GUIDE FOR

EXHAUST EMISSION ABATEMENT

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Updates

September 2017 consolidation includes:

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Foreword *(1 July 2017)*

International, regional, national and local air emissions legislation is driving the development of primary machinery technologies to reduce exhaust emissions, together with the use of alternative cleaner fuels, such as LNG, and secondary exhaust emissions aftertreatment systems.

For the ABS requirements for gas fueled ships, other than those covered by the IMO IGC Code, utilizing LNG or CNG as fuel, see Part 5C, Chapter 13 of the *Steel Vessel Rules*.

Key amongst these emissions drivers are the gaseous exhaust emissions legislated through IMO Annex VI Regulations 13 and 14 for nitrogen oxide emissions from diesel engines and sulfur oxide emissions from all fuel burning equipment onboard.

A number of techniques and design features are utilized by diesel engine manufacturers to reduce the primary exhaust NO_x emissions, but to achieve compliance with the IMO Tier III limit (that is to be effective in NO_x emission control areas from 1 January 2016), it is anticipated that the use of exhaust gas recirculation or selective catalytic reduction systems will be predominantly used.

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%, that will be effective from 1 January 2015 and 1 January 2020 (subject to review in 2018) 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 with any proposed alternative means of compliance, such as exhaust gas cleaning systems, permitted through Regulation 4 in association with any applicable IMO Guidelines. At the time of issuance of this Guide, the applicable Guidelines for Selective Catalytic Reduction (SCR) and SO_x exhaust gas cleaning systems are IMO Resolution MEPC.198(62) – *2011 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 15 July 2011 and IMO Resolution 184.(59) – *2009 Guidelines for Exhaust Gas Cleaning Systems*, adopted 17 July 2009. Acceptance of an exhaust emission abatement system as an alternative under MARPOL Annex VI is subject to approval by the flag Administration of the vessel.

In addition, safety and reliability aspects that fall within the scope of traditional Classification requirements are also included in this Guide. Accordingly, this Guide has been developed in order to provide guidance for the design and construction of exhaust emission abatement systems, focusing on SO_x scrubbers, SCR systems, and Exhaust Gas Recirculation (EGR) arrangements, and may be applied to all vessel types. An exhaust emission abatement system is considered approved upon verification of compliance with both the ABS requirements and the applicable IMO Regulations and Guidelines. Whilst compliance with the applicable IMO Regulations and Guidelines is a pre-requisite for ABS approval and notation, 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 applicable edition of the ABS *Rules for Building and Classing Steel Vessels (Steel Vessel Rules)* is to be used in association with this Guide.

The July 2017 revision incorporates IACS UR M77 (Sept. 2016), "*Storage and use of SCR reductants*", which prescribes requirements for storage and use of reductants (such as Marine NOx reduction agent AUS 40 to ISO18611:2014) in selective catalytic converters and also addresses the arrangement of the urea solution storage tanks.

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.

GUIDE FOR

EXHAUST EMISSION ABATEMENT

CONTENTS

SECTION 1 General

1 Scope and Application

This Guide is to be applied to exhaust emission abatement systems fitted to ABS classed vessels primarily covering SO_x scrubbers, SCR systems, Exhaust Gas Recirculation (EGR) arrangements, and to Exhaust Emissions Monitoring Systems (EEMS) associated with the aforementioned emission abatement systems, or EEMS 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 applicable notation will be assigned to a vessel with an exhaust emission abatement system upon verification of compliance with both the ABS requirements and the applicable IMO Regulations and Guidelines.

3 General

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. In the case of EGR systems, or SCR systems fitted before the turbocharging system, these are considered primary exhaust emission reduction techniques forming part of the total engine design and as such are to be integrated by, or under authorization of, the engine designer. Those applicable requirements for EGR systems contained within this Guide are supplementary to, and to be applied in association with, the requirements for diesel engines under Section 4-2-1 of the ABS *Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*.

This Guide is focused 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 an exhaust emission abatement 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 aspects of approving these exhaust emission abatement systems, covering 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 (SCR) and SO_x exhaust gas cleaning systems are IMO Resolution MEPC.198(62) – *2011 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 15 July 2011 and IMO Resolution 184.(59) – *2009 Guidelines for Exhaust Gas Cleaning Systems*, adopted 17 July 2009. Compliance with the applicable IMO Regulations is a pre-requisite for ABS notation in accordance with Subsection 1/9 of this Guide. However, this Guide is intended to cover only the Classification aspects, and the statutory approval would be made by ABS as a separate parallel process in the capacity of a Recognized Organization (RO) for the vast majority of flag Administrations.

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 if any additional or specific arrangements are needed to meet the requirements of the vessel, or operational port(s) Administrations.

5 Objectives

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 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, or be designed with suitable exhaust bypass arrangements to enable continued operation of the FOCU.
- 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.
- Safe 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 enable safe operation 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 enable safe handling, operation, maintenance, and repair.
- Means are to be provided for the safe 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

CO means Carbon Monoxide.

7.3 CO_2

CO_2 means Carbon Dioxide.

7.5 EGC

EGC means Exhaust Gas Cleaning.

7.7 EGR

EGR means 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

EEMS means Exhaust Emissions Monitoring System.

7.11 Fuel Oil Combustion Unit

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

7.13 HC

HC means Hydrocarbon.

7.15 MARPOL

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

7.17 MSDS

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

7.19 NO_x

NO_x means Nitrogen Oxides. Predominantly containing NO and NO_2 components and typically calculated as the total weighted emission with mass reference for NO_2 and determined using the relevant test cycles and measurement methods of the IMO NO_x Technical Code or ISO 8178.

7.21 O_2

O_2 means Oxygen.

7.23 PM

PM means Particulate Matter.

7.25 Recognized Organization (RO)

A *Recognized Organization (RO)* is 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

A *Recognized Standard* is an international or national standard acceptable to ABS.

7.29 Rules

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

7.31 SCR

SCR means 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.

7.33 SO_x

SO_x means 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 SO_2 and SO_3 emissions and are typically quantified as SO_2 emissions.

7.35 Urea

Urea or *carbamide* is an organic compound widely used as a nitrogen source for fertilizers or used in SCR applications where ammonia and water are mixed, typically as 32% or 40% urea solutions, for use as a reductant enabler for the catalytic process.

9 Classification Notations

9.1 General

The following vessel notations will be assigned where single or multi exhaust emission abatement systems are found to be in compliance with 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 catalysts 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

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. Where a water treatment system is incorporated in the EGR system, the washwater discharge criteria is to meet the requirements of IMO Resolution MEPC.184(59).

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 and the EGR system, or EGR version of the engine, is to be approved by incorporation to the existing diesel 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.

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.

SECTION 2 EGC – SO_x Scrubbers

1 General

This Section provides requirements on the arrangements and system design for exhaust emission abatement systems primarily designed 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 184.(59) – *2009 Guidelines for Exhaust Gas Cleaning Systems*, adopted 17 July 2009. Compliance with the applicable IMO Regulations is a pre-requisite for ABS approval of the EGC system in accordance with the requirements of this Guide, and the statutory approval aspects would be made by ABS as a separate parallel process in the capacity of a Recognized Organization for the vast majority of flag Administrations.

3 Plans and Data to be Submitted

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 position at which exhaust emission monitoring and washwater monitoring 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 safe 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 sheets 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

i) 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, or be designed with suitable exhaust bypass arrangements to enable continued operation of the FOCU.

ii) 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).

iii) 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

i) Installation and operation of an exhaust emission abatement 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.

ii) Details are to be submitted demonstrating the exhaust flow compatibility of the EGC 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 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

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 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.

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 need to be made 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

Exhaust emission abatement 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.

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 diesel 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

i) Where provided, heat exchangers 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

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 as per 4-8-2/3.1.1 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 may 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 at all times is possible, 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.

11.1.3 Interconnections of Exhaust Gas Piping

i) Normally, exhaust pipes from diesel engines and flue gas pipes from oil-fired boilers are to be routed separately and not interconnected. However, interconnected exhaust piping systems to a common exhaust emission abatement unit may be accepted subject to the arrangements preventing the passage or leakage of exhaust gases to other equipment or spaces that may then pose a safety risk to that equipment or health risk to the vessel's crew or passengers. The return of exhaust gas flow from a running fuel oil combustion unit to another stopped, or in operation, FOCU is to be prevented.

ii) The integrated EGC system is to be designed not to exceed the backpressure limits specified by the connected engines or boilers. Fans installed for this purpose are to meet the redundancy requirements of 2/9.1iii) of this Guide.

11.1.4 Exhaust Gas Scrubber and Scrubber Piping Insulation

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) 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 EGC 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.

11.3 Washwater Piping

11.3.1 Piping and Connections

i) In general, pipe fittings and joints are to meet the requirements of the *Steel Vessel Rules* for certification in 4-6-1/7.1, materials in 4-6-2/3, and design in 4-6-2/5.5 and 4-6-2/5.15, subject to the limitations in 4-6-5/Table 3.

Molded non-metallic expansion joints, where used, are to be of an approved type (see 4-6-2/5.8.1, 4-6-2/Table 2 of the *Steel Vessel Rules* for Cu and Cu Alloy and 4-6-2/Table 5 of the *Steel Vessel Rules* for pipe thickness).

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

iii) 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 Section 4-6-3 of the *Steel Vessel Rules*. For the purpose of these Rules, "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 4-6-3/5.11 of the *Steel Vessel Rules*).

iv) Flexible hoses are to comply with the requirements of 4-6-2/5.7 of the *Steel Vessel Rules*.

11.3.2 Remote Control Valves

i) Upon loss of control power, the remote control valves are to remain in the last ordered position, provided there is a readily accessible manual means to close the valves, or are to fail safe in accordance with the FMEA.

ii) Remote control valves are to be clearly identified and are to be provided with position indicators at the local and EGC system remote control station, as applicable.

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.

11.3.3 Overboard Discharges

i) The overboard discharges of any exhaust emission abatement system are not to be interconnected to other systems.

ii) Special attention is to be paid to the corrosion resistivity of EGC washwater overboard discharge piping. Where applicable, adequate arrangements are to be provided to prevent galvanic corrosion due to the use of dissimilar metals.

iii) Due consideration is to be given to the location of overboard discharges with respect to vessel propulsion features, such as thrusters or propellers. As applicable, discharges are to be arranged to enable safe sampling of water discharge plumes.

11.5 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 EGC 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 2/11.5 of this Guide and the requirements for the residue tank in 2/11.7 of this Guide.

11.5.1 Material for Piping Systems, NaOH Storage Tank and EGC Residue/NaOH Overflow Tank

The material of the NaOH related piping systems, NaOH storage tank, EGC 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.

11.5.2 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 EGC residue/ NaOH overflow tank, are to be provided.

11.5.3 Arrangement of the NaOH Storage Tank and EGC Residue/NaOH Overflow Tank

i) The NaOH storage and EGC residue/NaOH overflow tank are not to be situated where spillage or leakage therefrom 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).

ii) Where necessary, the NaOH storage tank is to be provided with an appropriate heating system to prevent freezing.

11.5.4 Filling, Vents, and Overflows for NaOH Tank and EGC Residue/NaOH Overflow Tank

i) *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 EGC 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 EGC residue/NaOH overflow tank.

ii) *Vents.* The NaOH storage and EGC residue/NaOH overflow tanks are to be provided with vent pipes complying with 4-6-4/9 of the *Steel Vessel Rules*, and the outlets are to terminate in a safe location [see 4-6-4/9.3.5(b)ii) of the *Steel Vessel Rules*] 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 vessel. Alternatively, the tanks are to be fitted with appropriately sized pressure/vacuum valves.

iii) *Overflow Protection.* Means are to be provided to prevent NaOH from spilling or accidently overflowing from the storage and EGC 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 4-6-4/13.5.4 and 4-6-4/9.5.2 of the *Steel Vessel Rules* that is led to the EGC residue/NaOH overflow tank. Further, in all cases, the EGC 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.

11.5.5 Sounding and Temperature Indication for the NaOH Storage and EGC Residue/NaOH Overflow Tanks

i) Sounding arrangements are to be provided for the NaOH storage and EGC residue/NaOH overflow tanks, and are to comply with the sounding requirements applicable to fuel oil tanks of 4-6-4/11.3.7 of the *Steel Vessel Rules*.

ii) 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 required in 4-6-4/11.3.7 of the *Steel Vessel Rules*, (i.e., flat "glass-type", fitted with a self-closing valve at each end).

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

iv) The NaOH storage and EGC 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.

11.5.6 Spill Trays

i) Those areas of the NaOH storage and EGC 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 EGC 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 EGC residue/NaOH overflow tank is to be fitted with a non-return valve.

11.5.7 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.

11.5.8 Ventilation Arrangements

The NaOH storage and EGC 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.

11.5.9 Personnel Protection

For the protection of crew members, the vessel 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.

11.5.10 Safety Notices for the Compartment or at the Location of Tanks Containing NaOH

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.

11.7 Residue System

i) 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, in accordance with 4-6-4/5.7.4 of the *Steel Vessel Rules*.

The EGC residue tank is to be designed to facilitate cleaning.

Where EGC 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 2/11.5 of this Guide are to be applied.

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

iii) The capacity of the EGC 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 EGC residue can be discharged. In the absence of precise data, a figure of 30 days is to be used.

iv) The EGC residue tank is to be provided with vent pipes complying with 4-6-4/9 of the *Steel Vessel Rules*.

v) The residue tank is to be arranged with a high level alarm.

vi) Sounding arrangements are to be provided for the EGC residue tank in accordance with 4-6-4/11.3.7 of the *Steel Vessel Rules*.

vii) For those vessels 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 EGC residue tank, provided the tank meets the requirements of 2/11.7i) through vi) of this Guide, EGC residue record logs satisfy the requirements of MEPC.184(59), and residues are disposed at MARPOL reception facilities.

Combined engine room sludge and EGC residue tanks are to be sized to provide adequate capacity based on the sludge tank capacity requirements of 4-6-4/5.7.3 of the *Steel Vessel Rules* plus the capacity requirements for EGC residue tanks of 2/11.7iii) of this Guide.

13 Control, Alarm, and Monitoring System

13.1 General

i) The control system for the exhaust emission abatement system may be connected to an integrated control system or may be a standalone system.

ii) 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 vessel.

An FMEA, or equivalent, demonstrating the safety system design basis is to be submitted.

iii) Where fitted, exhaust emissions monitoring systems are to meet the requirements of Section 5 of this Guide.

13.3 Control and Monitoring System

i) Automatic control, monitoring (including washwater discharge criteria), alarm, and safety functions are to be provided for the EGC system so that operations remain within preset parameters for all fuel oil combustion unit(s) and exhaust emission abatement system operating conditions. For vessels with **ACC** or **ACCU** notations, the alarm and monitoring systems are to be integrated in the vessel's centralized monitoring systems that conform to the requirements for **ACC** or **ACCU** notations.

ii) The temperatures, pressures, and flows in the EGC system and associated systems are to be controlled and monitored as follows:

a) A local control and monitoring system for the EGC 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. The control and monitoring systems are to comply with the requirements of 4-9-2/3.1 of the *Steel Vessel Rules*, as applicable.

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 Section 2, Table 1 of this Guide, and are to include the following parameters:

1) EGC system pump/fan/motor operational status

2) Status of any EGC system valves

3) EGC system parameters for operational safety

4) Level indication of EGC system tanks/hoppers

5) Status of any EGC system alarms, shutdowns and Emergency Stop

d) The computer-based control systems are to comply with the applicable requirements of Section 4-9-3 of the *Steel Vessel Rules* as a Category II system based on 4-8-3/15 of the *Steel Vessel Rules*

iii) The power supply arrangements for the control and monitoring system are to meet the requirements of 4-9-2/5.3 of the *Steel Vessel Rules*.

13.5 Safety Shutdown System

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

i) Means are to be provided to indicate the parameters causing shutdown.

ii) Upon activation of the safety shutdown system, alarms are to be given at the normal control position and at the local control position.

iii) In the event where shutdown by the safety shutdown system is activated, the restart should not occur automatically, unless after the system is reset.

Monitoring and safety shutdowns are to be in accordance with Section 2, Table 1 of this Guide.

15 FMEA Integration Test

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 SCR 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 2/13.1ii) of this Guide.

17 Surveys During Construction

17.1 General

This Subsection pertains to surveys during fabrication at the manufacturer's facility and installation and testing of EGC 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.

17.3 Surveys at Manufacturer's Facility

See Section 2, Table 2 of this Guide for certification requirements of EGC SO_x scrubber units and associated systems. Survey requirements for equipment components and packaged units at the manufacturer's facility are summarized in the relevant sections of the applicable Rules/Guides.

17.5 Surveys During Installation

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

i) Inspection and verification that the foundations and attachments of the principal components of the EGC abatement unit and associated systems are in accordance with the approved plans and particulars.

ii) Piping systems are to be visually examined and pressure-tested, as required by the *Steel Vessel Rules*. Pressure tests conducted on Class I piping (see 4-6-1/Table 1 of the *Steel Vessel Rules*) systems should preferably be recorded on test charts for the duration of their tests.

iii) Electrical wiring and connections are to be in accordance with Part 4, Chapter 8 of the *Steel Vessel Rules* and checked for continuity and proper workmanship.

iv) Instrumentation is to be tested to confirm proper operation as per its predetermined set points.

v) Pressure relief and safety valves installed on the unit are to be tested.

vi) Control system and shutdowns are to be tested for proper operation.

vii) The EGC SO_x scrubber unit is to be checked for proper operation in accordance with the ABS-approved installation test procedure.

17.7 Surveys During Trials

During the initial commissioning trials, the EGC 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 ABS-approved testing procedure during sea trials.

TABLE 1
Monitoring and Safety System Functions for EGC-SO_x Scrubber Systems

Monitored Parameters	*Display*	*Alarm Activated*	*Automatic EGC Shutdown and Automatic EGC 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 EGC unit	X	High	X (High-High)
Exhaust gas temperature after EGC unit	X	High	X (High-High)
Exhaust gas pressure after FOCU unit	X	High	X (High-High)
Differential pressure across EGC unit [3]	X	High	X (High-High)
EGC washwater pumps, alkali system pumps or dry system feeder units	Running	Stop [2]	
EGC washwater or alkali system valves	Position		
Control-actuating medium of the EGC washwater and alkali system valves, where provided	Running	Failed	
EGC system washwater and alkali system supply pressure	X	Low	X (Low-Low)
EGC system washwater and alkali system supply temperature	X	High	X (High-High)
Water level in wet EGC 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]
EGC residue tank level	X	High	X (High-High)
Control power supply	Running	Failed	
Emergency shutdown	X	X	X

Notes:

1 Automatic bypass of the EGC unit is only applicable to those EGC units not suitable for dry running (see 2/7.9 of this Guide).

2 Failure of essential EGC system motors driving pumps, fans or feed systems is to activate the standby units, where fitted (see 2/9.9.3 of this Guide).

3 Applicable to dry scrubber type only.

4 Independent safety shutdown system as required by 2/13.5 of this Guide.

5 Automatic shutdown is to activate the close coupled alkali storage tank valves required by 2/11.5.7iii) of this Guide.

TABLE 2
Certification of EGC-SO_x Scrubber Systems at the Manufacturer's Facility

This Table has been prepared for guidance only and annotated to agree with the *Steel Vessel 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 *Steel Vessel Rules*. This list is not to be considered as substitutive or integrative of the content of the *Steel Vessel Rules* and/or other applicable Regulations. In case of conflict between the content of this list and the applicable *Steel Vessel Rules* and other applicable regulations, the latter are to be considered applicable.

Code	*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*
EGC SO_x scrubber reaction chamber	X	X	X
Exhaust bypass or isolation valves	X		
Exhaust fans/motors (1)	X		X
Heat exchangers	X		X
Water treatment system	X		X
Washwater, alkali system and essential EGC system pumps (2)	X		X
Washwater, alkali and EGC residue associated piping	X		
Control system	X		
Automatic shutdown and safety system	X		

Notes:

1 Applicable for motors over 100 kW (135 hp) only. For motors less than 100 kW (135 hp), certification by ABS not required, acceptance based on manufacturer's documentation and guarantee (see 2/9.9.1 of this Guide).

2 Applicable to pumps fitted to EGC systems connected to fuel oil combustion units rated at 2250 kW and above or diesel engines having cylinders of more than 300 mm (11.8 in.) bore [see 2/9.1i) of this Guide].

SECTION 3 EGC – Selective Catalytic Reduction Systems

1 General

This Section provides requirements on the arrangements and system design for exhaust emission abatement systems primarily designed for the removal of NO_x emissions using Selective Catalytic Reduction (SCR) systems. 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 supplementary Guidelines to MARPOL Annex VI Regulation 13 and the NO_x Technical Code for SCR systems are IMO Resolution MEPC.198(62) – *2011 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 15 July 2011. Compliance with the applicable IMO Regulations is a pre-requisite for ABS approval of the SCR system in accordance with the requirements of this Guide and the statutory approval aspects would be made by ABS as a separate parallel process in the capacity of a Recognized Organization for the vast majority of flag Administrations.

3 Plans and Data to be Submitted

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

- General arrangement of the SCR installation, layout, and systems
- Documentation detailing the SCR specification, including details of the SCR catalyst reaction chamber and catalysts, reductant specifications, exhaust system components/modifications, mixing arrangements, reductant injection nozzles/injectors, and soot blowing details
- Analyses demonstrating compatibility of the SCR system with the engine (see 3/7.3 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
- Material specifications for the SCR unit, pumps, valves, reductant tanks, piping, distribution systems, filters, 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 reductant storage tanks
- Details of all piping systems, including details of piping and associated components, pumps, reductant dosing systems, air supply systems, design pressures, temperatures, insulation, and drip trays
- 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 probes are to be located
- Details of all electrical equipment installed for the SCR unit and associated systems, including computer-based systems
- Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the SCR exhaust emission abatement system [see 3/13.1ii) of this Guide]. *Note:* This can be a standalone document, or for those integrated SCR units, be incorporated in the engine FMEA required by Appemdix 4-2-1A1 of the *Steel Vessel Rules.*
- Emergency shutdown arrangements

- SCR FMEA integration test report (see Subsection 3/15 of this Guide)
- Operating and maintenance instruction manuals, including MSDS sheets and details for handling of hazardous and non-hazardous chemicals used in the SCR exhaust emission abatement system
- Testing procedures during installation and commissioning trials

5 SCR 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 SCR 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 SCR 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 or non-hazardous chemicals that may be used in the exhaust emission abatement system and identification of the relevant responsible parties.

The manuals may be produced as standalone documents or incorporated within the general engine operation and service manuals required by 4-2-1/1.9.3 of the *Steel Vessel Rules*.

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

7 SCR System Configuration and Vessel Integration

7.1 General

i) SCR units are typically installed in the exhaust system of a diesel engine, if applicable, before the exhaust gas economizer and as close as possible to the engine because of the relatively high exhaust gas temperatures required by the catalysts for effective NO_x reduction reactions.

The SCR units may be installed in place of the conventional exhaust silencer or in parallel to the silencer where incorporated in a SCR bypass configuration. The exhaust systems from a number of fuel oil combustion units may be led to a common SCR unit (see 3/11.1.3 of this Guide).

For slow speed diesel engines with inherently low relative exhaust gas temperatures, this may necessitate the integration of the SCR reaction chamber and catalysts before the turbocharger exhaust turbine. The SCR catalysts may also be integrated with the engine by close coupling to the engine, typically applicable to small high-speed diesel engines. In these cases, the SCR unit is considered a primary exhaust emission reduction technique that forms part of the total engine design and as such is to be integrated by, or under authorization of, the engine designer. In those instances, the applicable requirements for SCR systems contained within this Section of the Guide are supplementary to, and to be applied in association with, the requirements for diesel engines under Section 4-2-1 of the *Steel Vessel Rules*. The integration of a SCR system to an already approved diesel engine is not considered an engine type defining parameter change as per 4-2-1/13.7.2 of the Rules.

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.

ii) SCR systems are to be designed to enable continued operation of the engine at the times the SCR 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 engine.

iii) The response of the mechanical and electrical systems of the first SCR unit in a particular design series is to be demonstrated by the FMEA integration test of Subsection 3/15 of this Guide.

7.3 Compatibility with the Engine

i) Installation and operation of an exhaust emission abatement system is to be compatible with the engine and not to cause any adverse effects on the engine performance such as excessive back pressures or temperatures during operation.

ii) Details are to be submitted demonstrating the exhaust flow compatibility of the SCR unit with the connected engine over the whole operational range of the engine. This data should demonstrate that the operating parameters of the engine do not exceed the approved design limits with the SCR system in operation. In the case of multi-engine SCR units, this compatibility evaluation is to show that the SCR unit is capable of accommodating the maximum combined exhaust flows of all the connected engines for the worst case scenario for that particular vessel arrangement and operational profile. Consideration will be given to those SCR units that incorporate extractive exhaust fans or air blowing systems to maintain the FOCU operating parameters within the approved design limits.

It is to be noted that the normal and limit values for exhaust back pressure of engines fitted with SCR exhaust emission abatement systems, together with other regulatory aspects, are to be detailed in the approved IMO Annex VI Regulation 13 Technical Files by the Administration or RO responsible for the NO_x certification.

iii) The range of suitable fuels and oils for which the SCR unit is capable of continual operation, in particular with respect to sulfur content or other elements known to cause catalyst clogging, is to be declared by the SCR or engine manufacturer and included in the SCR or engine specification documentation and instruction manuals required by Subsections 3/3 and 3/5 of this Guide.

Minimum exhaust gas temperatures, reductant flow rate limits, or other operating parameters that prohibit or limit SCR operation with the indicated range of suitable fuels and/or sulfur content are to be clearly defined in the manuals.

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 3/9.1 and 3/9.11.3 of this Guide).

Consideration will be given to alternative means of compliance or operational measures 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 sufficient spare parts onboard is an example 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 3/13.1ii) of this Guide.

7.7 Essential Services

For the purposes of design, construction, testing, and survey, SCR 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 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*.

7.11 Inspection and Maintenance

Exhaust emission abatement 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. Exemptions may be granted to those small SCR units not intended to be dismantled in service and typically integrated with high speed mass produced diesel engines.

9 SCR System Equipment

9.1 Pumps/Fans

i) Unless alternative means of compliance in accordance with 3/7.5 of this Guide are applicable, redundant pumps, essential for the continual operation of the SCR 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 exhaust emission abatement system at full rating. See also 3/9.11.3 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 SCR units will suffice rather than providing individual standby pumps for each SCR unit.

ii) Unless alternative means of compliance in accordance with 3/7.5 of this Guide are applicable and where exhaust fans form part of the SCR 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 Heat Exchangers

Where provided, heat exchangers are to be designed, constructed, and certified in accordance with Section 4-4-1 of the *Steel Vessel Rules*. Suitability of the heat exchanger materials for the intended media is to be demonstrated.

9.5 SCR Reductant System *(1 July 2017)*

Exhaust emission abatement systems using SCR technologies usually use an ammonia reductant introduced as a urea/water solution into the exhaust stream, prior to the catalyst blocks. For automotive and land-based engine applications, this reductant solution is typically a 32% urea solution meeting the ISO 22241 standard (AUS 32). A specific marine engine urea standard utilizing a 40% (AUS 40) urea solution has been developed by ISO (18611 series).

The SCR manufacturer is to detail the specification of the reductant solution(s) appropriate for use with the SCR system and any specific installation considerations that may be applicable for storage, handling, and use of the reductant. Urea is typically not classified as dangerous according to MSDS but can be an eye, skin, and respiratory irritant, and hence there is a need for the provision of appropriate safety features and personnel protective equipment.

The key fluid media components of the SCR reductant system typically comprise reductant storage tank, pumps, filters, dosing units, and injectors with associated control system. The specific requirements for SCR reductant system components using urea as a reductant are given under 3/11.3 of this Guide.

Arrangements using alternative reductant solutions, such as aqueous ammonia or anhydrous ammonia, will be considered on a case-by-case basis.

9.7 SCR Reaction Chamber

i) Details of the SCR catalyst specifications, geometry, and fixing arrangements of the catalyst elements in the reaction chamber are to be submitted.

ii) The catalyst elements are to be securely mounted in the reaction chamber to provide effective gas sealing under all operational temperatures to provide effective reaction processes and prevent the passage of unreacted ammonia to the atmosphere.

iii) Access arrangements for the catalyst elements are to provide easy removal and maintenance in service. Sufficient space around the SCR reaction chamber for replacing the catalyst elements is to be provided.

iv) Provision is to be made to indicate that catalyst elements have been removed from the reaction chamber so that reduction injection may be stopped.

v) Arrangements are to be provided to prevent the blocking or clogging of SCR catalyst elements which could create excessive exhaust backpressures for the connected engine, a reduction in catalyst reaction efficiency, and a fire hazard through soot accumulation. In general, this is expected to be achieved by control system limits on reductant injection strategies and by the inclusion of soot blowing arrangements for the catalyst chamber. Details of the soot blowing arrangements, where provided, are to be submitted for review.

The reductant injection strategies are to monitor exhaust temperatures and prevent reductant injection at those operating temperatures and modes that would cause excessive fouling of the catalyst elements by, for example, the formation of ammonia sulfates.

Arrangements are to be such that blocked catalyst elements will not prevent operation of the engine.

vi) Monitoring, alarm, and shutdown arrangements are to be provided to indicate:

a) An abnormal pressure rise across the SCR reaction chamber

b) Reductant injection rates above the conversion capability of the catalysts elements

c) Injection of reductant when the engine is not running or there is a fault with the catalyst elements or the associated SCR reductant components or systems

9.9 Pneumatic Systems

i) Details of the pneumatic systems used for reductant injection, soot blowing, and any other associated SCR systems are to be submitted. Pneumatic systems are to comply with the requirements of 4-6-7/5 of the *Steel Vessel Rules*.

ii) Air supply for these systems may be taken from existing vessel infrastructure provided it does not compromise the air start supply and reserve requirements of 4-6-5/9 of the *Steel Vessel Rules*.

9.11 Electrical System

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

9.11.1 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*.

9.11.2 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 SCR system, and for minimum comfortable conditions of habitability as per 4-8-2/3.1.1 of the Rules.

9.11.3 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 3/9.1 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.

9.11.4 Circuit Protection Devices and Compatibility

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

11 SCR System Piping

11.1 Exhaust Gas Piping Systems

11.1.1 Exhaust Gas Piping/Reaction Chamber Materials and Installation

i) Exhaust gas piping materials located before the reductant injection mixing sections or SCR reaction chamber may be of the same material specification as the standard exhaust gas piping.

ii) The sections of the SCR exhaust system and reaction chamber that are subjected to exhaust gas and reductant mixtures are to be constructed of suitable corrosion resistant materials.

Details of the exhaust mixers, mixing chambers, reductant nozzles, or injectors are to be submitted. Injection arrangements are to be designed to provide effective mixing of the reductant and exhaust gas.

iii) 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*.

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 SCR system exhaust piping systems are to prevent the passage of exhaust gases to other engines or machinery spaces.

Where bypass arrangements for the SCR system 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 atmosphere at all times is possible, either through the SCR system 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.

11.1.3 Interconnections of Exhaust Gas Piping

i) Normally exhaust pipes from diesel engines are to be routed separately and not interconnected. However, interconnected exhaust piping systems to a common exhaust emission abatement unit may be accepted subject to the arrangements preventing the passage or leakage of exhaust gases to other equipment or spaces that may then pose a safety risk to that equipment or health risk to the vessel's crew or passengers. The return of exhaust gas flow from a running engine to another stopped, or in operation, engine is to be prevented.

ii) The combined SCR system is to be designed not to exceed the back pressure limits specified by the connected engines or boilers. Fans installed for this purpose are to meet the redundancy requirements of 3/9.1ii) of this Guide.

11.1.4 Exhaust Gas Piping and SCR Reaction Chamber Insulation

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) 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 SCR 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.

11.3 Reductant Piping Systems – Urea Solution

The requirements for the reductant piping systems detailed in this Subsection are based on the use of ammonia as a reductant introduced in a urea/water solution at 32% or 40% concentrations.

11.3.1 Piping and Connections

i) In general, pipe fittings and joints are to meet the requirements of the *Steel Vessel Rules* for certification in 4-6-1/7.1, materials in 4-6-2/3, and design in 4-6-2/5.5 and 4-6-2/5.15, subject to the limitations in 4-6-5/Table 3.

ii) The reductant piping and venting systems are to be independent of other ship service piping and/or systems.

iii) Reductant piping systems are not to be located in accommodation, service, or control spaces.

iv) Supply, bunkering, and transfer lines for reductant systems, with the exception of those associated with injector equipment, 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.

v) The material of the reductant related piping systems, tanks, and other components which may come into contact with the reductant solution is to be of a suitable grade of non-combustible alloyed steel, plastic, or other compatible material established to be suitable for the application.

Non-alloyed steels, copper, copper containing alloys, and zinc-coated steels are not to be used for reductant storage or piping systems.

vi) 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 Section 4-6-3 of the *Steel Vessel Rules*. For the purpose of these Rules, "plastic" means both thermoplastic and thermosetting plastic materials, with or without reinforcement, such as polyvinyl chloride (PVC) and fiber reinforced plastics (FRP). Plastic piping is to meet Level 3 fire endurance testing requirements (see 4-6-3/5.11 of the *Steel Vessel Rules*).

vii) Flexible hoses are to comply with the requirements of 4-6-2/5.7 of the *Steel Vessel Rules*.

11.3.2 Filters and Strainers

Filters are to be provided in reductant piping systems to minimize the entry of harmful foreign material that may affect operation and closure of regulating valves, dosing valves, or other essential system components. The filters are to be designed to withstand the maximum working pressure of the system.

11.3.3 Arrangement of the Urea Storage Tank *(1 July 2017)*

i) The urea storage tank is not to be situated where spillage or leakage therefrom can constitute a hazard by falling onto combustibles or heated surfaces and is to be located in a well-ventilated area away from heat sources.

The urea storage tank may be located within the engine room. If installed in a separate compartment, the area is to be served by an effective mechanical supply and exhaust ventilation system providing not less than 6 air changes per hour which is independent from the ventilation system of accommodation, service spaces, or control stations. In addition, if located in a separate compartment, the ventilation system is to be capable of being controlled from outside the compartment and is to be maintained in operation continuously except when the storage tank is empty and has been thoroughly air purged. If the ventilation stops, an audible and visual alarm is to be provided outside the compartment adjacent to each point of entry, and inside the compartment, together with a warning notice requiring the use of such ventilation.

Alternatively, where a urea storage tank is located within an engine room a separate ventilation system is not required when the general ventilation system for the space is arranged so as to provide an effective movement of air in the vicinity of the storage tank and is to be maintained in operation continuously except when the storage tank is empty and has been thoroughly air purged.

Where urea based ammonia solution is stored in integral tanks, the following are to be considered during the design and construction:

a) These tanks may be designed and constructed as an integral part of the hull, (e.g. double bottom, wing tanks).

b) These tanks are to be coated with appropriate anti-corrosion coating and cannot be located adjacent to any fuel oil and fresh water tank.

c) These tanks are to be fitted with but not limited to level gauge, temperature gauge, high temperature alarm, low level alarm.

ii) The urea storage tank is to be protected from excessively high or low temperatures applicable to the particular urea concentration of the solution (e.g., above 30°C and below 0°C for a 40% solution). Depending on the operational area of the vessel, this may necessitate the fitting of heating and/or cooling systems. The physical conditions recommended by applicable recognized standards (such as ISO 18611-3) are to be considered to avoid impairment of the urea solution during storage.

iii) Every pipe emanating from a tank containing urea, which, if damaged, would allow urea to escape from the tank, is to be provided with a manual closing valve located directly on the tank.

iv) The urea storage tank is to be provided with vent pipes complying with 4-6-4/9 of the *Steel Vessel Rules*, and the outlets are to terminate in a safe location [see 4-6-4/9.3.5(b)ii) of the *Steel Vessel Rules*] in the weather and arranged to prevent entrance of water into the urea tank.

The vents are not to 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 vessel. Alternatively, the tanks are to be fitted with appropriately sized pressure/vacuum valves.

v) The urea storage tank is to be provided with temperature and level monitoring arrangements. High and low level alarms together with high and low temperature alarms are to be provided.

vi) Urea storage tanks are to be arranged so that they can be emptied of urea, purged and vented.

11.3.4 Spill Trays

Urea storage tanks with a capacity of 500 liters (132 US gallons) and above are to be located within spill trays fitted with a high level alarm.

11.3.5 Personnel Protection *(1 July 2017)*

For the protection of crew members, the vessel is to have on board suitable protective equipment consisting of large aprons, rubber gloves with long sleeves, rubber boots, coveralls of chemical-resistant material, dust respirator, and tight-fitting chemical safety goggles or face shields or both. Eyewash and safety showers are to be provided. The location and number of these eyewash stations and safety showers are to be derived from the detailed installation arrangements.

11.3.6 Safety Notices for the Compartment or at the Location of Tanks Containing Urea

Safety instructions relating to precautions and corrective response actions are to be posted in the compartment containing urea and beside the entrance to the compartment. Detailed guidelines given in the MSDS are to be followed.

13 Control, Monitoring, and Safety Systems

13.1 General

i) The control system for the SCR exhaust emission abatement system may be connected to an integrated control system or may be a standalone system. Where the SCR control system is integrated in the base engine design, the control system is to be integrated with, or in direct communication with, the engine control system.

ii) 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 vessel.

An FMEA, or equivalent, demonstrating the safety system design basis is to be submitted.

iii) Where fitted, exhaust emissions monitoring systems are to meet the requirements of Section 5 of this Guide.

13.3 Control and Monitoring System

i) Automatic control, alarm, and safety functions are to be provided for the SCR system so that operations remain within preset parameters for all diesel engine and exhaust emission abatement system operating conditions. For vessels with **ACC** or **ACCU** notations, the alarm and monitoring systems are to be integrated in the vessel's centralized monitoring systems that conform to the requirements for **ACC** or **ACCU** notations.

ii) The temperatures, pressures, and flows in the SCR system and associated systems are to be controlled and monitored as follows:

a) A local control and monitoring system for the SCR 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. This may be integrated with the engine control system and/or be a standalone system.

b) The design of the control system is to provide identification of faults in the equipment, as well as the process system. The control and monitoring systems are to comply with the requirements of 4-9-2/3.1 of the *Steel Vessel Rules*, as applicable.

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 Section 3, Table 1 of this Guide and are to include the following parameters:

1) SCR system pump/fan/motor operational status

2) Status of any SCR system valves

3) SCR system parameters for operational safety

4) Level indication of SCR system tanks

5) Status of any SCR system alarms, shutdowns and Emergency Stop

d) Injection of reductant solutions outside the exhaust gas temperature limits specified by the catalyst manufacturer is to be prohibited by the control system [see 3/9.7vi) of this Guide], and control strategies are to minimize ammonia slip.

e) The computer-based control systems are to comply with the applicable requirements of Section 4-9-3 of the *Steel Vessel Rules* as a Category II system based on 4-8-3/15 of the *Steel Vessel Rules*.

iii) The power supply arrangements for the control and monitoring system are to meet the requirements of 4-9-2/5.3 of the *Steel Vessel Rules*.

13.5 Safety Shutdown System

A shutdown system is to be provided. This safety shutdown system is to be based on the following principles:

i) Means are to be provided to indicate the parameters causing shutdown.

ii) Upon activation of the safety shutdown system, alarms are to be given at the normal control position and at the local control position.

iii) In the event where shutdown by the safety shutdown system is activated, the restart should not occur automatically, unless after the system is reset.

Monitoring and safety shutdowns are to be in accordance with Section 3, Table 1 of this Guide.

15 FMEA Integration Test

An integration test is to be undertaken on the first SCR unit in a particular design series to verify that the operation and response of the complete SCR 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 3/13.1ii) of this Guide.

17 Surveys During Construction

17.1 General

This Subsection pertains to surveys during fabrication at the manufacturer's facility and installation and testing of SCR units onboard. As applicable, these surveys may be incorporated with the certification, shop test, and shipboard tests required by the applicable aspects of 4-2-1/13 and 4-2-1/15 of the *Steel Vessel Rules*. 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.

17.3 Surveys at Manufacturer's Facility

See Section 3, Table 2 of this Guide for certification requirements of SCR units and associated systems. Survey requirements for equipment components and packaged units at the manufacturer's facility are summarized in the relevant sections of the applicable Rules/Guides.

17.5 Surveys During Installation

The following surveys are to be carried out to the satisfaction of the attending Surveyor on the SCR unit and associated systems during installation and testing:

i) Inspection and verification that the foundations and attachments of the principal components of the SCR abatement unit and associated systems are in accordance with the approved plans and particulars.

ii) Piping systems are to be visually examined and pressure-tested, as required by the *Steel Vessel Rules*. Pressure tests conducted on Class I piping systems (see 4-6-1/Table 1 of the *Steel Vessel Rules*) should preferably be recorded on test charts for the duration of their tests.

iii) Electrical wiring and connections are to be in accordance with Part 4, Chapter 8 of the *Steel Vessel Rules* and checked for continuity and proper workmanship.

iv) Instrumentation is to be tested to confirm proper operation as per its predetermined set points.

v) Pressure relief and safety valves installed on the unit are to be tested.

vi) Control system and shutdowns are to be tested for proper operation.

vii) The SCR unit is to be checked for proper operation in accordance with the ABS approved installation test procedure.

17.7 Surveys During Trials

During the initial commissioning trials, the SCR 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 ABS-approved testing procedure during sea trials.

TABLE 1
Monitoring and Safety System Functions for SCR Systems

Monitored Parameters	*Display*	*Alarm Activated*	*Automatic SCR Shutdown and Automatic SCR 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, as applicable	Running	Failed	
Exhaust gas temperature before SCR chamber	X	High	X (High-High)
Exhaust gas temperature after SCR chamber	X	High	X (High-High)
Exhaust gas backpressure after the engine	X	High	X (High-High)
Differential pressure across SCR chamber	X	High	X (High-High)
Reductant dosing pumps	Running	Stop (2)	
Reductant system supply pressure	X	Low	X (Low-Low)
Reductant storage tank temperature	X	Low/High	X (High-High)
Reductant storage tank level	X	Low/High	X (Low-Low)
Reductant tank drip tray level (3)		High	X (High-High)
Pneumatic supply pressure, injector and soot blowing systems	X	Low	X (Low-Low)
Control power supply	Running	Failed	
Emergency shutdown	X	X	X

Notes:

1 Automatic bypass of the SCR unit is only applicable to those SCR units fitted with exhaust gas bypass arrangements (see 3/7.1 of this Guide).

2 Failure of essential SCR system motors driving pumps or fans is to activate the standby units, where fitted (see 3/9.11.3 of this Guide).

3 Urea storage tanks of 500 liters (132 US gallons) and above only (see 3/11.3.4 of this Guide).

TABLE 2
Certification of SCR Systems at the Manufacturer's Facility

This Table has been prepared for guidance only and annotated to agree with the *Steel Vessel 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 *Steel Vessel Rules*. This list is not to be considered as substitutive or integrative of the content of the *Steel Vessel Rules* and/or other applicable Regulations. In case of conflict between the content of this list and the applicable *Steel Vessel Rules* and other applicable regulations, the latter are to be considered applicable.

Code	*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*
SCR unit	X	X	X
Exhaust piping	X		
Exhaust bypass or isolation valves	X		
Exhaust fans/motors (1)	X		X
Heat exchangers	X		X
Reductant system piping	X		
Pneumatic systems	X		
Control system	X		
Automatic shutdown and safety system	X		

Notes:

1 Applicable for motors over 100 kW (135 hp) only. For motors less than 100 kW (135 hp), certification by ABS not required, acceptance based on manufacturers documentation and guarantee (see 3/9.11.1 of this Guide).

SECTION 4 EGC – Exhaust Gas Recirculation Systems

1 General

Exhaust Gas Recirculation systems fitted for the purposes of reducing diesel engine NO_x emissions are considered primary exhaust emission reduction techniques forming part of the total engine design and as such are to be integrated by, or under authorization of, the engine designer. Those applicable requirements for EGR systems contained within this Guide are supplementary to, and to be applied in association with, the requirements for diesel engines under Section 4-2-1 of the *Steel Vessel Rules*.

Those EGR systems that incorporate extensive off-engine systems that are 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, may be assigned the **EGC-EGR** notation in accordance with 1/9.7 of this Guide. Where a water treatment system is incorporated in the EGR system, the washwater discharge criteria is to meet the requirements of IMO Resolution MEPC.184(59).

The **EGC-EGR** notation is not intended to be applied to those vessels that have installed engines that incorporate all EGR system components within the base engine design and, for example, may be primarily designed for use with low sulfur fuels. For those engines, the EGR system, or EGR version of the engine, is to be approved by incorporation to the existing diesel engine approval.

3 Plans and Data to be Submitted

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

- General arrangement of the EGR installation, layout, and systems
- Documentation detailing the EGR specification and associated water treatment systems, including details of EGR specific components such as coolers, blowers, valves, etc.
- Hull plans showing the foundation and attachments of accessories to the vessel's structure, including scantlings, welding details, and foundation details of principal components
- Material specifications for the EGR equipment and associated systems, including coolers, blowers, 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 position at which exhaust emission or EGR rate monitoring and washwater monitoring are to be located
- Details of all electrical equipment installed for the EGR unit and associated systems, including computer-based systems
- Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the EGR exhaust emission abatement system [see 4/13.1ii) of this Guide]. *Note:* This can form a supplement or be incorporated in the engine FMEA required by Appendix 4-2-1A1 of the *Steel Vessel Rules.*

- Emergency shutdown arrangements
- EGR FMEA integration test report (see Subsection 4/15 of this Guide)
- Operating and maintenance instruction manuals, including MSDS sheets and details for handling of hazardous and non-hazardous chemicals used in the EGR exhaust emission abatement system
- Testing procedures during installation and commissioning trials

5 EGR 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 EGR 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 EGR system 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 may be produced as standalone documents or incorporated within the general engine operation and service manuals required by 4-2-1/1.9.3 of the *Steel Vessel Rules*.

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

7 EGR System Configuration and Vessel Integration

7.1 General

i) Exhaust Gas Recirculation is the process of recirculating a portion of the diesel engine exhaust gases, typically up to 40%, back to the engine cylinders for the purpose of reducing the amount of excess oxygen within the cylinder and thereby reducing engine NO_x emissions. This is considered a primary exhaust emission reduction technique and as such is to be integrated by, or under authorization of, the engine designer.

Furthermore, the relatively high sulfur content of marine fuels would typically necessitate the use of cleaning processes to be applied to the exhaust gases to avoid engine fouling and corrosion issues, similar to the water treatment systems applied to SO_x scrubbers, and hence those aspects of the EGR system are to comply with the requirements of this Guide and the washwater discharge criteria, of IMO Resolution MEPC.184(59).

The integration of an EGR system to an already approved diesel engine is not considered an engine type defining parameter change as per 4-2-1/13.7.2 of the Rules.

ii) EGR systems are to be designed to enable continued operation of the engine at the times the EGR system is not in operation, either through operational selection, equipment failure, or system deterioration through partial blocking/clogging.

iii) The response of the mechanical and electrical systems of the first EGR unit in a particular design series is to be demonstrated by the FMEA integration test of Subsection 4/15 of this Guide.

7.3 Compatibility with the Engine

i) Installation and operation of the EGR system is to be compatible with the engine and not to cause any adverse effects on the engine performance such as excessive back pressures or temperatures during operation.

ii) The range of suitable fuels for which the EGR system is capable of continual operation, in particular with respect to sulfur content and other fuel elements known to cause fouling issues, is to be declared by the EGR manufacturer and included in the EGR specification documentation and instruction manuals required by Subsections 4/3 and 4/5 of this Guide.

7.5 Redundancy

Redundancy of equipment is to be provided for those rotating and reciprocating components that form part of the EGR essential supplementary systems, such as pumps, fans, blowers, etc. (see 4/9.1 and 4/9.7.3 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 sufficient spare parts onboard is an example 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 4/13.1ii) of this Guide.

7.7 Essential Services

For the purposes of design, construction, testing, and survey, EGR 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 Prevention of Flooding

i) For EGR systems that incorporate a wet washwater scrubbing process, arrangements are to be provided to prevent the ingress of scrubber washwater into the engine under any circumstance.

ii) Monitoring, alarm, and shutdown arrangements are to be provided to prevent an abnormal rise of washwater level in the EGR scrubber unit.

7.11 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*.

9 EGR System Equipment

9.1 Pumps/Blowers

i) Where provided, pumps used in EGR SO_x scrubber washwater, dosing, discharge, etc., systems, essential for the continual operation of the EGR exhaust emission abatement 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 diesel engines rated at 2250 kW and above or having cylinders of more than 300 mm (11.8 in.) bore.

ii) Unless alternative means of compliance in accordance with 4/7.5 of this Guide are applicable, redundant washwater, dosing, discharge, etc., pumps, essential for the continual operation of the EGR water systems, are to be provided. There are to be at least two of these essential pumps, 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 4/9.7.3 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 EGR units will suffice rather than providing individual standby pumps for each EGR unit.

iii) Unless alternative means of compliance in accordance with 4/7.5 of this Guide are applicable and where exhaust fans or blowers form part of the EGR system and are essential for continual operation of the exhaust emission abatement system at full rating, such fans or blowers are to be installed in a redundant arrangement. The number and power of the fans or blowers should be such that if one unit, or group of units, is out of service the capacity of the remaining units is not to be less than 100% of the total required.

iv) High-speed blowers of 100 kW (135 hp) and over are to be designed, constructed, and certified in accordance with the applicable parts of Section 4-2-2 of the *Steel Vessel Rules*.

9.3 Heat Exchangers/EGR Exhaust Gas Coolers

i) Where provided, heat exchangers are to be designed, constructed, and certified in accordance with Section 4-4-1 of the *Steel Vessel Rules*.

ii) EGR exhaust gas coolers are not subject to 4/9.3i) of this Guide. Suitability of the cooler materials for the exhaust gases is to be demonstrated.

The coolers are to be hydrostatically tested on the water side to 4 bar (4.1 kgf/cm^2, 57 psi), but not less than 1.5 times the design pressure on the water side, either in the manufacturer's plant or in the presence of the Surveyor, after installation onboard the vessel. See also 4-2-1/13.3 of the *Steel Vessel Rules* for acceptance of manufacturer's certificate.

9.5 Chemical Treatment System

The specific requirements for chemical treatment system components are given under 4/11.5 of this Guide.

9.7 Electrical System

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

9.7.1 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*.

9.7.2 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 EGR system, and for minimum comfortable conditions of habitability as per 4-8-2/3.1.1 of the Rules.

9.7.3 Standby Pump/Fan Arrangements

i) In the event of failure of the essential exhaust emission abatement system pumps or fans/blowers, the standby pump or fan/blower required by 4/9.1 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/blower 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/blower may be fed from the other separate section of the switchboard.

9.7.4 Circuit Protection Devices and Compatibility

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

11 EGR 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 EGR SO_x scrubber, where fitted, may be of the same material specification as the standard engine 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.

11.1.2 Exhaust Gas Piping Valves

i) Valves used in the EGR exhaust system 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) The EGR exhaust system valves are to be arranged for automatic position control and position monitoring in association with the EGR control and monitoring system.

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.

11.1.3 EGR Scrubber and EGR System Insulation

Hot surfaces of EGR systems 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) 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 EGR 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.

11.3 Washwater Piping

11.3.1 Piping and Connections

i) Where applicable, the EGR SO_x washwater system pipe fittings and joints are in general to meet the requirements of the *Steel Vessel Rules* for certification in 4-6-1/7.1, materials in 4-6-2/3 and design in 4-6-2/5.5 and 4-6-2/5.15, subject to the limitations in 4-6-5/Table 3.

Molded non-metallic expansion joints, where used, are to be of an approved type (see 4-6-2/5.8.1, 4-6-2/Table 2 of the *Steel Vessel Rules* for Cu and Cu Alloy and 4-6-2/Table 5 of the *Steel Vessel Rules* for pipe thickness).

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

iii) 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 Section 4-6-3 of the *Steel Vessel Rules*. For the purpose of these Rules, "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 4-6-3/5.11 of the *Steel Vessel Rules*).

iv) Flexible hoses are to comply with the requirements of 4-6-2/5.7 of the *Steel Vessel Rules*.

11.3.2 Remote Control Valves

i) Upon loss of control power, the remote control valves are to remain in the last ordered position, provided there is a readily accessible manual means to close the valves or are to fail safe in accordance with the FMEA.

ii) Remote control valves are to be clearly identified and are to be provided with position indicators at the local and EGR system remote control station, as applicable.

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.

11.3.3 Overboard Discharges

i) The overboard discharges of any exhaust emission abatement system are not to be interconnected to other systems.

ii) Special attention is to be paid to the corrosion resistivity of EGR washwater overboard discharge piping. Where applicable, adequate arrangements are to be provided to prevent galvanic corrosion due to the use of dissimilar metals.

iii) Due consideration is to be given to the location of overboard discharges with respect to vessel propulsion features, such as thrusters or propellers. As applicable, discharges are to be arranged to enable safe sampling of water discharge plumes.

11.5 Chemical Treatment Piping Systems

The requirements for the washwater chemical treatment system detailed in this Paragraph are based on the use of Caustic Soda (NaOH) in the EGR scrubber water treatment system, as applicable. 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 EGR 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 4/11.5 of this Guide and the requirements for the residue tank in 4/11.7 of this Guide.

11.5.1 Material for Piping Systems, NaOH Storage Tank, and EGR Residue/NaOH Overflow Tank

The material of the NaOH related piping systems, NaOH storage tank, EGR residue/NaOH overflow tanks, 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.

11.5.2 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 EGR residue/ NaOH overflow tank, are to be provided.

11.5.3 Arrangement of the NaOH Storage Tank and the EGR Residue/NaOH Overflow Tank

i) The NaOH storage and EGC residue/NaOH overflow tank are not to be situated where spillage or leakage therefrom 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).

ii) Where necessary, the NaOH storage tank is to be provided with an appropriate heating system to prevent freezing.

11.5.4 Filling, Vents, and Overflows for NaOH Tank and EGR Residue/NaOH Overflow Tank

i) *Filling.* The NaOH storage tank is to be provided with a fill line from the bunker station and a shut off valve is to be provided at the bunkering station.

Overflow and/or drains leading to the EGR 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 EGR residue/NaOH overflow tank.

ii) *Vents.* The NaOH storage and EGR residue/NaOH overflow tanks are to be provided with vent pipes complying with 4-6-4/9 of the *Steel Vessel Rules*, and the outlets are to terminate in a safe location [see 4-6-4/9.3.5(b)ii) of the *Steel Vessel Rules*] 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 vessel. Alternatively, the tanks are to be fitted with appropriately sized pressure/vacuum valves.

iii) *Overflow Protection.* Means are to be provided to prevent NaOH from spilling or accidently overflowing from the storage and EGR 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 4-6-4/13.5.4 and 4-6-4/9.5.2 of the *Steel Vessel Rules* that is led to the EGR residue/NaOH overflow tank. Further, in all cases, the EGR 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.

11.5.5 Sounding and Temperature Indication for the NaOH Storage and EGR Residue/NaOH Overflow Tanks

i) Sounding arrangements are to be provided for the NaOH storage and EGR residue/NaOH overflow tanks, and are to comply with the sounding requirements applicable to fuel oil tanks of 4-6-4/11.3.7 of the *Steel Vessel Rules*.

ii) 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 required in 4-6-4/11.3.7 of the *Steel Vessel Rules*, (i.e., flat "glass-type"), fitted with a self-closing valve at each end.

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

iv) The NaOH storage and EGR residue/NaOH overflow tank are to be provided with local and remote temperature monitoring arrangements. The remote temperature indication is to be installed at the manned control station.

11.5.6 Spill Trays

i) Those areas of the NaOH storage and EGR 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 EGR 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 EGR residue/NaOH overflow tank is to be fitted with a non-return valve.

11.5.7 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.

11.5.8 Ventilation Arrangements

The NaOH storage and EGR 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.

11.5.9 Personnel Protection

For the protection of crew members, the vessel 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.

11.5.10 Safety Notices for the Compartment or at the Location of Tanks Containing NaOH

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.

11.7 Residue System

i) 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 in accordance with 4-6-4/5.7.4 of the *Steel Vessel Rules*.

The EGR residue tank is to be so designed as to facilitate cleaning.

Where EGR 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 4/11.5 of this Guide are to be applied.

ii) The material of the EGR residue tank is to be selected based on the corrosive nature of the EGR residue.

iii) The capacity of the EGR residue tank is to be based on the expected residue volumes applicable to the exhaust gas cleaning process and the maximum period of voyage between ports where EGR residue can be discharged. In the absence of precise data, a figure of 30 days is to be used.

iv) The EGR residue tank is to be provided with vent pipes complying with 4-6-4/9 of the Rules.

v) The residue tank is to be arranged with a high level alarm.

vi) Sounding arrangements are to be provided for the EGR residue tank in accordance with 4-6-4/11.3.7 of the *Steel Vessels Rules*.

vii) For those vessels 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 EGR residue tank, provided the tank meets the requirements of 4/11.7i) through vi) of this Guide, EGR residue record logs satisfy the requirements of MEPC.184(59), and residues are disposed at MARPOL reception facilities.

Combined engine room sludge and EGR residue tanks are to be sized to provide adequate capacity based on the sludge tank capacity requirements of 4-6-4/5.7.3 of the *Steel Vessel Rules* plus the capacity requirements for EGR residue tanks of 4/11.7iii) of this Guide.

13 Control, Alarm, and Monitoring System

13.1 General

i) The EGR control system is to be integrated with, or in direct communication with, the engine control system. Control systems for associated systems, such as water treatment plants, may be connected to an integrated control system or may be a standalone system.

ii) 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 vessel.

An FMEA, or equivalent, demonstrating the safety system design basis is to be submitted.

iii) Where fitted, exhaust emissions monitoring systems are to meet the requirements of Section 5 of this Guide.

13.3 Control and Monitoring System

i) Automatic control, monitoring (including washwater discharge criteria), alarm, and safety functions are to be provided for the EGR system so that operations remain within preset parameters for all engine operating conditions. For vessels with **ACC** or **ACCU** notations, the alarm and monitoring systems are to be integrated in the vessel's centralized monitoring systems that conform to the requirements for **ACC** or **ACCU** notations.

ii) The temperatures, pressures and flows in the EGR system and associated systems are to be controlled and monitored as follows:

a) A local control and monitoring system for the EGR 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. This may be integrated with the engine control system and/or be a standalone system.

b) The design of the control system is to provide identification of faults in the equipment, as well as the process system. The control and monitoring systems are to comply with the requirements of 4-9-2/3.1 of the *Steel Vessel Rules*, as applicable.

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 Section 4, Table 1 of this Guide and are to include the following parameters:

1) EGR system pump/fan/blower/motor operational status

2) Status of any EGR system valves

3) EGR system parameters for operational safety

4) Level indication of EGR system tanks

5) Status of any EGR system alarms, shutdowns and Emergency Stop

d) The computer-based control systems are to comply with the applicable requirements of Section 4-9-3 of the *Steel Vessel Rules* as a Category II system based on 4-8-3/15 of the *Steel Vessel Rules*.

iii) The power supply arrangements for the control and monitoring system are to meet the requirements of 4-9-2/5.3 of the *Steel Vessel Rules*.

13.5 Safety Shutdown System

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

i) Means are to be provided to indicate the parameters causing shutdown.

ii) Upon activation of the safety shutdown system, alarms are to be given at the normal control position and at the local control position.

iii) In the event where shutdown by the safety shutdown system is activated, the restart should not occur automatically, unless after the system is reset.

Monitoring and safety shutdowns are to be in accordance with Section 4, Table 1 of this Guide.

15 FMEA Integration Test

An integration test is to be undertaken on the first EGR unit in a particular design series to verify that the operation and response of the complete EGR 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 4/13.1ii) of this Guide.

17 Surveys During Construction

17.1 General

This Subsection pertains to surveys during fabrication at the manufacturer's facility and installation and testing of EGR equipment and associated systems onboard. These surveys may be incorporated with the certification, shop test, and shipboard tests required by the applicable aspects of 4-2-1/13 and 4-2-1/15 of the *Steel Vessel Rules*. 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.

17.3 Surveys at Manufacturer's Facility

See Section 4, Table 2 of this Guide for certification requirements of EGR equipment and associated systems. Survey requirements for equipment components and packaged units at the manufacturer's facility are summarized in the relevant sections of the applicable Rules/Guides.

17.5 Surveys During Installation

The following surveys are to be carried out to the satisfaction of the attending Surveyor on the EGR equipment and associated systems during installation and testing:

i) Inspection and verification that the foundations and attachments of the principal components of the EGR equipment and associated systems are in accordance with the approved plans and particulars.

ii) Piping systems are to be visually examined and pressure-tested, as required by the *Steel Vessel Rules*. Pressure tests conducted on Class I piping (see 4-6-1/Table 1 of the *Steel Vessel Rules*) systems should preferably be recorded on test charts for the duration of their tests.

iii) Electrical wiring and connections are to be in accordance with Part 4, Chapter 8 of the *Steel Vessel Rules* and checked for continuity and proper workmanship.

iv) Instrumentation is to be tested to confirm proper operation as per its predetermined set points.

v) Pressure relief and safety valves installed on the unit are to be tested.

vi) Control system and shutdowns are to be tested for proper operation.

vii) The EGR system is to be checked for proper operation in accordance with the ABS-approved installation test procedure.

17.7 Surveys During Trials

During the initial commissioning trials, the EGR equipment and associated systems are to be confirmed for their satisfactory operation, including associated controls, alarms, and shutdowns. The tests are to be conducted in accordance with the ABS-approved testing procedure during sea trials.

TABLE 1
Monitoring and Safety System Functions for EGR Systems

Monitored Parameters	*Display*	*Alarm Activated*	*Automatic EGR Shutdown*
EGR exhaust fan/blower motors	Running	Stop (1)	
EGR exhaust bypass, isolation, mixing valves, where provided	Position		
Control-actuating medium of the EGR exhaust bypass or isolation valves	Running	Failed	
Exhaust gas temperature before EGR unit	X	High	X (High-High)
Exhaust gas temperature after EGR unit	X	High	X (High-High)
Engine air intake O_2 concentration (or EGR rate)	X	Low/High	X (Low-Low/ High-High)
Differential pressure across EGR scrubber unit or EGR circuit, as applicable	X	High	X (High-High) (2)
EGR washwater pumps, alkali system pumps	Running	Stop (1)	
EGR washwater or alkali system valves	Position		
Control-actuating medium of the EGR washwater and alkali system valves, where provided	Running	Failed	
EGR washwater and alkali system supply pressure	X	Low	X (Low-Low)
EGR washwater and alkali system supply temperature	X	High	X (High-High)
Water level in EGR scrubber	X	High	X (High-High) (2)
Alkali storage tank temperature	X	Low/High	X (High-High)
Alkali storage tank level	X	Low/High	X (Low-Low)
Alkali system drip tray level	X	High	X (High-High) (3)
EGC residue tank level	X	High	X (High-High)
Control power supply	Running	Failed	
Emergency shutdown	X	X	X

Notes:

1 Failure of essential EGR system motors driving pumps, fans or blowers is to activate the standby units, where fitted (see 4/9.7.3 of this Guide).

2 Independent safety shutdown system as required by 4/13.5 of this Guide.

3 Automatic shutdown is to activate the close coupled alkali storage tank valves required by 4/11.5.7iii) of this Guide.

TABLE 2
Certification of EGR Equipment and Systems at the Manufacturer's Facility

This Table has been prepared for guidance only and annotated to agree with the *Steel Vessel 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 *Steel Vessel Rules*. This list is not to be considered as substitutive or integrative of the content of the *Steel Vessel Rules* and/or other applicable Regulations. In case of conflict between the content of this list and the applicable *Steel Vessel Rules* and other applicable regulations, the latter are to be considered applicable.

Code	*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*
EGR SO_x scrubber unit, as applicable	X	X	X
Exhaust piping	X		
Exhaust bypass or mixing valves	X		
Exhaust fans/blowers [1, 2]	X		X
Heat exchangers [3]	X		X
Water treatment system	X		X
Washwater, alkali system and essential EGR system pumps [4]	X		X
Washwater, alkali and EGR residue associated piping	X		
Control system	X		
Automatic shutdown and safety system	X		

Notes:

1 Applicable for motors over 100 kW (135 hp) only. For motors less than 100 kW (135 hp), certification by ABS not required, acceptance based on manufacturer's documentation and guarantee (see 4/9.7.1 of this Guide).

2 High-speed blowers of 100 kW (135 hp) and over are to be designed, constructed, and certified in accordance with the applicable parts of Section 4-2-2 of the *Steel Vessel Rules* [see 4/9.1iv) of this Guide].

3 For EGR coolers, see 4/9.3ii) of this Guide.

4 Applicable to pumps fitted to EGR systems connected to diesel engines rated at 2250 kW and above or having cylinders of more than 300 mm (11.8 in.) bore [see 4/9.1i) of this Guide].

SECTION 5 Exhaust Emission Monitoring Systems

1 General

The requirements in this Section provide guidance on the arrangements and system design for permanently installed Exhaust Emission Monitoring Systems (EEMS) designed for the monitoring of gaseous exhaust emission constituents, primarily for compliance verification of the NO_x and SO_x emissions. These monitoring systems would, as a minimum, necessitate the measurement of the NO_x, SO_2, and CO_2 gaseous species. Additional exhaust emission measurements for the purposes of fuel efficiency verification, or other gaseous species such as HC, CO, O_2, or exhaust smoke/opacity/PM measurements, not specifically required for compliance verification, may be considered on an optional and case-by-case basis.

The intent is that these requirements supplement the statutory specification, calibration, testing, and survey requirements of the applicable IMO Regulations and Guidelines. At the time of issuance of this Guide, the applicable IMO requirements are detailed in the Revised MARPOL Annex VI and NO_x Technical Code 2008, IMO Resolution MEPC.198(62) – *2011 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 15 July 2011 and IMO Resolution 184.(59) – *2009 Guidelines for Exhaust Gas Cleaning Systems*, adopted 17 July 2009. NO_x emissions monitoring systems may be installed for the purpose of monitoring exhaust emission abatement systems or for application as an alternative onboard NO_x verification procedure in accordance with the requirements for Direct Measurement and Monitoring Systems of 6.4 and Appendix 8 of the NO_x Technical Code.

Compliance with the applicable IMO Regulations is a pre-requisite for ABS approval of the exhaust emission monitoring system in accordance with the requirements of this Guide, and the statutory approval aspects would be made by ABS as a separate parallel process in the capacity of a Recognized Organization for the vast majority of flag Administrations.

3 Plans and Data to be Submitted

Plans and specifications covering the exhaust emission monitoring system arrangements are to be submitted and are, as applicable, to include:

- General arrangement of the exhaust emission monitoring system installation, layout, and systems
- Documentation detailing the exhaust emission monitoring equipment and associated system specifications
- Details of the exhaust emission sampling and piping systems, including details of probes, pre-filters, heated lines, air supply arrangements, pure and calibration gas lines, design pressures, temperatures, materials, and insulation
- 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 emissions monitoring probes are to be located
- Details of all electrical equipment installed for the EEMS equipment and associated systems
- Schematic diagrams and operational descriptions of the exhaust emission monitoring equipment and associated systems power supply arrangements
- Electrical one line diagrams depicting type, size, and protection of electrical cables used in the EEMS control and monitoring equipment
- Operating and maintenance instruction manuals
- Testing procedures during installation and commissioning trials

5 EEMS 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 exhaust emission monitoring 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 EEMS together with identification of the relevant responsible parties and special instructions for the health and safety implications of handling and proximity to exhaust gases and the storage and handling of pressurized bottles of pure and calibration gases. Special attention is to be paid to maintaining the continued serviceability and accuracy of the monitoring system.

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

7 Exhaust Emission Monitoring Systems

7.1 General

i) Exhaust emissions monitoring systems may typically be installed for the purpose of, but not limited to, verifying compliance with MARPOL Annex VI Regulations 13 and 14 for NO_x or SO_x gaseous emissions and may also be installed in association with an EGC aftertreatment system.

ii) Alternative emissions monitoring system design principles are permitted provided analyzer equivalency is demonstrated [see also 5/9.7i) of this Guide]. Accordingly, the requirements for certain design features, such as sample handling and pneumatic systems detailed under 5/9.5 and 5/9.11 of this Guide, respectively, may not be applicable to all exhaust emissions monitoring systems.

iii) The notation for an exhaust emissions monitoring system may be assigned to a vessel fitted with, or without, an exhaust emission abatement system; see Subsection 1/9 of this Guide.

7.3 Inclinations

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

9 EEMS Equipment

9.1 General

i) Due consideration is to be given to the safety implications related to the handling and proximity of exhaust gases, the measurement equipment, and the storage and use of pressurized pure and calibration gases. Such implications are to be documented in the operation and maintenance manuals and suitable warning notices positioned at the sample points and measurement equipment.

ii) Where practicable, permanent access platforms are to be installed to enable safe operation and maintenance of the exhaust emission monitoring equipment.

9.3 Sample Probes for Gaseous Emissions

i) The gaseous sampling probes are to be positioned to enable sampling of a representative exhaust gas sample after the engine, turbocharger, or EGC system, in accordance with the location and temperature criteria of 5.9.3.1 and 5.9.3.2 of the NO_x Technical Code.

Sample probes are to meet the design requirements of 1.2.1 of Appendix 3 of the NO_x Technical Code.

ii) A sample probe connection flange designed in accordance with Section 5 of Appendix 8 of the NO_x Technical Code and 5/9.3i) of this Guide is to be provided for each engine or FOCU required to be monitored.

iii) The sample probe connection flanges are preferably to be installed in accessible locations, clear of or protected from obstructions or moving equipment, in order to permit regular inspection and/or periodic servicing.

iv) In order to establish the capability of the sample probe to withstand fatigue, which is likely to occur due to vibrations under operating conditions, each sample probe design is to be vibration tested in accordance with a recognized standard, such as IEC 60068-2-6 for location on diesel engines, as per 4-9-8/Table 1, Item 5, to 10g of the *Steel Vessel Rules*.

9.5 Sample Handling

i) Where applicable, pre-filters and heated sample lines are preferably to be installed in accessible locations, clear of or protected from obstructions or moving equipment, in order to permit regular inspection and/or periodic servicing.

Pre-filters and heated lines are to meet the design requirements of 1.2.2-5 of Appendix 3 of the NO_x Technical Code.

ii) In order to establish the capability of the pre-filters and sample lines to withstand fatigue, which is likely to occur due to vibrations under operating conditions, each design is to be vibration tested in accordance with a recognized standard, such as IEC 60068-2-6, as per 4-9-8/Table 1, Item 5, to 4g of the *Steel Vessel Rules*.

iii) Hot surfaces of pre-filters or heated lines 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) 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 sampling components 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.

9.7 Analyzer Specifications and Calibration

i) The EEMS gaseous analyzers are to be in accordance with the principles and specifications of Appendix 3 of the NO_x Technical Code or else demonstrated as equivalent in accordance with ISO 5725-1 and 5725-2, as permitted by 5.4.2 of the NO_x Technical Code and ISO 8178-1 Section 7, to the satisfaction of ABS.

ii) Calibration of the EEMS analyzers is to be in accordance with Appendix 4 of the NO_x Technical Code or else demonstrated as equivalent to the satisfaction of ABS.

9.9 Data Recording and Processing Device

i) The EEMS is to be capable of recording calibration and emissions monitoring data. This capability may be incorporated within the EEMS control or integrated system.

ii) The data recording device should be capable of preparing data and reports over specified time periods in a readily readable format capable of being downloaded and printed by an attending Surveyor.

9.11 Pneumatic Systems

i) Where applicable, details of the pneumatic arrangements used for exhaust emission monitoring systems are to be submitted and are to comply with the requirements of 4-9-2/5.7 of the *Steel Vessel Rules*.

ii) Air supply for these systems may be taken from existing vessel infrastructure provided it does not compromise the air start supply and reserve requirements of 4-6-5/9 of the *Steel Vessel Rules*.

11 Monitoring System

11.1 General

The control system for the exhaust emission monitoring system may be connected to an integrated control system or may be a standalone system.

11.3 Monitoring System

i) The design of the monitoring system is to provide identification of faults in the equipment, as well as the process system.

ii) The system is to be of a self-monitoring type, and means of testing the alarms are to be provided.

iii) The computer-based monitoring systems are to comply with the applicable requirements of Section 4-9-3 of the *Steel Vessel Rules* as a Category II system based on 4-8-3/15 of the *Steel Vessel Rules*.

iv) The electronic control equipment is to be performance tested in the presence of the Surveyor or by a recognized testing laboratory, in accordance with the criteria of 4-9-8/Tables 1 and 2 of the *Steel Vessel Rules*.

v) The power supply arrangements for the monitoring system are to meet the requirements of 4-9-2/5.3 of the *Steel Vessel Rules*.

Monitoring is to be in accordance with Section 5, Table 1 of this Guide.

13 Surveys During Construction

13.1 General

This Subsection pertains to surveys during installation and testing of EEMS units onboard.

13.3 Surveys During Installation

The following surveys are to be carried out to the satisfaction of the attending Surveyor on the EEMS unit and associated systems during installation and testing:

i) Piping systems are to be visually examined and pressure-tested, as required by the *Steel Vessel Rules*. Pressure tests conducted on Class I piping systems (see 4-6-1/Table 1 of the *Steel Vessel Rules*) should preferably be recorded on test charts for the duration of their tests.

ii) Electrical wiring and connections are to be in accordance with Part 4, Chapter 8 of the *Steel Vessel Rules* and checked for continuity and proper workmanship.

iii) Instrumentation is to be tested to confirm proper operation as per its predetermined set points.

iv) Pressure relief and safety valves installed on the unit are to be tested.

v) Control system and alarms are to be tested for proper operation.

vi) The EEMS unit is to be checked for proper operation in accordance with the ABS approved installation test procedure.

13.5 Surveys During Trials

During the initial commissioning trials, the EEMS is to be confirmed for its satisfactory operation, including associated controls, alarms, and shutdowns. The tests are to be conducted in accordance with the ABS-approved testing procedure during sea trials.

TABLE 1
Monitoring System Functions for EEMS Systems

Monitored Parameters	*Display*	*Alarm Activated*
Analyzer/EEMS power supply	X	Failed
Pneumatic air supply, as applicable		Failed
Exhaust gas sample temperature	X	Low/High
Pre-filter and heated line temperature, as applicable	X	Low/High
Sampling flow rate, as applicable	X	Low
Data logging	X	Failed

SECTION 6 Surveys After Construction and Maintenance of Class

1 General

This Section pertains to periodical surveys after construction for the equipment described in Sections 1 to 5 of this Guide.

1.1 Definitions

For definitions related to the surveys of equipment covered by this Guide, see Section 1 of this Guide and 7-1-1/3 of the ABS *Rules for Survey After Construction (Part 7)*.

1.3 Modifications

When it is intended to carry out any modifications to the exhaust emission abatement system, associated components, or monitoring equipment, which may affect classification, including substitutions of material differing from that originally installed, the details of such modifications are to be submitted for review. If ABS determines that the modification will affect classification, the affected system or component to be modified will be subject to the review, testing, and survey requirements in accordance with this Guide.

3 Survey Intervals

3.1 Annual Survey

An Annual Survey of a vessel fitted with exhaust emission abatement equipment, monitoring equipment, and installed classed systems covered by this Guide is to be carried out within three (3) months before or after each annual anniversary date of the crediting of the previous Special Periodical Survey or original construction date. For vessels on Continuous Survey, all Continuous Survey requirements for those parts (items) due are generally to be completed each year. The Annual Survey will not be credited and the Certificate of Classification will not be endorsed unless Continuous Survey items that are due or overdue at the time of the Annual Survey are either completed or granted an extension.

3.3 Special Periodical Survey

A Special Periodical Survey of exhaust emission abatement equipment, associated systems, and monitoring equipment is to be completed within five years after the date of build or after the crediting date of the previous Special Periodical Survey. The fifth Annual Survey must be credited as a requirement of the Special Periodical Survey. The interval between Special Periodical Surveys may be reduced by the Committee.

The Special Periodical Survey may be commenced at the fourth Annual Survey and be continued with completion by the fifth anniversary date. Where the Special Periodical Survey is commenced prior to the fourth Annual Survey, the entire survey is to be completed within fifteen (15) months if such work is to be credited to the Special Periodical Survey.

A Special Periodical Survey will be credited as of the completion date of the survey but not later than five years from date of build or from the date recorded for the previous Special Periodical Survey. If the Special Periodical Survey is completed within three (3) months prior to the due date, the Special Periodical Survey will be credited to agree with the effective due date. Special consideration may be given to Special Periodical Survey requirements in unusual cases. Consideration may be given for extensions of Rule-required Special Periodical Surveys under exceptional circumstances.

3.5 Continuous Survey Program

At the request of the Owner, and upon approval of the proposed arrangements, a system of Continuous Surveys may be undertaken, whereby the Special Periodical Survey requirements are carried out in regular rotation to complete all of the requirements of the particular Special Periodical Survey within a five-year period. The proposed arrangements are to provide for survey of approximately 20% of the total number of survey items during each year of the five-year period. Reasonable alternate arrangements may be considered as recommended by the manufacturer.

Generally, each part (item) surveyed becomes due again for survey approximately five (5) years from the date of the survey, and the due parts (items) are generally to be completed each year. For Continuous Surveys, a suitable notation will be entered in the *Record* and the date of the completion of the cycle published.

ABS may withdraw its approval for Continuous Survey if the Surveyor's recommendations are not complied with.

3.7 Survey Based upon Preventative Maintenance Techniques

A properly conducted approved program of preventative-maintenance/condition-monitoring plan may be credited as satisfying the requirements of Special Continuous Survey. This plan must be in accordance with Appendix 7-A-14 "Surveys Based on Preventative Maintenance Techniques" of the ABS *Rules for Survey After Construction (Part 7)*.

5 Surveys

5.1 Annual Surveys

5.1.1 General

The following should be carried out during each Annual Survey of the exhaust emission abatement equipment, associated systems, and monitoring equipment unless all the requirements of Subsection 6/7 of this Guide are complied with:

i) *General.* The logbooks are to be examined with regard to correct functioning of the exhaust emission abatement systems, emissions monitoring, and washwater monitoring systems, etc. The hours per day of the prime movers, EGC SO_x scrubbers, SCR systems, EGR systems, exhaust emission monitoring systems, as applicable, are to be considered together with historical records.

ii) *Operating and Maintenance Instruction Manual.* The approved instructions and manuals covering the operations, safety, and maintenance requirements and occupational health hazards relevant to exhaust emission abatement units and associated systems are to be confirmed as being aboard the vessel.

iii) *Instrumentation, Control, Monitoring, and Safety Systems.* The instrumentation, control, monitoring, and safety equipment applicable to each particular type of installed exhaust emission abatement unit and associated systems, including indicators and alarms, is to be confirmed in satisfactory operating conditions. The examination is to be made with one or more ship's service generator(s) in operation and the control system energized to permit random checking of function indicators, alarms, and such control actuators as may be operational. Installed interlocks, where applicable, are to be verified in working condition.

iv) *Exhaust Gas Handling Piping and Machinery.* All piping, hoses, bellows, blowers/fans, heaters, dry scrubbing equipment, soot blowing equipment, emergency shutdown or bypass valves, remote operating valves, and machinery and equipment associated with processing or distribution of exhaust gases is to be examined, as far as possible. Stopping of pumps, fans, and blowers upon emergency shutdown of the system is to be confirmed.

Where applicable, exhaust system bypass, isolation, or mixing valve sealing arrangements are to be examined.

The integrity and effectiveness of insulation arrangements is to be confirmed.

v) *Water Treatment, Reductant, and Residue Systems*. All tanks, piping, hoses, pumps, strainers, separators, filtration units, dosing systems, and equipment associated with processing of washwater, injection of reductant or collection of exhaust residues are to be examined and verified to be in operational condition.

vi) *Drip Trays, Overflow Arrangements, and Insulation.* Drip trays, overflow arrangements, shielding, or insulation installed for the protection of personnel or the vessel from the effects of hazardous or corrosive chemicals used in exhaust emission abatement systems or system temperatures are to be examined for continued suitability for their intended service.

vii) *Electrical Equipment.* Electrical equipment associated with the operation or monitoring of exhaust emission abatement systems is to be examined for continued suitability for its intended service and installation area.

viii) *Personal Protective Equipment.* The required PPE equipment and facilities are to be confirmed as being onboard and in an operational condition.

ix) *Warning Notices.* The location of the applicable warning notices is to be confirmed.

x) *Spare Parts.* Spare parts are to be verified as available onboard in consideration of the equipment redundancy arrangements.

5.1.2 EGC – SO_x Scrubbers

The following are to be examined, so far as applicable, during each Annual Survey. Insulation need not be removed, but any deterioration or evidence of leakage is to be investigated:

i) *External Examination.* External examination of all components including scrubber units, piping, tanks, fans, insulation, valves, pumps, drip trays, etc., including foundations and attachments.

ii) *Equipment Operation.* Confirmation of correct operation of all rotating and reciprocating components, such as exhaust gas fans, water treatment pumps, dry handling conveyors, ventilation fans, etc.

iii) *Control Valves.* Verify the correct operation of all remotely operated or automatically controlled valves in the exhaust, water treatment, or dry handling systems.

iv) *System Operation.* Examination of the exhaust emission abatement system during working condition. Multi-mode SO_x scrubbers are to be tested in all operational modes as far as practicable.

5.1.3 EGC – SCR Systems

The following are to be examined, so far as applicable, during each Annual Survey. Insulation need not be removed, but any deterioration or evidence of leakage is to be investigated:

i) *External Examination.* External examination of all components, including SCR reaction chamber, injectors, dosing units, soot blowing equipment, piping, tanks, insulation, valves, pumps, drip trays, etc., including foundations and attachments.

ii) *Equipment Operation.* Confirmation of correct operation of all rotating and reciprocating components, such as dosing pumps, ventilation fans, etc.

iii) *Control Valves.* Verify the correct operation of all remotely operated or automatically controlled valves in the exhaust, reductant dosing, or soot blowing systems.

iv) *System Operation.* Examination of the exhaust emission abatement system during working condition.

5.1.4 EGC – EGR Systems

The following are to be examined, so far as applicable, during each Annual Survey. Insulation need not be removed, but any deterioration or evidence of leakage is to be investigated:

i) *External Examination.* External examination of all components including scrubbers, EGR coolers, piping, tanks, blowers, insulation, valves, pumps, drip trays, etc., including foundations and attachments.

ii) *Equipment Operation.* Confirmation of correct operation of all rotating and reciprocating components such as exhaust gas blowers, water treatment pumps, ventilation fans, etc.

iii) *Control Valves.* Verify the correct operation of all remotely operated or automatically controlled valves in the exhaust or water treatment systems.

iv) *System Operation.* Examination of the exhaust emission abatement system during working condition at full EGR rate. Multi-mode systems are to be tested in all operational modes as far as practicable.

5.1.5 Exhaust Emissions Monitoring Systems

The following are to be examined, so far as applicable, during each Annual Survey. Insulation need not be removed, but any deterioration or evidence of leakage is to be investigated:

i) *External Examination.* External examination of all components including exhaust gas sample probes, pre-filters, heated lines, analyzer units, pneumatic systems, span and calibration gases, etc.

ii) *System Operation.* Examination of the EEMS during calibration and exhaust gas sampling conditions; verification of the emissions monitoring and data logging functions is to be undertaken.

5.3 Special Periodical Survey

In addition to the items covered by the Annual Survey listed in 6/5.1 of this Guide, the Special Survey of the exhaust emission abatement equipment, associated systems, and monitoring equipment is also to include the following:

i) *Washwater, Water Treatment, and Dosing Pumps.* All washwater, water treatment pumps, and reductant dosing pumps are to be examined including opening for examination, as deemed necessary.

ii) *Exhaust Fans and Blowers.* All exhaust fans, EGR blowers and associated prime movers are to be examined including opening for examination, as deemed necessary.

iii) *Control Valves.* All bypass, mixing, isolating, shut-down, or control valves in the exhaust, water treatment, and dosing systems are to be inspected and proven operable. Pressure relief valves are to be function-tested. A random selection of valves is to be opened for examination and adjusted as necessary.

iv) *Control Actuators.* All mechanical, hydraulic, and pneumatic control actuators and their power systems are to be examined and tested as considered necessary.

v) *Electrical Equipment.* The electrical equipment is to be examined to include the physical condition of electrical cables and supports, together with insulation resistance testing of the windings of electrical control motors and actuators. Where a proper record of testing is maintained, consideration may be given to accepting recent readings.

vi) *Automatic Controls.* Automatic controls for components associated with the exhaust emission abatement equipment and associated systems, including auto-changeover for system pumps/fans and electrical power supply, are to be examined for functionality and for continued system serviceability.

vii) *Instrumentation, Control, Monitoring, and Safety Systems.* Control systems are to be subjected to dock trials to verify correct operation of the following automatic functions, alarms, and safety systems:

- Function test of the monitoring and alarm systems
- Function test of safety systems, including override of system functions, if provided
- Manual control of the EGC equipment and systems
- Automatic changeover of designated machinery associated with the exhaust emission abatement equipment.

7 Alternative Surveys

ABS is at all times ready to consider alternative survey arrangements which can be shown, through either satisfactory service experience or a systematic analysis based on sound engineering principles, to meet the overall safety, serviceability, and standards of the *Steel Vessel Rules* and this Guide. Alternative to requirements particularly contained in Subsection 6/5 of this Guide, an In-Service Inspection Plan (ISIP) may be developed by the Owner and submitted to the Assistant Chief Surveyor's office for review. A stamped copy of the ISIP placed onboard the vessel is to be referenced during all of the scheduled surveys.