



GUIDE FOR

EXHAUST EMISSION ABATEMENT

JANUARY 2018

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Foreword (2018)

International, regional, national and local air emissions legislation is driving the development of primary engine technologies and secondary exhaust emissions abatement systems to reduce exhaust emissions from ships. These techniques are primarily aimed at meeting IMO MARPOL Annex VI Regulations 13 and 14 requirements for nitrogen oxide emissions from diesel engines and sulfur oxide emissions from all fuel-burning equipment on board.

A number of techniques and design features are utilized by internal combustion engine manufacturers to reduce NO_x emissions. However, to achieve compliance with the IMO Tier III limit (effective on ships constructed on or after 1 January 2016 which operate in the North American or United States Caribbean Sea NO_x emission control areas and other future emission control areas that may be designated by IMO), it is anticipated that the predominant exhaust emission abatement technologies used will be Exhaust Gas Recirculation (EGR) or Selective Catalytic Reduction (SCR) systems.

The IMO limits SO_x emissions by regulating the sulfur content of marine fuels, and it is anticipated that the reductions in the emission control area and global sulfur limits to 0.1% and 0.5%, effective from 1 January 2015 and 1 January 2020 respectively, will promote increasing use of exhaust gas cleaning systems, such as SO_x scrubbers.

In all cases, the air emissions performance testing, statutory certification, and statutory survey aspects are regulated through Annex VI in association with any applicable IMO Guidelines. At the time of issuance of this Guide, the applicable Guidelines for Selective Catalytic Reduction are IMO Resolution MEPC.291(71) – 2017 Guidelines Addressing Additional Aspects to the NO_x Technical Code 2008 With Regard to Particular Requirements Related to Marine Diesel Engines Fitted With Selective Catalytic Reduction (SCR) Systems, adopted 7 July 2017. The applicable Guidelines for SO_x exhaust gas cleaning systems are IMO Resolution MEPC.259(68) – 2015 Guidelines for Exhaust Gas Cleaning Systems, adopted 15 May 2015. Acceptance of a SO_x exhaust gas cleaning system is regulated as an alternative, or equivalent method, under MARPOL Annex VI Regulation 4 and is subject to approval by the flag Administration of the vessel.

This Guide has been developed in order to provide guidance and requirements for the design and construction of exhaust emission abatement systems, focusing on SO_x scrubbers, SCR systems, and EGR arrangements, and may be applied to all vessel types. An exhaust emission abatement system is considered to be fully approved upon verification of compliance with both the ABS requirements and the applicable IMO Regulations and Guidelines. This Guide covers only the Classification approval aspects, and statutory approval would be made by ABS as a separate parallel process in the capacity of a Recognized Organization for the vast majority of flag Administrations.

The optional exhaust emission abatement notations detailed under 1/9.3 through 1/9.9 will be assigned upon request and where the exhaust emission abatement system has been verified to be in compliance with the applicable requirements of this Guide. Where a notation has not been requested, the exhaust emission abatement system is to be verified to be in compliance with the minimum requirements prescribed under 1/9.11 of this Guide. This is applicable to new construction and existing vessel modifications.

The applicable edition of the ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules) is to be used in association with this Guide.

This Guide becomes effective on the first day of the month of publication.

Users are advised to periodically check the ABS website at www.eagle.org to verify the most current and applicable version of this Guide.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.



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SECTION 1 General

1 Scope and Application (2018)

This Guide is to be applied to exhaust emission abatement systems fitted to ABS classed vessels **and covers** SO_x scrubbers, SCR systems **and** EGR arrangements, **together with** Exhaust Emissions Monitoring Systems (EEMS) **fitted in conjunction** with the aforementioned emission abatement systems, or installed as an alternative Onboard NO_x Verification Procedure in accordance with the Direct Measurement and Monitoring Method of the NO_x Technical Code.

The **optional exhaust emission abatement** notations **detailed under 1/9.3 through 1/9.9** will be assigned to a vessel **upon request and where the** exhaust emission abatement system **has been verified to be in** compliance with the **applicable** requirements of this Guide. **Where a notation has not been requested, the exhaust emission abatement system is to be verified to be in compliance with the minimum requirements prescribed under 1/9.11 of this Guide. This is applicable to new construction and existing vessel modifications.**

3 General (2018)

This Guide focuses on the safety and reliability aspects of exhaust emission abatement equipment that fall within the scope of traditional Classification requirements and is to be applied to those Exhaust Gas Cleaning (EGC) systems covering SO_x scrubbers, SCR systems, and EGR arrangements. SO_x scrubbers and SCR units are generally installed downstream of the Fuel Oil Combustion Unit (FOCU) and are considered secondary aftertreatment systems. Compatibility of these EGC systems with the FOCU is to be verified as part of the approval process, preferably in consideration of the FOCU equipment manufacturer. **A Low Pressure SCR system is one where the SCR reaction chamber and catalysts are integrated after the exhaust gases have passed through the turbocharger.** In the case of EGR systems, or SCR systems fitted before **an engine** turbocharging system (**High Pressure SCR**), these are considered primary exhaust emission reduction techniques forming part of the total engine design and as such are to be integrated by the engine designer **or a third party under the authorization of the engine designer.** Those applicable requirements for EGR **and SCR** systems contained within this Guide are supplementary to, and to be applied in association with, the requirements for **internal combustion** engines under Section 4-2-1 of the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*.

This Guide focuses **on** those systems designed to reduce gaseous exhaust emissions species legislated through the International Maritime Organization (IMO) Annex VI Regulations 13 and 14 for nitrogen oxide (NO_x) emissions from diesel engines and sulfur oxide (SO_x) emissions from all fuel burning equipment on board. Acceptance of **a SO_x exhaust gas cleaning** system under MARPOL Annex VI, as an alternative means of compliance through Regulation 4, is subject to approval by the flag Administration of the vessel.

The regulatory **requirements** covering the air emissions performance, testing, statutory certification, and statutory survey aspects are regulated through Annex VI in association with any **other** applicable IMO Guidelines. At the time of issuance of this Guide, the applicable Guidelines for Selective Catalytic Reduction are IMO Resolution MEPC.291(71) – *2017 Guidelines Addressing Additional Aspects to the NO_x Technical Code 2008 With Regard to Particular Requirements Related to Marine Diesel Engines Fitted With Selective Catalytic Reduction (SCR) Systems*, adopted **7 July 2017**. **The applicable Guidelines for SO_x exhaust gas cleaning systems are** IMO Resolution MEPC.259(68) – *2015 Guidelines for Exhaust Gas Cleaning Systems*, adopted **15 May 2015**. This Guide is intended to cover only the Classification aspects, and the statutory approval **may** be made by ABS as a separate parallel process in the capacity of a Recognized Organization (RO) for the vast majority of flag Administrations, **when authorized by the flag.**

Individual flag Administrations may have in place additional requirements pertaining to the operation of EGC systems for vessels operating in their territorial waters, in particular with respect to those systems producing a washwater discharge associated with the exhaust gas cleaning process. These requirements may necessitate additional vessel features, performance standards, equipment, reporting and record keeping, or operational practices that are not covered by the IMO regulations or this Guide. Accordingly, any party selecting an exhaust emission abatement system for a particular vessel is encouraged to verify **the need for** any additional or specific arrangements to meet the requirements of the vessel **flag Administration, coastal state or port Authorities**.

5 Objectives (2018)

The objective of this Guide is to provide criteria for the design, construction, installation, survey, and operation of machinery and equipment associated with exhaust emission abatement systems in order to minimize risks to the vessel, crew, and the environment. The intent is that these requirements supplement the statutory emissions performance testing, survey, and certification requirements of the aforementioned IMO Regulations and Guidelines. Detailed requirements are provided in each of the Sections of this Guide to achieve this objective in accordance with the following key principles and requirements:

- Installation and operation of an exhaust emission abatement system is to be compatible with the fuel oil combustion unit and not to cause any adverse effects on the FOCU performance, such as excessive back pressures/temperatures, or is to incorporate additional features to mitigate such effects.
- Materials of construction and workmanship are to be in accordance with the requirements of the *ABS Rules for Materials and Welding (Part 2)* or to an alternate standard specifically approved in accordance with the design of the exhaust emission abatement system.
- Exhaust emission abatement systems are to be designed to enable continued operation of the FOCU at the times the EGC system is not in operation, either through operational selection, equipment failure, or system deterioration through partial blocking/clogging.
- Where applicable, exhaust emission abatement units and their associated equipment and systems are to be designed to minimize the risks associated with the storage, handling, consumption, and disposal of hazardous or non-hazardous chemicals or consumables essential for operation of the EGC system. Appropriate personnel protection arrangements and equipment are to be provided.
- As applicable, means are to be provided to suitably mitigate the risk to the FOCU or vessel from internal flooding associated with water scrubbing systems.
- Redundancy of equipment is to be provided for those rotating and reciprocating components that form part of the exhaust emission abatement unit supplementary systems, such as pumps, fans, blowers, etc., and due diligence is to be exercised and demonstrated in the assessment of critical components, equipment, and systems. Alternatively the carriage of spare parts onboard or alternative means of compliance or operation will be accepted to meet this objective.
- Means are to be provided to prevent the passage or leakage of exhaust gases to other equipment or spaces that may then pose a safety risk to that equipment or a health risk to the vessel's crew or passengers.
- Exhaust emission abatement systems are to be arranged for easy inspection and maintenance and where applicable the ability to replace internal components is to be provided.
- Hot surfaces of exhaust emission abatement 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 (428°F), they are to be suitably insulated with non-combustible materials.
- **Appropriate** storage and operational arrangements and procedures are to be in place for any specialized or hazardous gases used in exhaust emission abatement units or monitoring systems.
- Automation, instrumentation, monitoring, and control systems are to be provided to **facilitate automated operation and monitoring** of exhaust emission abatement systems.
- Operation and maintenance manuals are to be provided for all exhaust emission abatement units and associated equipment and systems to **facilitate** handling, operation, maintenance, and repair.

- Means are to be provided for the storage and disposal of any exhaust residues associated with operation of the exhaust emission abatement system.
- Fire protection, detection and extinguishing arrangements are to be provided to protect the vessel and crew from possible fire hazards associated with the operation of exhaust emission abatement units and their associated systems together with any applicable hazardous or non-hazardous consumables.

7 Definitions and Abbreviations

7.1 CO

Carbon Monoxide.

7.3 CO₂

Carbon Dioxide.

7.5 EGC

Exhaust Gas Cleaning.

7.7 EGR

Exhaust Gas Recirculation. The process whereby part of the exhaust gas flow is redirected back to the combustion cylinder of an engine for the purposes of reducing NO_x emissions.

7.9 EEMS

Exhaust Emissions Monitoring System.

7.11 Fuel Oil Combustion Unit (FOCU)

Any engine, boiler, gas turbine, or other fuel oil fired equipment, excluding shipboard incinerators.

7.13 HC

Hydrocarbon.

7.15 MARPOL

The IMO International Convention for the Prevention of Pollution from Ships, 1973, as modified by the protocol of 1978.

7.17 MSDS

Material Safety Data Sheet. Sometimes referred to as Safety Data Sheet (SDS) or Product Safety Data Sheet (PSDS).

7.19 NO_x

Nitrogen Oxides. Predominantly containing NO and NO₂ components and typically calculated as the total weighted emission with mass reference for NO₂ and determined using the relevant test cycles and measurement methods of the IMO NO_x Technical Code or ISO 8178.

7.21 O₂

Oxygen.

7.23 PM

Particulate Matter.

7.25 Recognized Organization (RO)

An organization that has been delegated by an Administration to undertake surveys and certification on the Administrations behalf in accordance with the IMO guidelines adopted by Resolution A.739(18), as amended, and the specifications adopted by IMO Resolution A.789(19), as amended.

7.27 Recognized Standard

An international or national standard acceptable to ABS.

7.29 Rules

The applicable edition of the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*.

7.31 SCR (2018)

Selective Catalytic Reduction. An exhaust aftertreatment system whereby the exhaust gases are mixed with a reductant, such as ammonia introduced in a urea/water solution, and passed over a catalyst, such as vanadium, located in the downstream exhaust system for the purposes of NO_x reduction of the exhaust gases.

A *High Pressure SCR* is an SCR system integrated onto an engine before the exhaust gas passes through the turbo charger.

A *Low Pressure SCR* is an SCR system integrated onto an engine after the exhaust gas passes through the turbo charger.

7.33 SO_x

Sulfur Oxide emissions. All sulfur emissions from fuel oil combustion machinery are caused by the combustion reactions with the sulfur introduced by the fuel which predominately include SO₂ and SO₃ emissions and are typically quantified as SO₂ emissions.

7.35 Urea (2018)

The most common reductant source used in SCR applications is *urea*, where ammonia and deionized water are mixed, typically in 32.5% concentrations for automotive use, commonly known as AUS-32 or Diesel Exhaust Fluid, and 40% concentration in the marine industry. Where the term *urea* is used in this Guide, this refers to 40% marine grade urea, commonly known as AUS-40.

9 Classification Notations

9.1 General (2018)

The optional vessel notations detailed under 1/9.3 through 1/9.9 of this Guide will be assigned upon request and where single or multi exhaust emission abatement systems are found to be in compliance with the applicable requirements of this Guide.

9.3 EGC – SO_x Scrubbers

Where an exhaust gas cleaning system primarily designed for the reduction of SO_x emissions using exhaust gas scrubbing is designed, constructed, and tested in accordance with Section 2 of this Guide, the **EGC-SO_x** notation may be assigned.

9.5 EGC – SCR Systems

Where an exhaust gas cleaning system primarily designed for the reduction of NO_x emissions by the use of Selective Catalytic Reduction is designed, constructed, and tested in accordance with Section 3 of this Guide, the **EGC-SCR** notation may be assigned.

9.7 EGC – EGR Systems (2018)

Where an exhaust gas cleaning system primarily designed for the reduction of NO_x emissions by the use of exhaust gas recirculation is designed, constructed, and tested in accordance with Section 4 of this Guide, the **EGC-EGR** notation may be assigned. This notation is intended to be applied to those EGR systems that incorporate extensive off-engine systems designed for the purposes of removing the sulfur by-products from the exhaust gases that originate from the fuel and incorporate, for example, water scrubbing and water cleaning systems.

For those engine designs that incorporate all EGR system components within the base engine design and, for example, may be primarily designed for use with low sulfur fuels, then the **EGC-EGR** notation may not be assigned.

The EGR version of the engine is to be approved by incorporation to the existing **internal combustion** engine approval.

9.9 Exhaust Emission Monitoring Systems

The notation for an exhaust emissions monitoring system may be assigned to a vessel fitted with, or without, an exhaust emission abatement system. Where a permanently installed exhaust emission monitoring system is designed, constructed and tested in accordance with Section 5 of this Guide the **EEMS** notation may be assigned.

9.11 Minimum Requirements for Systems Where EGC Notation is not Requested (2018)

Where a vessel is fitted with an exhaust emission abatement system and the optional vessel notations detailed under 1/9.3 through 1/9.9 are not requested, the installed exhaust emission abatement system is to comply with the minimum requirements prescribed in Section 1, Table 1 and is to be verified by an ABS Surveyor during installation. This is applicable to new construction and existing vessel modifications.

11 Operating and Maintenance Instruction Manuals

Detailed instruction manuals are to be provided onboard, covering the operations, safety, and maintenance requirements and occupational health hazards relevant to the particular exhaust emission abatement unit and associated systems.

The manuals are to include, but not be limited to, the regular testing and maintenance procedures and schedules for the monitoring systems, safety shut-off systems, and the integrity of backup systems together with identification of the relevant responsible parties.

In addition, there is further guidance regarding the contents of the operating and maintenance manuals in each of the individual Sections of this Guide. Reference is to be made to the requirements in each Section of this Guide.

13 Alternatives

Equipment, components, and systems for which there are specific requirements in this Guide, or its associated references, may incorporate alternative arrangements or comply with the requirements of alternative recognized standards, in lieu of the requirements in this Guide. This, however, is subject to such alternative arrangements or standards being determined by ABS as being not less effective than the overall safety requirements of this Guide or associated references. Where applicable, requirements may be imposed by ABS in addition to those contained in the alternative arrangements or standards so that the intent of this Guide is met. In all cases, the equipment, component, or system is subject to design review, survey during construction, tests, and trials, as applicable, by ABS for purposes of verification of its compliance with the alternative arrangements or standards. The verification process is to be to the extent as intended by this Guide.

15 Certification

Design review, survey, testing, and the issuance of reports or certificates constitute the certification of machinery, equipment, and systems (see also 4-1-1/3 of the *Steel Vessel Rules*). There is guidance on the certification requirements for machinery, equipment, and systems in each of the applicable individual Sections of this Guide. The applicable edition of the *Steel Vessel Rules* is to be used in association with the subject Guide.

TABLE 1
Minimum Requirements for EGC Systems where EGC Notation
is not Requested (2018)

<i>EGC System</i>	<i>Guide Reference</i>
Section 2 – EGC SOx Scrubbers	
Exhaust System Bypass	2/7.9
Configuration and Vessel Integration	2/7.1i), 2/7.3i)
Prevention of Flooding	2/7.11
Vessel Stability	2/7.15
Electrical Load Analysis	2/9.9.2ii)
Piping	2/11.1.2ii), 2/11.1.3i), 2/11.1.4, 2/11.3.1
NaOH Supply System	2/11.5
Safety Shutdown System	2/13.5
Section 3 – EGC SCR Systems	
Exhaust System Bypass	3/7.1ii)
Configuration and Vessel Integration	3/7.1ii), 3/7.3i)
Electrical Load Analysis	3/9.11.2ii)
Piping	3/11.1.2ii), 3/11.1.3i), 3/11.1.4
Urea Supply System	3/11.3
Safety Shutdown System	3/13.5
Section 4 – EGC EGR Systems	
Configuration and Vessel Integration	4/7.1ii), 4/7.3i)
Prevention of Flooding	4/7.9
EGR Blowers	4/9.1iv)
Electrical Load Analysis	4/9.7.2ii)
Piping	4/11.1.3, 4/11.3.1,
NaOH Supply System	4/11.5
Safety Shutdown System	4/13.5
Section 5 - Exhaust Emission Monitoring Systems	
Gases	5/9.1i)
Piping	5/9.5iii)



SECTION 2 EGC – SO_x Scrubbers

1 General (2018)

This Section provides requirements on the arrangements and system design for exhaust **gas cleaning** systems designed **primarily** for the removal of SO_x emissions, or SO_x scrubbers, as they are commonly known. The intent is that these requirements supplement the statutory emissions performance testing, survey, and certification requirements of the applicable IMO Regulations and Guidelines. At the time of issuance of this Guide, the applicable Guidelines for SO_x exhaust gas cleaning systems are IMO Resolution **MEPC.259(68) – 2015 Guidelines for Exhaust Gas Cleaning Systems**, adopted **15 May 2015**. The statutory approval aspects **may** be made by ABS as a separate parallel process in the capacity of a Recognized Organization for the vast majority of flag Administrations, **when authorized by the flag**.

3 Plans and Data to be Submitted (2018)

Plans and specifications covering the SO_x scrubber arrangements are to be submitted and are, as applicable, to include:

- General arrangement of the SO_x scrubber installation, layout, and systems
- Documentation detailing the SO_x scrubber specification
- Analyses demonstrating compatibility of the scrubber with the fuel oil combustion units (see 2/7.3 of this Guide)
- Hull plans showing the foundation and attachments to the vessel's structure, including scantlings, welding details, and foundation details of principal components
- Documentation detailing the effect on Load Line and Stability of the exhaust emission abatement system (see 2/7.15 of this Guide)
- Material specifications for the scrubber unit, pumps, valves, storage/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 exhaust emission abatement system
- Arrangement and capacity of tanks for storage, chemicals, process washwater, exhaust gas cleaning residues, etc.
- Details of all piping systems, including details of piping and associated components, design pressures, temperatures, insulation, and drip trays, where applicable
- Descriptions and schematic diagrams for the control and monitoring systems, including set points for abnormal conditions and details of the location and positions **where** exhaust emission monitoring and washwater monitoring **systems** are to be located
- Details of all electrical equipment installed for the SO_x scrubber unit and associated systems, including computer-based systems
- Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the operation of the SO_x scrubber [see 2/13.1ii) of this Guide]
- Emergency shutdown arrangements

- SO_x scrubber unit FMEA integration test report (see Subsection 2/15 of this Guide)
- Operating and maintenance instruction manuals, including MSDS and details for handling of hazardous and non-hazardous chemicals used in the SO_x exhaust emission abatement system
- Testing procedures during installation and commissioning trials

5 EGC-SO_x System Operation and Maintenance Manuals

In accordance with Subsection 1/11 of this Guide, detailed instruction manuals are to be provided onboard, covering the operations, safety, and maintenance requirements and occupational health hazards relevant to the SO_x exhaust emission abatement equipment and associated systems.

These manuals are to include, but not necessarily be limited to, the procedures and schedules for operation, inspection, testing and maintenance of the SO_x scrubber and associated systems, the regular testing and maintenance procedures for the monitoring systems, safety shutoff systems, and the integrity of backup systems, together with special instructions for the bunkering, storage, and use of hazardous and non-hazardous chemicals that may be used in the exhaust emission abatement system and identification of the relevant responsible parties.

The manuals are to be submitted for review solely to verify the presence of all the information required by this Section.

7 EGC-SO_x System Configuration and Vessel Integration

7.1 General

- (2018)** Exhaust emission abatement systems are to be designed to enable continued operation of the FOCU at the times the EGC system is not in operation, either through operational selection, equipment failure, or system deterioration through partial blocking/clogging.
- 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 (see 2/11.1.3 of this Guide).
- 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 Subsection 2/15 of this Guide.

7.3 Compatibility with Fuel Oil Combustion Units

- (2018)** Installation and operation of an exhaust emission abatement system is to be compatible with the fuel oil combustion unit(s) and **is** not to cause any adverse effects on the FOCU performance such as excessive back pressures or **high** temperatures during operation.
- Details are to be submitted demonstrating the exhaust flow compatibility of the EGC unit with the connected **FOCUs** 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 EGC system in operation. In the case of integrated scrubbers, this compatibility evaluation is to show that the EGC unit is capable of accommodating the maximum combined exhaust flows of all the connected oil burning equipment for the worst case scenario for that particular ship arrangement and operational profile. Consideration will be given to those EGC units that incorporate extractive exhaust fans to maintain the FOCU operating parameters within the approved design limits.

It is to be noted that exhaust emission abatement systems that cause diesel engines to operate outside the exhaust backpressure limits detailed in the approved IMO 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 RO responsible for the original certification.

7.5 Redundancy

Redundancy of equipment is to be provided for those rotating and reciprocating components that form part of the exhaust emission abatement unit essential supplementary systems, such as pumps, fans, blowers, etc. (see 2/9.1 and 2/9.9.3 of this Guide).

Consideration will be given to alternative means of compliance or operation to meet this objective on a case-by-case basis. As applicable, documentation is to be submitted demonstrating that the reliability of the system or component provides continued serviceability of the exhaust emission abatement system or the alternative means of operation provides continued compliance with the statutory environmental requirements, without compromising the vessel propulsion and maneuvering capability. The provision of adequate fuel tank capacity for low sulfur fuels, alternative operating modes or carriage of sufficient spare parts onboard are examples of vessel specific arrangements that may be considered by ABS as meeting this objective and should be justified with reference to the FMEA required by 2/13.1ii) of this Guide.

7.7 Essential Services

For the purposes of design, construction, testing, and survey, EGC units and associated components and systems are considered secondary essential services in accordance with 4-8-1/7.3.3 of the *Steel Vessel Rules*.

7.9 Exhaust Bypass/Dry Running of Scrubbers (2018)

EGC 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 exhaust emission abatement washwater 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.

All EGC units fitted to single main propulsion engines are to be installed with an exhaust bypass arrangement unless arranged for unrestricted flow of exhaust gas and with no risk of causing failure of the main propulsion engine.

7.11 Prevention of Fuel Oil Combustion Unit Flooding

- i) For EGC 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.
- ii) Monitoring, alarm, and shutdown arrangements are to be provided to prevent an abnormal rise of washwater level in the scrubber reaction chamber.

7.13 Inclinations

Exhaust emission abatement systems are to be designed for proper operation at the inclination requirements of 4-1-1/7.9 of the *Steel Vessel Rules*.

7.15 Vessel Stability

- i) For those existing ships fitting an exhaust emission abatement system as a retrofit conversion, a revision of the stability calculations may be required based on the additional weights of the EGC 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 vessel 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.
- ii) Documentation detailing the effect on Load Line and Stability of the exhaust emission abatement system, in accordance with the guidance of 2/7.15i) of this Guide, is to be submitted.

7.17 Inspection and Maintenance (2018)

EGC units are to be arranged for easy inspection and maintenance with at least one inspection port or hatch available for internal inspection of the main reaction chamber, and where applicable the ability to replace internal components is to be provided.

9 EGC-SO_x System Equipment**9.1 Pumps/Fans**

- i) Where provided, SO_x scrubber washwater, circulation, discharge, etc., pumps, essential for the continual operation of the EGC system, are to be tested and certified in accordance with 4-6-1/7.3 of the *Steel Vessel Rules*. This is applicable to exhaust emission abatement systems connected to fuel oil combustion units rated at 2250 kW and above or internal combustion engines having cylinders of more than 300 mm (11.8 in.) bore.
- ii) Unless alternative means of compliance in accordance with 2/7.5 of this Guide are applicable, redundant washwater, circulation, discharge, etc., pumps, essential for the continual operation of the EGC 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 exhaust emission abatement system at full rating. See also 2/9.9.3 of this Guide.

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

- iii) Unless alternative means of compliance in accordance with 2/7.5 of this Guide are applicable and where exhaust fans form part of the EGC system and are essential for continual operation of the exhaust emission abatement 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.

9.3 Exhaust Plume Heaters (2018)

- i) Where provided, heat exchangers within the exhaust are to be designed, constructed, and certified in accordance with Section 4-4-1 of the *Steel Vessel Rules*.
- ii) Where the introduction of hot air to the exit exhaust gases is used on exhaust emission abatement systems, the details of this auxiliary system are to be submitted for review and approval on a case-by-case basis.

9.5 Chemical Treatment System

The specific requirements for chemical treatment system components are given under 2/11.5 of this Guide.

9.7 Dry Scrubber Consumable Handling Equipment

- i) For dry type exhaust emission abatement systems, details of the granulate supply and discharge systems are to be submitted.
- ii) Unless alternative means of compliance in accordance with 2/7.5 of this Guide are applicable, drive arrangements for the exhaust cleaning reductant consumable are to be arranged in a redundant arrangement.

9.9 Electrical System

The electrical system and electrical equipment requirements in this Paragraph are to be applied in association with the requirements of Part 4, Chapter 8 of the *Steel Vessel Rules*.

9.9.1 Electrical Motors and Controllers

Motors and motor controllers of 100 kW (135 hp) and over are to be certified in accordance with Part 4, Chapter 8 of the *Steel Vessel Rules*.

9.9.2 Electrical Load Analysis (2018)

- i) 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 and for minimum comfortable conditions of habitability as per 4-8-2/3.1.1 of the *Steel Vessel Rules*.
- ii) The electrical loads associated with the SO_x exhaust gas cleaning system are to be included in the electric-plant load analysis required by 4-8-1/5.1.5 of the *Steel Vessel Rules*.

9.9.3 Standby Pump/Fan Arrangements

- i) In the event of failure of the essential exhaust emission abatement system pumps or fans, the standby pump or fan required by 2/9.1 of this Guide, 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.

9.9.4 Circuit Protection Devices and Compatibility

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

11 EGC-SO_x System Piping

11.1 Exhaust Gas Piping Systems

11.1.1 Exhaust Gas Piping/Scrubber Materials and Installation

- i) Exhaust gas piping materials located before the SO_x scrubber unit are to be of the same material specification as the standard exhaust gas piping.
- ii) The sections of the scrubber that are subjected to washwater (e.g., the interior reaction chamber or washwater piping/nozzles, etc.) are to be constructed of suitable corrosion resistant materials.
- iii) Exhaust gas piping materials used after the SO_x scrubber unit are to be of a corrosion resistant material such as stainless steel.
- iv) The exhaust piping systems for exhaust emission abatement systems are to meet the applicable requirements of 4-6-2/9 and 4-6-5/11 of the *Steel Vessel Rules*.
- v) Exhaust gas piping and piping components constructed of non-metallic materials are to comply with 4-6-2/3 of the *Steel Vessel Rules* and to be specifically approved for the intended application.

11.1.2 Exhaust Gas Piping Valves

- i) Valves used in the exhaust system of emission abatement systems are to meet the requirements of 4-6-2/5.11 of the *Steel Vessel Rules* and, in general, are to comply with a recognized standard and are to be permanently marked in accordance with the requirements of that standard.

The valves are to be constructed of corrosion resistant materials.
- ii) Isolation and bypass valves used in EGC system exhaust piping systems are to prevent the passage of exhaust gases to other fuel oil combustion units or machinery spaces.

Where bypass arrangements for the SO_x scrubber unit are provided, the isolation and bypass valves are to be arranged in an interlocked, fail safe manner, such that free flow of exhaust gases to the atmosphere is possible at all times, either through the scrubber unit or through the bypass. Bypass valves are to be provided with a local position indicator.
- iii) Valves are to be installed in accessible locations, clear of or protected from obstructions, moving equipment, and hot surfaces, in order to permit regular inspection and/or periodic servicing.