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GUIDELINES FOR SO_x SCRUBBER SYSTEMS

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CHAPTER 1 GENERAL

1.1 Application

1.1.1 These guidelines provide requirements on the arrangement and system designs for exhaust gas cleaning systems (EGC systems) primarily designed for removal of SO_x emissions, or SO_x scrubbers, as they are common known. These guidelines also apply to ships which, during the new-building phase, are planned and partly prepared for later installation of an EGC systems for the removal of SO_x.

1.1.2 In addition to the requirements in these guidelines, the construction, control systems, tests, inspections and certification procedures related to SO_x scrubber are to comply with IMO Res. MEPC.259(68) "2015 Guidelines for Exhaust Gas Cleaning Systems", adopted on 15 May 2015, as amended.

1.1.3 Environmental protection notation **SO_x Scrubber** may be assigned to ships equipped with SO_x scrubbers in accordance with the requirements given in these guidelines.

1.1.4 Environmental protection notation **SO_x Scrubber Ready** may be assigned to ships for compliance with the requirements as the time of contract for construction of the new-building and verifies the ship's suitability for the future SO_x scrubber installation. The SO_x scrubber system shall comply with this guidelines, CR Rules for the Construction and Classification of Steel Ships (hereinafter referred to as the Rules) and statutory requirements in force at time of installation, regardless of SO_x Scrubber Ready notation.

- (a) The scheme for verification of SO_x Scrubber Ready notation is to include the following:
- (i) Phase I: Preliminary Design Review (refer to 1.3.2(a))
 - (ii) Phase II: General Design Assessment (refer to 1.3.2(b))
 - (iii) Phase III: Detail Design Approval (refer to 1.3.2(c))

Additional verification extent may be included, wherein further preparations of the ship for a later conversion can be included, up to full review of the scrubber documentation according to these guidelines and certification and installation of piping and sub-systems.

- (b) The notation requires pre-selection of a SO_x scrubber manufacturer, based on agreement between owner and shipyard. This system may however be substituted with a similar system at time of conversion, under special considerations. The scrubber manufacture used as basis for the notation should not be a prototype or in other ways be of a novel design, unless the design has been qualified by a recognized organization acceptable to the Society.

1.2 Definitions

1.2.1 "Fuel Oil Combustion Unit (FOCU)" means any engine, boiler, gas turbine, or other fuel oil fired equipment, excluding shipboard incinerators.

1.2.2 "MSDS" means Material Safety Data Sheet. Sometimes referred to as Safety Data Sheet (SDS) or Product Safety Data Sheet (PSDS).

1.2.3 "SO_x" means sulphur oxide.

1.3 Plans and Data to be Submitted

1.3.1 Following plans and specifications covering the SO_x scrubber arrangements are to be submitted:

- (a) General arrangement of the SO_x scrubber installation, layout, and systems
- (b) Documentation detailing the SO_x scrubber specification
- (c) Analyses demonstrating compatibility of the scrubber with the FOCUs
- (d) Hull plans showing the foundation and attachments to the ship's structure, including scantlings, welding details, and foundation details of principal components
- (e) Documentation detailing the effect on Load Line and Stability of the SO_x scrubber system
- (f) Material specifications for the scrubber unit, pumps, valves, storage tanks, process tanks, residue tanks, piping, distribution systems, separators, and associated components, including a corrosion assessment detailing the corrosive effect of system liquids, vapors, and gases on the materials used in the system
- (g) Arrangement and capacity of tanks for storage, chemicals, process washwater, exhaust gas cleaning residues, etc.
- (h) Details of all piping systems (e.g. washwater, chemical treatment and residue), including details of piping and associated components, design pressures, temperatures, insulation, and drip trays, where applicable
- (i) Descriptions and schematic diagrams for the control and monitoring systems, including set points for abnormal conditions and details of the location and position at which exhaust emission monitoring and washwater monitoring are to be located
- (j) Details of all electrical equipment installed for the SO_x scrubber unit and associated systems, including computer-based systems
- (k) Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the SO_x scrubber
- (l) Emergency shutdown arrangements
- (m) SO_x scrubber unit FMEA integration test report
- (n) Operating and maintenance instruction manuals, including MSDS sheets and details for handling of hazardous and non-hazardous chemicals used in the system
- (o) Testing procedures during installation and commissioning trials

1.3.2 Documentation for SO_x Scrubber Ready

The scheme for verification of **SO_x Scrubber Ready** notation is separated into three Phases (Phase I, II, and III). In general, the extent of Phase III covers Phase II and Phase II covers Phase I. However, when requested by the Owner,

the specific design group(s) could be reviewed in accordance with the corresponding requirements given in Phase III during Phase I or Phase II. The definitions of design groups and their associated descriptive letters are as follows.

- Hull structural arrangement and reinforcement (descriptive letter **SR**)
- SOx scrubber system configuration and ship integration (descriptive letter **SC**)
- Exhaust gas system arrangement (descriptive letter **EG**)
- Washwater system arrangement (descriptive letter **W**)
- Chemical treatment system arrangement (descriptive letter **CT**)
- Residue System (descriptive letter **R**)

If the ship is in compliance with all the requirements specified in Phase III (see 1.3.2(c)) which covers 6 design groups requirements, the notation and the character (III) will be assigned to the ship, e.g. **SOx Scrubber Ready-III**.

If the ship is in compliance with the requirements of specific design group(s) during Phase I or II, the character (I or II) followed by the notation and the descriptive letter(s) in parentheses may be assigned to the ship, e.g. **SOx Scrubber Ready-I (SR)**.

The documentation including plans and specifications for SOx Scrubber Ready notation is to be submitted according to each phase as mentioned below. The submitted documentation is to be reviewed in accordance with Chapter 2 to Chapter 4 and to be surveyed in accordance with Chapter 5.

(a) Phase I: Preliminary Design Review

The purposes of Phase I is to evaluate the basic suitability of a particular ship design to be capable of future installation of a SOx scrubber system for emission removal. Basic suitability includes the reserved spaces and the arrangement of the ship for encompassing the necessary equipment and the associated systems of SOx scrubber system.

The following documentation is to be submitted for review during Phase I.

- (i) General arrangement of the ship
- (ii) General description and schematic diagram of applied SOx scrubber system
- (iii) Arrangement of the machinery space including SOx scrubber system equipment
- (iv) General arrangement of the SOx scrubber installation, layout, and systems
- (v) Arrangement and capacity of tanks for storage, chemicals, process washwater, exhaust gas cleaning residues, etc.
- (vi) Schematic diagram for electrical, control, alarm, and monitoring system
- (vii) Exhaust gas system arrangement
- (viii) Washwater system arrangement (if applicable)
- (ix) Chemical treatment system arrangement (if applicable)
- (x) Preliminary study on Load Line and Stability in relation to the effect of the SOx scrubber system installations and arrangement

Where the ship is in compliance with the requirements of Preliminary Design Review, the character (I) will be assigned after the Notation **SOx Scrubber Ready**, e.g. **SOx Scrubber Ready-I**.

If the ship is in compliance with the requirements of specific design group(s) in Phase III during Phase I, the descriptive letter(s) for the specific design group(s) may be assigned in parentheses after the notation **SOx Scrubber Ready**, e.g. **SOx Scrubber Ready-I (SR)**.

(b) Phase II: General Design Assessment

During Phase II, it is categorized in separate design groups as (i) to (vi) below. The design details to be reviewed for each system would be general. Detailed information such as particular equipment manufacturers and installations are not required except for the SOx scrubber.

For new-building ships, the drawings and supporting documentation shall be reviewed for compliance with the Rules for ships having the same applicability date as the Rules applied for the classed ship.

The requirements for washwater chemical treatment system described in this guidelines are based on the use of Caustic Soda (NaOH) solution. If other chemicals to be used, the requirements should be consistent with the intent of the requirements for NaOH but would need to be assessed on a case-by-case basis.

The following documentation is to be submitted for assessment during Phase II.

- (i) Hull structural arrangement and reinforcement
 - (1) Hull structural arrangement where the SO_x scrubber unit is encompassed
 - (2) SO_x scrubber unit foundation and attachments to the ship's structure
 - (3) Hull reinforcement for accommodating the SO_x scrubber unit
- (ii) SO_x scrubber system configuration and ship integration (refer to Chapter 2)
 - (1) Specifications for SO_x scrubber and Fuel Oil Combustion Units (FOCU)
 - (2) Compatibility analysis of the SO_x scrubber with FOCU
 - (3) General arrangement of the SO_x scrubber installation and auxiliary equipment
 - (4) Schematic diagram for SO_x scrubber system
 - (5) Electrical load analysis
 - (6) Schematic diagram and description of control and monitoring systems
 - (7) Emergency shutdown arrangement
 - (8) Description of the redundancy configuration
 - (9) Documentation detailing the effect on Load Line and Stability of the SO_x scrubber system, in accordance with 2.7.1.
- (iii) Exhaust gas system (refer to 3.2.1)
 - (1) Exhaust gas piping system including piping diagram and associated components
 - (2) Exhaust gas SO_x scrubber and SO_x scrubber piping insulation
 - (3) Exhaust gas isolation and bypass valves arrangement
- (iv) Washwater system (refer to 3.2.2)
 - (1) Washwater piping system including piping diagram and associated components
 - (2) Arrangement and capacity of tanks for storage and washwater processing
 - (3) SO_x Scrubber washwater supply and overboard discharge arrangement
 - (4) Sea chest arrangement and capacity
- (v) Chemical treatment system, if applicable (refer to 3.2.3)
 - (1) Chemical treatment piping system including piping diagram and associated components
 - (2) Arrangement and capacity of the NaOH storage tank and NaOH overflow tank
 - (3) General arrangement of NaOH bunker station system
- (vi) Residue system (refer to 3.2.4)
 - (1) Residue system including piping diagram and associated components
 - (2) Arrangement and capacity of EGC residue tank

Where the ship is in compliance with the requirements of Phase II, the character (II) will be assigned after the Notation **SO_x Scrubber Ready**, e.g. **SO_x Scrubber Ready-II**.

If the ship is in compliance with the requirements of specific design groups in Phase III during Phase II, the descriptive letter for specific design group may be assigned in parentheses after the notation **SO_x Scrubber Ready**, e.g. **SO_x Scrubber Ready-II (SR, EG)**.

(c) Phase III: Detail Design Approval

Phase III is the final step for SO_x Scrubber Ready and incorporates both the detailed drawings approval and the installation of specified equipment onboard the ship. The design groups in this Phase are the same as

Phase II. If the ship is in compliance with the requirements of each design group listed below during Phase I or Phase II, the descriptive letter(s) for the specific design group(s) may be assigned in parentheses after the notation **SOx Scrubber Ready**.

The following documentation is to be submitted for assessment during Phase III.

- (i) Hull structural arrangement and reinforcement (descriptive letter **SR**)
 - (1) Detailed hull drawings for the space where the SOx scrubber unit is encompassed
 - (2) SOx scrubber foundation and attachments to the ship's structure including scantling, welding details.
 - (3) Detailed drawings for the foundation of principal components
 - (4) Strength analysis for SOx scrubber foundation and supporting structures under both static and dynamic load due to ship's movement (if applicable)
 - (5) Details of the sea chest for suction and overboard discharge arrangements
 - (6) Material specifications for major structures, weld procedure
- (ii) SOx scrubber system configuration and ship integration (descriptive letter **SC**) (see Chapter 2)
 - (1) Documentation detailing the SOx scrubber and Fuel Oil Combustion Units specification
 - (2) Analyses demonstrating compatibility of the SOx scrubber with FOCU (refer to 2.2)
 - (3) Details of all electrical equipment installed for the SOx scrubber unit and associated systems, including computer-based systems
 - (4) Material specifications for the SOx scrubber unit, pumps, valves, storage tanks, process tanks, residue tanks, piping, distribution systems, separators, and associated components, including a corrosion assessment detailing the corrosive effect of system liquids, vapors, and gases on the materials used in the SOx scrubber system
 - (5) Descriptions and schematic diagrams for the control and monitoring systems, including set points for abnormal conditions and details of the location and position at which exhaust emission monitoring and washwater monitoring are to be located
 - (6) Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the SOx scrubber (refer to 4.1.2)
 - (7) Electrical load analysis
 - (8) Emergency shutdown arrangement
 - (9) Documentation detailing the redundancy configuration (refer to 3.1.1 and 3.1.5(b))
 - (10) Operating and maintenance instruction manuals, including MSDS sheets and details for handling of hazardous and non-hazardous chemicals used in the SOx scrubber system
 - (11) Documentation detailing the effect on Load Line and Stability of the SOx scrubber system, in accordance with 2.7.1
 - (12) Testing procedures during installation and commissioning trials
- (iii) Exhaust gas system arrangement (descriptive letter **EG**) (refer to 3.2.1)
 - (1) Details of exhaust gas piping system and associated components, materials, design pressures, temperatures, insulation, isolation and bypass valves arrangement
- (iv) Washwater system arrangement (descriptive letter **W**) (refer to 3.2.2)
 - (1) Arrangement and capacity of tanks for storage and washwater processing
 - (2) Details of washwater piping system and associated components, materials, design pressures, temperatures, and drip trays, where applicable
 - (3) Sea chest arrangement and capacity
 - (4) SOx Scrubber washwater supply and overboard discharge arrangement
- (v) Chemical treatment system arrangement (if applicable) (descriptive letter **CT**) (refer to 3.2.3)
 - (1) Arrangement and capacity of the NaOH storage tank and NaOH overflow tank
 - (2) Details of chemical treatment piping system and associated components, design pressures, temperatures, and drip trays, where applicable

- (3) General arrangement of NaOH bunker station system
- (4) Tank filling, vents, sounding, and overflow arrangement
- (5) Ventilation arrangement for the location of NaOH storage and overflow tank
- (vi) Residue System (descriptive letter **R**) (refer to 3.2.4)
 - (1) Details of residue piping system and associated components, materials, design pressures, temperatures, and drip trays, where applicable
 - (2) Arrangement and capacity of EGC residue tank
 - (3) Tank vents and sounding arrangement

Where the ship is in compliance with all of requirements of Phase III, the character (III) will be assigned after the Notation **SOx Scrubber Ready**, e.g. **SOx Scrubber Ready-III**.

CHAPTER 2 DESIGN REQUIREMENTS

2.1 General Requirements

2.1.1 In addition to the requirements in these guidelines, pipes, valves, pipe fittings, auxiliaries, etc. are to satisfy corresponding requirements of the Rules for the Construction and Classification of Steel Ships (hereinafter referred to as the Rules).

2.1.2 SO_x scrubber systems are to be designed to enable continued operation of the FOCU at the times the SO_x scrubber system is not in operation, either through operational selection, equipment failure, or system deterioration through partial blocking/clogging, or be designed with suitable exhaust bypass arrangements to enable continued operation of the FOCU.

2.1.3 The exhaust systems from a number of fuel oil combustion units may be led to a common SO_x scrubber unit, sometimes known as an integrated scrubber.

2.1.4 The response of the mechanical and electrical systems of the first SO_x scrubber unit in a particular design series is to be demonstrated by the FMEA integration test of 2.9.

2.2 Compatibility with Fuel Oil Combustion Units

2.2.1 Installation and operation of an SO_x scrubber system is to be compatible with the fuel oil combustion unit(s) and not to cause any adverse effects on the FOCU performance such as excessive back pressures or temperatures during operation.

2.2.2 Details are to be submitted demonstrating the exhaust flow compatibility of the SO_x scrubber unit with the connected fuel oil combustion unit(s) over the whole operational range of the fuel oil combustion units. This data should demonstrate that the operating parameters of the oil burning units do not exceed the approved design limits with the SO_x scrubber system in operation.

2.2.3 It is to be noted that SO_x scrubber systems that cause diesel engines to operate outside the exhaust backpressure limits detailed in the approved MARPOL Annex VI Regulation 13 Technical Files may invalidate the emissions certification and will require a re-approval of the engine NO_x certification by the Administration or Recognized Organization responsible for the original certification.

2.3 Redundancy

2.3.1 Redundancy of equipment is to be provided for those rotating and reciprocating components such as pumps, fans, blowers, etc. that form part of the SO_x scrubber unit essential supplementary systems.

2.3.2 Consideration will be given to alternative means of compliance or operation to meet this objective on a case-by-case basis. The provision of adequate fuel tank capacity for low sulfur fuels, alternative operating modes or carriage of sufficient spare parts onboard are examples of ship specific arrangements that may be considered by CR as meeting this objective and should be justified with reference to the FMEA.

2.4 Exhaust Bypass/Dry Running of Scrubbers

2.4.1 SO_x scrubber units that incorporate a wet washwater scrubbing process are to be capable of being operated without the washwater system in operation, without sustaining thermal damage, or are to be installed with an exhaust bypass arrangement or changeover system to enable continued operation of the fuel oil combustion units in the event the SO_x scrubber system is not in operation, either through operational selection or equipment failure. As applicable, evidence of material suitability is to be submitted for dry running of SO_x scrubbers.

2.5 Prevention of Fuel Oil Combustion Unit Flooding

2.5.1 For SO_x scrubber units that incorporate a wet washwater scrubbing process, arrangements are to be provided to prevent the ingress of scrubber washwater into the fuel oil combustion unit under any circumstance. In general, the design of the inlet exhaust piping is to be arranged to prevent direct free flow of washwater back to the FOCU.

2.5.2 Monitoring, alarm, and shutdown arrangements are to be provided to prevent an abnormal rise of washwater level in the scrubber reaction chamber.

2.6 Inclination

2.6.1 SO_x scrubber systems are to be designed for proper operation at the inclination requirements of 1.6.1 of Part IV of the Rules.

2.7 Ship Stability

2.7.1 For those existing ships fitting an SO_x scrubber system as a retrofit conversion, a revision of the stability calculations may need to be made based on the additional weights of the SO_x scrubber system and increased wind profile. In general, if the change in lightship displacement exceeds 2% (excluding any certified weights, if any) of the lightship displacement from the most recent approved lightship data and/or the change in lightship Longitudinal Center of Gravity (LCG), relative to the most recent approved lightship data, exceeds 1.0% of the Length Between Perpendiculars (LBP), a stability test may be required on the ship and stability calculations would need to be revised to indicate the changes. Where a ship is within these limits, immediate update of the Stability Booklet may not be required if there is sufficient margin in the conditions contained in the booklet. In this case, the principal particular page would need to be updated, and the ship would be required to use the latest lightship properties when assessing new conditions.

2.7.2 Documentation detailing the effect of the SO_x scrubber system on Load Line and Stability is to be submitted.

2.8 Inspection and Maintenance

2.8.1 SO_x scrubber systems are to be arranged for easy inspection and maintenance with at least one inspection port available for internal inspection of the main reaction chamber, and where applicable, the ability to replace internal components is to be provided

2.9 Failure Modes and Effects Analysis (FMEA) Integration Test

2.9.1 An integration test is to be undertaken on the first SO_x scrubber unit in a particular design series to verify that the operation and response of the complete SO_x scrubber mechanical and electrical systems are as predicted for all operational modes. The scope of these tests is to be determined based on the FMEA required by 4.1.2.

CHAPTER 3 SO_x SCRUBBER SYSTEM

3.1 Equipment

3.1.1 Pumps and fans

- (a) Where provided, SO_x scrubber washwater, circulation, discharge, etc., pumps, essential for the continual operation of the SO_x scrubber system, are to be tested and certified in accordance with relevant requirements of the Rules. This is applicable to SO_x scrubber systems connected to fuel oil combustion units rated at 2250 kW and above or diesel engines having cylinders of more than 300 mm bore.
- (b) Unless alternative means of compliance in accordance with 2.3 are applicable, redundant washwater, circulation, discharge, etc., pumps, essential for the continual operation of the SO_x scrubber water systems, 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 SO_x scrubber system at full rating.

For ships fitted with two or more identical SO_x scrubber systems, the provision of a common standby pump (for each essential system) capable of serving all SO_x scrubber units will suffice rather than providing individual standby pumps for each SO_x scrubber unit.

- (c) Unless alternative means of compliance in accordance with 2.3 are applicable and where exhaust fans form part of the SO_x scrubber system and are essential for continual operation of the system at full rating, such fans are to be installed in a redundant arrangement. The number and power of the fans should be such that if one fan, or a group of fans, is out of service, the capacity of the remaining fan(s) is not to be less than 100% of the total required.

3.1.2 Exhaust plume heaters

- (a) Where provided, heat exchangers are to be designed, constructed, and certified in accordance with relevant requirements of Part V of the Rules.
- (b) Where the introduction of hot air to the exit exhaust gases is used on SO_x scrubber systems, the details of this auxiliary system are to be submitted for review and approval on a case-by-case basis.

3.1.3 Chemical treatment system

- (a) The specific requirements for chemical treatment system components are given under 3.2.3.

3.1.4 Dry scrubber consumable handling equipment

- (a) For dry type SO_x scrubber systems, details of the granulate supply and discharge systems are to be submitted.
- (b) Unless alternative means of compliance in accordance with 2.3 are applicable, drive arrangements for the exhaust cleaning reductant consumable are to be arranged in a redundant arrangement.

3.1.5 Electrical system

The electrical system and electrical equipment (e.g. electrical motors and controllers) are to satisfy corresponding requirements of Part VII of the Rules.

(a) Electrical load analysis

The number and capacity of generators are to be sufficient under normal seagoing conditions with one generator in reserve to carry those loads for essential services, which include the scrubber system, and for minimum comfortable conditions of habitability.

(b) Standby pump/fan arrangements

(i) In the event of failure of the essential SO_x scrubber system pumps or fans, the standby pump or fan required by 3.1.1, where provided, is to be automatically started and put into service. This failure is to be alarmed at the local and remote control station(s), as applicable.

(ii) Where provided, each standby pump or fan is to be fed from separate sections of the switchboard such that in the event of failure of one section of the switchboard the standby pump or fan may be fed from the other separate section of the switchboard.

(c) Circuit protection devices and compatibility

Circuit breakers are to be installed for miscellaneous SO_x scrubber system electrical loads and are to be compatible with the prospective short circuit current level calculated at the switchboards.

3.2 Piping Systems

3.2.1 Exhaust gas piping systems

(a) Exhaust gas piping materials located before the SO_x scrubber unit may be of the same material specification as the standard exhaust gas piping.

(b) Exhaust gas piping materials used after the SO_x scrubber unit are to be of a corrosion resistant material such as stainless steel.

(c) The exhaust piping systems for SO_x scrubber systems are to satisfy corresponding requirements of Part VI of the Rules.

(d) Exhaust gas piping and piping components constructed of non-metallic materials are to be specifically approved for their intended application.

(e) Hot surfaces of SO_x scrubber units or their associated equipment or systems likely to come into contact with the crew during operation are to be suitably guarded or insulated. Where the surface temperatures are likely to exceed 220 °C and where any leakage, under pressure or otherwise, of fuel oil, lubricating oil, or other flammable liquid is likely to come into contact with the SO_x scrubber unit or exhaust pipes, these surfaces are to be suitably insulated with non-combustible materials that are impervious to such liquids. Insulation material not impervious to oil is to be encased in sheet metal cladding or an equivalent impervious sheath.

3.2.2 Washwater piping systems

(a) The piping material for the corrosive scrubber washwater system is to be selected based on the corrosive nature of the liquid media.

- (b) Pipes and piping components made of thermoplastic or thermosetting plastic materials, with or without reinforcement, may be used in piping systems subject to compliance with the requirements of 2.8 of Part VI of the Rules. For the purpose of these guidelines, "plastic" means both thermoplastic and thermosetting plastic materials, with or without reinforcement, such as polyvinyl chloride (PVC) and fiber reinforced plastics (FRP). Plastic washwater piping is to meet Level 3 fire endurance testing requirements (see 2.8.4 of Part VI of the Rules)
- (c) Flexible hoses are to comply with the requirements of 2.9 of Part VI of the Rules.
- (d) The overboard discharges of any SO_x scrubber system are not to be interconnected to other systems.
- (e) Due consideration is to be given to the location of overboard discharges with respect to ship propulsion features, such as thrusters or propellers.

3.2.3 Chemical treatment piping systems

The requirements for the washwater chemical treatment system detailed in this subsection are based on the use of Caustic Soda (NaOH) solution. If other chemicals are to be used, the requirements should be consistent with the intent of the requirements for Caustic Soda but would need to be assessed on a case-by-case basis.

The requirements detailed below are also based on an arrangement whereby the SO_x scrubber residue tank is also used as an overflow tank for the NaOH storage tank. Arrangements that separate these functions into separate tanks may be applied, and in which case, the requirements for the overflow tank are detailed in 3.2.3 and the requirements for the residue tank in 3.2.4.

- (a) Material for piping systems, NaOH storage tank and SO_x scrubber residue/NaOH overflow tank
The material of the NaOH related piping systems, NaOH storage tank, SO_x scrubber residue/NaOH overflow tank, drip trays, and any other components which may come into contact with the NaOH solution or sludge is to be of a suitable grade of stainless steel or other corrosion-resistant material established to be suitable for the application. Aluminum, zinc, brass, or galvanized steel components are not to be used.
- (b) Bunkering of NaOH
 - (i) The bunker station(s) for NaOH 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 NaOH contacting or mixing with other incompatible materials. Alternatively, closed or semi-enclosed bunker stations may be approved subject to the provision of effective ventilation.
 - (ii) Spill trays, which may be of the dry type or having means of drainage to the SO_x scrubber residue/NaOH overflow tank, are to be provided.
- (c) Arrangement of the NaOH storage tank and SO_x scrubber residue/NaOH overflow tank
 - (i) General
The NaOH storage and SO_x scrubber residue/NaOH overflow tank are not to be situated where spillage or leakage there from can constitute a hazard by falling onto combustibles or heated surfaces. In particular, these tanks are not to be located over boilers or in close proximity to steam piping (supply or returns).
Where necessary, the NaOH storage tank is to be provided with an appropriate heating system to prevent freezing.
 - (ii) Filling
The NaOH storage tank is to be provided with a fill line from the bunker station, and a shutoff valve is to be provided at the bunkering station.

Overflow and/or drains leading to the SO_x scrubber residue/NaOH overflow tank are to enter at or near the top of the tank. However, if this is determined to be impracticable, these lines are to be fitted with a non-return valve at the SO_x scrubber residue/NaOH overflow tank.

(iii) Vents

The NaOH storage and SO_x scrubber residue/NaOH overflow tanks are to be provided with vent pipes complying with 3.2 of Part VI of the Rules, and the outlets are to terminate in a safe location in the weather.

The vents that are open to the weather should not be subject to deterioration due to the concentrations involved, and the arrangement is to be such that the potential source of moisture from the vents does not present any danger to the crew or ship. Alternatively, the tanks are to be fitted with appropriately sized pressure/vacuum valves.

(iv) Overflow protection

Means are to be provided to prevent NaOH from spilling or accidentally overflowing from the storage and SO_x scrubber residue/NaOH overflow tanks. Accordingly, the NaOH storage tank is to be fitted with a high level alarm. Alternatively, the NaOH storage tank may be fitted with an overflow arrangement complying with 3.2 of Part VI of the Rules that is led to the SO_x scrubber residue/NaOH overflow tank. Further, in all cases, the SO_x scrubber residue/NaOH overflow tank is to be fitted with a high level alarm. Other anti-spilling arrangements may be considered on a case-by-case basis.

(v) Sounding

Sounding arrangements are to be provided for the NaOH storage and SO_x scrubber residue/NaOH overflow tanks, and are to comply with the sounding requirements applicable to fuel oil tanks of 3.4 of Part VI of the Rules.

A sight glass is not to be used unless the materials of construction are compatible with the concentration of caustic soda solution involved, it is well protected from mechanical damage, and the arrangements are equivalent to that of flat "glass-type" fitted with a self-closing valve at each end.

In addition to local level gauging, the NaOH storage and SO_x scrubber residue/NaOH overflow tanks are to have remote level gauging indication at the manned control station.

(vi) Temperature indication

The NaOH storage and SO_x scrubber residue/NaOH overflow tanks are to be provided with local and remote temperature monitoring arrangements. The remote temperature indication is to be installed at the manned control station.

(d) Spill trays

(i) Those areas of the NaOH storage and SO_x scrubber residue/NaOH overflow tanks that could result in leakage, locations where leakage from pumps and other associated equipment such as strainers, heaters, flanges, valves, etc., which may require occasional dismantling for examination or maintenance may occur, and where leakage may otherwise normally be expected are to be located within spill trays.

(ii) Either drainage arrangements for the spill tray that lead to the dedicated SO_x scrubber residue/NaOH overflow tank are to be provided or arrangements to activate an alarm in the event of spillage are to be provided. Where drainage arrangements are provided, the drain line to the SO_x scrubber residue/NaOH overflow tank is to be fitted with a non-return valve.

(e) Miscellaneous piping arrangements

(i) The NaOH piping systems are to be independent of other ship service piping and/or systems.

(ii) Piping systems for NaOH systems are not to be located in accommodation, service, or control spaces.

(iii) Every pipe emanating from a tank containing NaOH, which, if damaged, would allow NaOH to escape from the tank, is to be provided with a positive closing valve located directly on the tank. The positive closing valve is to be provided with means of closure both locally and from a readily accessible and safe position outside of the space.

- (iv) The pipe joints 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.
 - (v) Supply, bunkering and transfer lines for NaOH systems are not to be located over boilers or in close proximity to steam piping, exhaust systems, hot surfaces required to be insulated, or other sources of ignition.
- (f) Ventilation arrangements
- (i) The NaOH storage and SO_x scrubber residue/NaOH overflow tanks may be located within the engine room or in a separate compartment. In either location, the area is to be served by an effective mechanical exhaust ventilation system with ventilation inlets located where any vapors would be expected to accumulate. In addition, if located in a separate compartment, the ventilation system is to be capable of being controlled from outside the compartment.
- (g) Personnel protection
- (i) For the protection of crew members, the ship shall have on board suitable protective equipment consisting of large aprons, rubber gloves with long sleeves, rubber boots, coveralls of chemical-resistant material, and tight-fitting chemical safety goggles or face shields or both. The protective clothing and equipment shall cover all skin so that no part of the body is left unprotected. An eyewash and safety shower should be nearby.
- (h) Safety notices
- (i) Safety instructions relating to precautions and corrective response actions are to be posted in the compartment containing NaOH, and beside the entrance to the compartment. Detailed guidelines given in the MSDS are to be followed.

3.2.4 Residue systems

- (a) 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.
The SO_x scrubber residue tank is to be designed to facilitate cleaning.
Where SO_x scrubber residue tanks used in closed loop chemical treatment systems are also used as the overflow tank for the NaOH storage tank, the additional requirements of 3.2.3 are to be applied.
- (b) The material of the SO_x scrubber residue tank is to be selected based on the corrosive nature of the residue.
- (c) The capacity of the SO_x scrubber residue tank is to be based on the expected residue volumes applicable to the number and type of installed SO_x scrubbers and the maximum period of voyage between ports where residue can be discharged. In the absence of precise data, a figure of 30 days is to be used.
- (d) The SO_x scrubber residue tank is to be provided with vent pipes complying with 3.2 of Part VI of the Rules.
- (e) The residue tank is to be arranged with a high level alarm.
- (f) Sounding arrangements are to be provided for the SO_x scrubber residue tank in accordance with 3.4 of Part VI of the Rules.

- (g) For those ships that do not undertake onboard incineration and collect all engine room sludge for disposal ashore, consideration will be given to arrangements utilizing a combined engine room sludge and SO_x scrubber residue tank, provided the tank meets the requirements of 3.2.4(a) through (f), SO_x scrubber residue record logs satisfy the requirements of MEPC. 259(68), and residues are disposed at MARPOL reception facilities.

Combined engine room sludge and SO_x scrubber residue tanks are to be sized to provide adequate capacity based on the sludge tank capacity requirements of the Rules plus the capacity requirements for SO_x scrubber residue tanks of 3.2.4(c).

CHAPTER 4 CONTROL, ALARM, AND MONITORING SYSTEMS

4.1 General

4.1.1 The control system for the SO_x scrubber system may be connected to an integrated control system or may be a standalone system

4.1.2 The system is to be designed such that a single fault of a component will not lead to a potentially dangerous situation for human safety and/or the ship. An FMEA, or equivalent, demonstrating the safety system design basis is to be submitted.

4.2 Control and Monitoring System

4.2.1 Automatic control, monitoring (including washwater discharge criteria), alarm, and safety functions are to be provided for the SO_x scrubber system so that operations remain within preset parameters for all fuel oil combustion unit(s) and SO_x scrubber system operating conditions. For ships with CAS or CAU notations, the alarm and monitoring systems are to be integrated in the ship's centralized monitoring systems that conform to the requirements for CAS or CAU notations

4.2.2 The temperatures, pressures, and flows in the SO_x scrubber system and associated systems are to be controlled and monitored as follows:

- (a) A local control and monitoring system for the SO_x scrubber system is to be provided to enable safe operation, maintenance, and effective control in the event of an emergency or failure of any remote controls.
- (b) The design of the control system is to provide identification of faults in the equipment, as well as the process system.
- (c) Indications of parameters necessary for the safe and effective operation of the exhaust emission abatement process are to be provided at the local and, as applicable, remote control station(s), as per Table 4-1, and are to include the following parameters:
 - SO_x scrubber system pump/fan/motor operational status
 - Status of any SO_x scrubber system valves
 - SO_x scrubber system parameters for operational safety
 - Level indication of SO_x scrubber system tanks/hoppers
 - Status of any SO_x scrubber system alarms, shutdowns and Emergency Stop
- (d) The computer-based control systems are to comply with the applicable requirements of the Rules.

4.2.3 The power supply arrangements for the control and monitoring system are to meet the requirements of 2.8 of Part VIII of the Rules.

4.3 Safety Shutdown System

4.3.1 An independent shutdown system is to be provided. This safety shutdown system is to be based on the following principles:

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

4.3.2 Monitoring and safety shutdowns are to be in accordance with Table 4-1.

Table 4-1 Monitoring and Safety System Functions for SO_x Scrubber Systems

Monitored Parameters	Display	Alarm Activated	Automatic Shutdown and Automatic Bypass ⁽¹⁾
Exhaust fan motors	Running	Stop ⁽²⁾	
Exhaust bypass or isolation valves, where provided	Position		
Control-actuating medium of the exhaust bypass or isolation valves	Running	Failed	
Exhaust gas temperature before SO _x scrubber unit	X	High	X (High-High)
Exhaust gas temperature after SO _x scrubber unit	X	High	X (High-High)
Exhaust gas pressure after FOCU unit	X	High	X (High-High)
Differential pressure across SO _x scrubber unit ⁽³⁾	X	High	X (High-High)
Washwater pumps, alkali system pumps or dry system feeder units	Running	Stop ⁽²⁾	
Washwater or alkali system valves	Position		
Control-actuating medium of the SO _x scrubber washwater and alkali system valves, where provided	Running	Failed	
SO _x scrubber system washwater and alkali system supply pressure	X	Low	X (Low-Low)
SO _x scrubber system washwater and alkali system supply temperature	X	High	X (High-High)
Water level in wet SO _x scrubber unit	X	High	X (High-High) ⁽⁴⁾
Alkali storage tank temperature	X	Low/High	X (High-High)
Alkali storage tank or dry silo level	X	Low/High	X (Low-Low)
Alkali system drip tray level	X	High	X (High-High) ⁽⁵⁾
SO _x scrubber residue tank level	X	High	X (High-High)
Control power supply	Running	Failed	
Emergency shutdown	X	X	X

Notes:

- (1) Automatic bypass of the SO_x scrubber unit is only applicable to those SO_x scrubber units not suitable for dry running (see 2.4)
- (2) Failure of essential SO_x scrubber system motors driving pumps, fans or feed systems is to activate the standby units, where fitted.
- (3) Applicable to dry scrubber type only.
- (4) Independent safety shutdown system as required by 4.3.
- (5) Automatic shutdown is to activate the close coupled alkali storage tank valves required by 3.2.3(e)(iii).

CHAPTER 5 SURVEYS DURING CONSTRUCTION

5.1 General

5.1.1 This subsection pertains to surveys during fabrication at the manufacturer's facility and installation and testing of SO_x scrubber units onboard. For surveys at the manufacturer's facility, the scope of the survey will be confined to only those items that are supplied by the manufacturer.

5.1.2 Surveys for SO_x Scrubber Ready

The survey of the systems and equipment installed on the ship for future SO_x scrubber system installation will be included in annual surveys and special surveys.

5.2 Surveys at Manufacturer's Facility

5.2.1 Survey requirements for equipment components and packaged units at the manufacturer's facility are to be in accordance with applicable requirements of the Rules. Reference can be made to Table 5-1.

5.3 Surveys During Installation

5.3.1 The following surveys are to be carried out to the satisfaction of the attending surveyor on the SO_x scrubber unit and associated systems during installation and testing:

- Inspection and verification that the foundations and attachments of the principal components of the SO_x scrubber unit and associated systems are in accordance with the approved plans and particulars.
- Piping systems are to be visually examined and pressure-tested, as required by Part VI of the Rules.
- Electrical wiring and connections are to be in accordance with Part VII of the Rules and checked for continuity and proper workmanship.
- Instrumentation is to be tested to confirm proper operation as per its predetermined set points.
- Pressure relief and safety valves installed on the unit are to be tested.
- Control system and shutdowns are to be tested for proper operation.
- The SO_x scrubber unit is to be checked for proper operation in accordance with the installation test procedure.

5.4 Surveys During Trials

5.4.1 During the initial commissioning trials, the SO_x scrubber unit is to be confirmed for its satisfactory operation, including associated controls, alarms, and shutdowns. The tests are to be conducted in accordance with the testing procedure during sea trials approved by the Society.

Table 5-1 Certification of SO_x Scrubber Systems at the Manufacturer's Facility

Cod	Explanation
DR	Design Review – Design review required.
MS	Manufacture Survey – Product is to be surveyed during fabrication stages by the Surveyor.
FS	Final Survey – Finished product is to be subject to final hydrostatic, nondestructive, operational testing, or any other required tests, and witnessed by the Surveyor at manufacturer's facility.

Equipment	DR	MS	FS
SO _x scrubber reaction chamber	X	X	X
Exhaust bypass or isolation valves	X		
Exhaust fans/motors	X		X
Heat exchangers	X		X
Water treatment system	X		X
Washwater, alkali system and essential SO _x scrubber system pumps	X		X
Washwater, alkali and SO _x scrubber residue associated piping	X		
Control system	X		
Automatic shutdown and safety system	X		

Notes:

- (1) This table has been prepared for guidance only and annotated to agree with the Rules. The list is not to be considered exhaustive; should additional equipment not listed be fitted onboard, same will be subject to special consideration for compliance with the Rules. This list is not to be considered as substitutive or integrative of the content of the Rules and/or other applicable regulations. In case of conflict between the content of this list and the Rules and other applicable regulations, the latter are to be considered applicable.