatibility with fuel oil combustion units (FOCUs)

2.2.1 Each EGC system intended to be installed is to be able to effectively treat the exhaust gas under the maximum continuous rating (MCR) of the FOCU(s) connected with the system. For diesel engines, MCR is the rated power; for boilers, MCR is the rated evaporation capacity or rated thermal power.

2.2.2 Where the EGC system is connected with more than one FOCU, if not all FOCUs connected with the system work simultaneously in actual operation, the exhaust gas treatment capacity of the EGC system can be determined according to the sum total of the maximum possible exhaust gas in actual operation instead of the total exhaust gas when all units work simultaneously.

2.2.3 The EGC system is to be compatible with the FOCU connected under all working conditions and operation modes and relevant information is to be submitted to the classification society for approval.

2.3 Exhaust backpressure

2.3.1 The exhaust backpressure, after installation of the EGC system, is to remain within the limits stated by FOCU manufacturers under all operating conditions.

2.3.2 Where an induced draught fan is fitted to maintain the required exhaust backpressure, a fan failure is not to prevent the FOCU from operating. Where the EGC system is fed from multiple FOCUs, the installation of the fan is to consider the backpressure requirement of all connected FOCUs.

2.3.3 Appropriate measures are to be taken to reduce the risk of fan (if any) not working properly due to corrosion or blockage.

2.4 Bypass or other equivalent measures

2.4.1 The design and arrangement of the EGC system is to ensure continued operation of the FOCUs in the event the EGC system is not in operation, either through operational selection or equipment failure.

2.4.2 Where a bypass is provided, a device indicating the working conditions of the bypass is to be fitted. The bypass is to work reliably and ensure the safe operation of the FOCU in any condition.

2.4.3 Where a bypass is not provided, it is to be ensured that even the EGC system stops working, high temperature exhaust gas generated by the FOCU can also be emitted smoothly without causing damages to the EGC system and its components. Under such circumstance, the design of the EGC system is also to consider risks such as the dust accumulation and carbonization after direct erosion of the high temperature exhaust gas.

2.5 Interconnections of exhaust gas piping

2.5.1 Normally, exhaust pipes from FOCUs are to be routed separately and not interconnected. However, interconnected exhaust piping systems to a common EGC system may be accepted subject to the agreement of CCS if the designer takes full consideration of the potential risks and makes effective isolation arrangements preventing the exhaust gas from flowing back to the stopped FOCU(s).

2.5.2 Effective measures are to be taken to prevent the isolated FOCU(s) from being started when the isolation unit is in the closed condition.

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

2.6 Selection, storage and transfer of desulfurization agent

2.6.1 Where MgO is used as the desulfurization agent, the content of MgO is preferable above 85% or complies with the provisions of the manufacturer of the EGC system, and the content of acid insolubles is preferably below 3% (dry basis).

2.6.2 The storage, transfer, preparation system of the desulfurization agent is to be provided with necessary means to control particle pollution.

2.6.3 Where powder desulfurization agent is used, the arrangement of the store handling area is to consider the wind direction.

2.6.4 Necessary measures are to be taken to prevent the desulfurization agent from moisture absorption, deterioration and hardening.

2.6.5 The capacity design of the desulfurization agent tank is to take into account the intended operation route of the ship, the sulphur content of the intended fuel oil, fuel oil consumption rate of the FOCUs, etc.

2.6.6 Where the desulfurization agent will cause harm to personnel, relevant working personnel are to wear suitable protective equipment consisting of large aprons, rubber gloves with long sleeves, coveralls of chemical-resistant material, and tight-fitting chemical safety goggles or face shields or both so that no part of the body is left unprotected when dangerous operations such as bunkering of the desulfurization agent, preparation of alkali solution/serous fluid are carried out onboard. The ship is to carry at least three sets of protective clothing and they are to be stored in readily accessible specialized storage cabins outside accommodation spaces. Eyewash and eyewash station are also to be near the bunkering manifold and pumps for the desulfurization agent.

2.6.7 The desulfurization agent storage tank and pump are not to be located in the control station, accommodation and service spaces. The spaces where desulfurization agent storage tank and pump are located are to be mechanically ventilated and the frequency of ventilation is not to be less than 8 times/h; the emergency access to the spaces are to be led directly from the open deck. Safety instructions relating to precautions and emergency response are to be posted in the desulphurization storage space, and beside the entrance to the space.

2.6.8 Where NaOH solution (hereinafter referred to as alkali) is used as the desulfurization agent, the following requirements are to be complied with:

(1) Aluminum, zinc, brass, or galvanized steel components are not to be used for piping systems, tanks, drip trays or any other components which may come into contact with the solution related to the storage and transfer of alkali.

(2) Alkali is to be maintained within the specified temperature range during the storage and transfer processes. Consequently, appropriate temperature control means are to be provided to prevent NaOH from crystallization when the temperature is too low or from over corrosive when the temperature is too high.

(3) The arrangement of the storage tanks is to take into account the impacts of heat transfer from other heated tanks or facilities. When spillage or leakage occurs, the solution will not fall onto combustibles or heated surfaces. In particular, these tanks are not to be located over boilers or in close proximity to steam piping.

(4) Air pipes, overflow pipes and sounding devices are to be provided for storage tanks in accordance with Section 10, Chapter 3, PART THREE of the Rules for Classification of Sea-going Steel Ships. The outlets of air pipes and sounding pipes (if provided) are to be led to a safe open location and necessary measures are to be taken to prevent harms to the personnel. The spilled alkali is to be led to appropriate overflow tanks or other tanks.

Where high level alarms are provided instead of overflow pipes, the following requirements are to be complied with:

① the design pressure of the tanks is to take into account the hydrostatic pressure generated by the height from the tank bottom to the air pipe outlet; and

② a suitable alkali drip tray is to be provided below the air pipe outlet.

(5) The storage tanks are to be provided with local temperature and level indicators and indication is to be available at the manned control station.

(6) Drip trays are to be provided where leakage may be expected to prevent the spilled alkali from falling onto or spreading to other structures or equipment and therefore causing damages.

(7) Drip trays are to be provided with drainage arrangements draining alkali in the trays to the overflow tank or other appropriate tanks. The drain line is to be fitted with a non-return valve. Alternatively, the storage tanks are to be fitted with spillage monitoring devices and quick-closing valves which can cut off alkali automatically and quickly when spillage occurs. When this design is adopted, the capacity of the drip tray is to be sufficient to hold possible spillage.

(8) The bunker station(s) is to be located on the open deck away from sources of ignition and arranged such that a spill at a bunker station would not result in alkali contacting or mixing with other incompatible materials. Alternatively, closed or semi-enclosed bunker stations may be accepted subject to the provision of effective ventilation. Drip trays are to be provided according to the requirements of 2.6.8(6)&(7) at bunkering joints or other locations where spillage may occur.

(9) Every pipe emanating from a storage tank, which, if damaged, would allow alkali to escape from the tank, is to be provided with a quick closing valve located directly on the tank. The valve is to be operable from a readily accessible safe location in addition to be able to be closed locally.

2.6.9 Where $Mg(OH)_2$ solution (hereinafter referred to serous fluid) is used as the desulfurization agent, relevant requirements of 2.6.8 are to be complied with following same safety principles according to the characteristics and dangerousness of the serous fluid.

2.7 Preparation and supply of alkali/serous fluid

2.7.1 Where solid desulfurization agent is used, necessary alkali/serous fluid preparation system is to be provided, preparing solid desulfurization agent into alkali/serous fluid with certain concentration for desulfurization unit.

2.7.2 The alkali/serous fluid preparation system is to be fitted with metering device. The prepared alkali/serous fluid concentration is to comply with the requirements for the desulfurization system and be controlled within the limits allowed by the process. The concentration and consumption volume of alkali/serous fluid are preferably included in the automatic control system.

2.7.3 Where MgO is used as the desulfurization agent, the fineness of the prepared alkali/serous fluid is to ensure 90% filtration rate of 200 mesh, otherwise a pre-treatment system is to be provided.

2.7.4 The preparation capacity of alkali/serous fluid is to be designed according to 150% of the desulfurization agent consumption in the design condition and storage tanks of sufficient capacity are to be provided. The capacity of the storage tanks is not to be less than 2h alkali/serous fluid consumption of the desulfurization system in the design condition.

2.7.5 Appropriate means are to be taken to prevent damages due to heat release during the preparation of alkali/serous fluid.

2.7.6 The alkali/serous fluid storage tanks are to be provided with anti-sediment means, such as installation of additional paddle mixer, pneumatic/hydraulic mixing equipment, etc.

2.7.7 At least 2 alkali/serous fluid supply pumps are to be fitted, any of which is to be able to provide the required alkali/serous fluid for the desulfurization system in the design condition and the other is for standby.

2.7.8 The supply of alkali/serous fluid is to be controlled automatically to ensure that the desulfurization efficiency of the system satisfies the design requirements continuously.

2.7.9 The alkali/serous fluid piping system is to be independent of other piping systems onboard and is not to be fitted in or through the accommodation, service spaces and control stations.

2.7.10 The alkali/serous fluid piping system is not to be arranged over boilers or in close proximity to steam piping, exhaust systems, hot surfaces required to be insulated, or other sources of ignition.

2.7.11 The joints of the alkali/serous fluid pipe lines are to be kept to a minimum. The direct connections of pipe lengths are to be all welded except for necessary flanged connections to valves and other equipment for maintenance in order to minimize risk of leakage from the pipe lines.

2.7.12 Drip trays are to be provided where leakage may be expected in the preparation and supply system of alkali/serous fluid to prevent the spilled alkali/serous fluid from falling onto or spreading to other structures or equipment and therefore causing damages.

2.7.13 Valves and fittings selected for the piping system are to be suitable to the characteristics of the working medium.

2.7.14 The alkali/serous fluid pipe lines are to be fitted with suitable means of filtering, the arrangement of which is to ensure that when the filter is being washed, alkali/serous fluid can still be provided uninterruptedly.

2.7.15 The alkali/serous fluid piping system is to be provided with draining and flushing facilities which drain and flush in a timely manner when the desulfurization system stops operation.

2.8 Washwater system

2.8.1 Pipelines and fittings of the washwater system are to take into account the characteristics of the contact medium, such as temperature and pH value for selection of suitable materials. Where plastic pipes are used, the requirements of 2.4.3, Chapter 2, PART THREE of the Rules for Classification of Sea-going Steel Ships are to be complied with.

2.8.2 The washwater system is to be provided with at least two circulation pumps and the inlets of the pumps are to be provided with filtration devices.

2.8.3 The washwater system is to be provided with necessary cooling system to ensure that the temperature of the washwater entering the scrubber is always maintained within the design limits.

2.8.4 The washwater overboard discharge system is not to be interconnected to other systems. The discharge pipelines and fittings are to take into account the corrosion-resistant means. Where dissimilar metals are used, consideration is to be given to galvanic corrosion.

2.8.5 It is to be ensured that the overboard discharges are always below the overboard water level in normal draught and effective measures are to be taken to prevent backflow of the overboard water.

2.8.6 The washwater overboard discharges are to be away from the sea suctions in so far as practicable and to take into account the vessel propulsion features to prevent corrosion to the propellers, thrusters or shell platings. Discharges are to be arranged to enable safe sampling of washwater.

2.9 Residue system

2.9.1 The residues generated from the exhaust gas cleaning process are to be stored in a designated residue tank, separate from the engine room sludge tank, and arranged for discharge to appropriate shore reception facilities.

2.9.2 The material of the EGC residue tank is to be selected based on the corrosive nature of the EGC residue.

2.9.3 The EGC residue tank is to be designed to facilitate cleaning. Where EGC residue tanks are also used as the overflow tank for the desulfurization agent storage tank, the additional requirements for the storage tank are to be applied.

2.9.4 The capacity of the EGC residue tank is to be based on the expected residue volumes applicable to the number and type of installed SOx scrubbers and the maximum period of voyage between ports where EGC residue can be discharged. In the absence of precise data, a figure of 30 days is to be used.

2.9.5 The EGC residue tank is to be provided with air pipes and sounding devices in accordance with Section 10, Chapter 3, PART THREE of the Rules for Classification of Sea-going Steel Ships. The outlets of air pipes and sounding pipes, if fitted, are to be led to safe open locations.

2.9.6 The EGC residue tank is to be provided with a high level alarm.

2.10 Exhaust system

2.10.1 The exhaust system is to comply with the requirements of the Guidelines and the materials, design, manufacturing, installation and arrangement of the system are also to comply with the relevant requirements of Chapters 1, 2, 4, 9, PART THREE of the Rules for Classification of Sea-going Steel Ships.

2.10.2 See 2.4 and 2.5 of the Guidelines for the requirements related to exhaust gas bypass and isolation.

2.10.3 The scrubber and its fittings installed in the exhaust system are to comply with the requirements of 3.1 of the Guidelines.

2.10.4 The exhaust gas inlets of the scrubber are to take full account of the corrosion likely to be caused by changes in temperature and humidity.

2.10.5 The exhaust gas inlet temperature is to be maintained within the limits specified by the manufacturer of EGC system.

2.10.6 Necessary corrosion prevention measures are to be taken for exhaust pipes and components downstream of the scrubber and necessary drains are to be provided to permit the discharge of any condensate formed.

2.10.7 Appropriate means are to be taken to prevent water vapour in the desulfurized exhaust gas from condensation, such as heating and insulation of the exhaust pipes.

2.11 Seawater/fresh water system

2.11.1 The seawater and/or fresh water system serving the exhaust gas desulfurization equipment is to comply with the relevant requirements of Chapters 1, 2, 3, PART THREE of the Rules for Classification of Sea-going Steel Ships.

2.11.2 Where the seawater/fresh water system of the EGC system is interconnected with other systems onboard, reliable means preventing backflow of water are to be provided.

2.11.3 The capacity of the seawater/fresh water system is to be sufficient to provide the desulfurization system with the required seawater/fresh water at the system's maximum working load without affecting normal operation of other essential auxiliary systems.

Chapter 3 Machinery equipment

3.1 Scrubbers

3.1.1 The scrubber and its fittings are to be made of corrosion-resistant stainless steel or other corrosion-resistant materials to be capable of withstanding acid and alkali corrosion and temperature changes of the medium with which the scrubber and its fittings are likely to come into contact.

3.1.2 The body, supporting members, etc. of the scrubber are to be able to withstand possible loads that might be encountered in the design conditions of the ship, including dynamic loads due to wave-induced motions.

3.1.3 The design of scrubber and its internal structure is to take into account resistance against abrasion, corrosion and erosion.

3.1.4 Reliable drainage arrangements are to be provided so that when the EGC system is not working or emergency requires, the washwater in the system can be drained to the designated tank immediately.

3.1.5 The scrubber is to be airtight, preventing exhaust gas and/or washwater from leaking into spaces.

3.1.6 The design of flue inlets of the scrubber is to take into account the backflow of the exhaust gas and deposition of particles.

3.1.7 Where the scrubber is designed with working level, means are to be taken to ensure the washwater level in the scrubber is maintained within the limits. Level indications and monitoring devices are to be provided to give alarm when the level exceeds the limits.

3.1.8 The scrubber is to be provided with an overflow arrangement in accordance with Section 10, Chapter 3, PART THREE of the Rules for Classification of Sea-going Steel Ships to prevent the backflow of the washwater to the fuel oil combustion unit. The overflow lines are to be dimensioned to accommodate 125% of maximum capacity of washwater pumps.

3.1.9 Where pH value of the washwater in the scrubber is used as an important parameter of the desulfurization control process, a washwater pH monitoring device is to be provided.

3.1.10 Necessary manholes/inspection holes, passages and platforms are to be provided to facilitate repair, inspection, maintenance and cleaning of the scrubber.

3.1.11 The design and arrangement of the spray system are to take into account the risks of deposit, clogging, abrasion and suitable flushing installation is to be provided.

3.1.12 Necessary dehumidifiers are to be provided to prevent the desulfurized exhaust gas from leaving the scrubber with droplets.

3.2 Pumps and fans

3.2.1 Redundant pumps, essential for the continual operation of the EGC system, are to be provided. There are to be at least two of these essential pumps, and the capacity of the pumps, with any one pump out of service, is to be sufficient for continuous operation of the EGC system at design working condition.

3.3 Pressure vessels

3.3.1 Pressure vessels used in the EGC system are to be designed, manufactured, installed and tested in accordance with Chapter 6, PART THREE of the Rules for Classification of Sea-going Steel Ships.

3.4 Bypass and isolation devices

3.4.1 Exhaust gas bypass and isolation devices are to comply with the requirements of 2.4 and 2.5, and to be approved and surveyed in accordance with Chapter 3, PART ONE of the Rules for Classification of Sea-going Steel Ships.

3.5 Washwater treatment units

3.5.1 The EGC system is to be provided with specialized washwater treatment units to carry out oxidation, deposition, separation of the desulfurized washwater in order to meet the discharge criteria specified by the Guidelines for Survey of EGC systems.

3.5.2 The capacity of washwater treatment units is to be sufficient to treat the amount of residue generated at the design working condition of the EGC system.

3.5.3 A washwater discharge monitoring system is to be provided according to the requirements of the Guidelines for Survey of EGC systems. The washwater is to be monitored prior to discharge and can only be discharged when the results are satisfactory.

Note: Chapter 8 of the Guidelines for Survey of EGC systems specifies washwater discharge criteria, including pH, PAH, turbidity and nitrates, as well as the monitoring and recording requirements for the above mentioned discharge indicators.

3.5.4 The washwater treatment units and their components are to be provided with suitable pressure release devices to prevent possible overpressure.

3.5.5 The installation and arrangement of the filters are to ensure continuous operation of the EGC system during cleaning and replacement.

3.5.6 Residues generated after the treatment of the washwater are to be stored and disposed of according to 2.9 of the Guidelines.

Chapter 4 Control, monitoring and safety protection

4.1 General requirements

4.1.1 The control, monitoring and safety systems are to comply with the provisions of Chapters 1 and 2, PART SEVEN of CCS Rules in addition to satisfying the requirements of this Chapter.

4.1.2 The desulfurization units are to be configured in accordance with the requirements of the Guidelines for Survey of EGC systems in addition to be provided with monitoring, alarm and safety protection in accordance with 4.2 of this Chapter.

4.2 Control, monitoring and safety systems

4.2.1 The desulfurization system is to be capable of automatic control operation and be provided with means for manual operation to ensure the working parameters of the EGC system and relevant fuel oil combustion units are maintained within the specified limits.

4.2.2 The monitoring and safety protection items of the EGC system are to be determined according to the results of the risk analysis. In general, monitoring, alarm and indication can be set up according to the requirements of Table 4.2.2. The control station of the EGC system is to be provided with relevant alarms and indications.

4.2.3 Emergency shutdown devices are to be provided in the local control station and central control room (if any) to stop the operation of the system and open the exhaust gas bypass (if fitted). The shutdown of the EGC system is not to affect the reliable operation of the FOCUs.

4.2.4 Where the remote control system (if any) fails, or in emergency, the EGC system is to be capable of being controlled and monitored locally. Important parameters required for the safe operation of the system as well as the working condition of the equipment are to be indicated in the local control station.

4.2.5 Upon activation of the safety shutdown system, alarms are to be given at the normal control position and at the local control position. Means are to be provided to indicate the parameters causing shutdown. In the event where shutdown by the safety shutdown system is activated, the restart should not occur automatically, unless after the system is manually reset.

Monitoring, alarm and safety protection **Table 4.2.2**

Monitored Parameters	Display	Alarm Activated	Automatic Shutdown and Bypass①
Exhaust gas booster fan, where provided	Running	Stop②	
Exhaust gas bypass or isolation, where provided	Position		
Control-actuating medium of the exhaust gas bypass or isolation valves	Running	Failed	
Exhaust gas temperature before scrubber	X	High	
Exhaust gas temperature after scrubber	X	High	X (High-High)
Differential pressure of exhaust gas across EGC unit③	X	High	X (High-High)
Washwater pumps and/or alkali solution/serous fluid pumps	Running	Stop②	
Washwater and alkali solution/serous fluid supply pressure	X	Low②	X (Low-Low)

Monitored Parameters	Display	Alarm Activated	Automatic Shutdown and Bypass①
Washwater and alkali solution/serous fluid supply temperature	X	High	
Water level in scrubber, if applicable	X	High	X (High-High)
Alkali storage tank temperature	X	Low/High	
Alkali storage tank level	X	Low/High	
Alkali system drip tray level, if applicable	X	High④	
Residue tank level	X	High	
Control, alarm and safety system power supply	Running	Failed	
Emergency shutdown	X	X	X

Notes: ① If the EGC unit is not suitable for working in the dry condition, the exhaust gas is to be automatically bypassed after shutdown.

② Standby fans or pumps are to be activated, where fitted. Otherwise automatic shutdown is to be activated and exhaust gas is to be bypassed.

③ Alarm is to be given before the backpressure exceeds the allowed maximum value of the FOCU.

④ Alarm is to be given after alkali leakage is detected and the supply of alkali is to be cut off automatically as required by 2.6.8(7).

Chapter 5 Operation manual

5.1 General requirements

5.1.1 The ship is to carry the EGC system operation manual onboard specifying procedures and plans for system operation, inspection, maintenance, safety, etc.

5.1.2 The manual is generally to include the following aspects:

(1) procedures and plans related to the operation, inspection, maintenance of the EGC system;

(2) procedures and plans related to routine testing and maintenance of the monitoring and safety system;

(3) special notes related to the bunkering, storage and usage of the chemical substances intended for the EGC system;

(4) working conditions and limitations related to the operation of the EGC system;

(5) emergency procedures.

5.2 Emergency procedures

5.2.1 Emergency procedures corresponding to the failures likely to occur during operation of the EGC system are to be developed, such as operation procedures and responsible person in case of emergency shutdown, exhaust bypass and isolation, washwater/alkali leakage, so as to reduce the impact on the safety operation of the ship and related FOCUs in so far as practicable.