TÜRK LOYDU

GUIDELINES for EXHAUST GAS CLEANING SYSTEMS

SEPTEMBER 2019

This latest edition incorporates all rule changes. The latest revisions are shown with a vertical line. The section title is framed if the section is revised completely. Changes after the publication of the rule are written in red colour.

Unless otherwise specified, these Rules apply to ships for which the date of contract for construction as defined in TL- PR 29 is on or after 1st of September 2019. New rules or amendments entering into force after the date of contract for construction are to be applied if required by those rules. See Rule Change Notices on TL website for details.

"General Terms and Conditions" of the respective latest edition will be applicable (see Rules for Classification and Surveys).

If there is a difference between the rules in English and in Turkish, the rule in English is to be considered as valid. This publication is available in print and electronic pdf version.

Once downloaded, this document will become UNCONTROLLED. Please check www.turkloydu.org for the amended and valid version.

TÜRK LOYDU

Head Office Postane Mah. Tersaneler Cad. No:26 Tuzla 34944 İSTANBUL / TÜRKİYE
Tel : (90-216) 581 37 00
Fax : (90-216) 581 38 00
E-mail : info@turkloydu.org
http://www.turkloydu.org

Regional Offices

Ankara Eskişehir Yolu Mustafa Kemal Mah. 2159. Sokak No : 6/4 Çankaya - ANKARA / TÜRKİYE
Tel : (90-312) 219 56 34
Fax : (90-312) 219 68 25
E-mail : ankara@turkloydu.org

İzmir Atatürk Cad. No :378 K.4 D.402 Kavalalılar Apt. 35220 Alsancak - İZMİR / TÜRKİYE
Tel : (90-232) 464 29 88
Fax : (90-232) 464 87 51
E-mail : izmir@turkloydu.org

Adana Çınarlı Mah. Atatürk Cad. Aziz Naci İş Merkezi No:5 K.1 D.2 Seyhan - ADANA / TÜRKİYE
Tel : (90- 322) 363 30 12
Fax : (90- 322) 363 30 19
E-mail : adana@turkloydu.org

Guidelines For Exhaust Gas Cleaning Systems

A. General

1. Scope

This Guideline is to be applied to exhaust gas cleaning (EGC) systems installed to **TL** classed vessels and covers scrubbers, Selective Catalytic Reduction (SCR) systems together with Exhaust Emissions Monitoring Systems (EEMONS) fitted in conjunction with the aforementioned gas cleaning systems.

2. Objectives

The objective of this Guideline is to provide criteria for the design, construction, installation, survey, and operation of machinery and equipment associated with EGC 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 IMO Regulations and Guidelines. Detailed requirements are provided in following sections to achieve this objective in accordance with the following key principles and requirements:

- Installation and operation of an EGC system is to be compatible with the fuel oil combustion unit and not to cause any adverse effects on the fuel oil combustion unit 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 **TL** Rules for Materials and Welding (**TL**, Part A, Chapter 2 and Chapter 3) .
- EGC systems are to be designed to enable continued operation of the fuel oil combustion unit 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 fuel oil combustion unit.
- Where applicable, EGC 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 fuel oil combustion unit 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 EGC 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.
- EGC 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 EGC 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 EGC units or monitoring systems.
- Automation, instrumentation, monitoring, and control systems are to be provided to enable safe operation of EGC systems.

3. Alternatives

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

4. Definitions and Abbreviations

4.1 EGC

EGC means Exhaust Gas Cleaning.

4.2 EEMONS

EEMONS means Exhaust Emissions Monitoring System.

4.3 Fuel Oil Combustion Unit

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

4.4 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.

4.5 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.

4.6 FMEA

FMEA means Failure Modes and Effects Analysis.

4.7 PVC

PVC means Polyvinyl Chloride.

4.8 FRP

FRP means Fiber Reinforced Plastics.

5. Class Notations

5.1 EGCS-SO_x

Where a ship equipped with scrubbers designed, constructed and tested according to this Guideline, the **EGCS-SO_x** notation may be assigned.

5.2 SCR

Where a ship equipped with Selective Catalytic Reduction catalysts designed, constructed, and tested according to this Guideline, the **SCR** notation may be assigned.

5.3 EEMONS

Where a ship equipped with permanently installed exhaust emission monitoring system designed, constructed, and tested according to this Guideline, the **EEMONS** notation may be assigned.

6. Operation and Maintenance Manuals

Detailed instruction manuals are to be provided onboard, covering the operations, safety, and maintenance requirements and occupational health hazards relevant to exhaust gas cleaning system 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 exhaust gas cleaning 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 gas cleaning 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.

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

B. SCR – Selective Catalytic Reduction Systems

1. General

This subsection provides requirements on the arrangements and system design for SCR systems primarily designed for the removal of NO_x emissions using 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 Guideline, the applicable supplementary Guidelines to MARPOL Annex VI Regulation 13 and the NO_x Technical Code for SCR systems are IMO Resolution MEPC.291(71) – 2017 Guidelines Addressing Additional Aspects to the NO_x Technical Code 2008

With Regard to Particular Requirements Related to Marine Diesel Engines Fitted With SCR Systems, adopted 7 July 2017. Compliance with the applicable IMO Regulations is a pre-requisite for **TL** approval of the SCR system in accordance with the requirements of this Guideline.

2. 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 system
- 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 B. 4.2)
- 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 SCR 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
- FMEA to determine possible failures and their effects in the safe operation of the SCR exhaust gas cleaning system [see B. 7.1ii]. Note: This can be a standalone document, or for those integrated SCR units, be incorporated in the engine FMEA required by **TL**, Part B, Chapter 4, Machinery, Section 2, B.
- Emergency shutdown arrangements
- SCR FMEA integration test report (see B.8)
- Operating and maintenance instruction manuals, including Material Safety Data Sheets (MSDS) and details for handling of hazardous and non-hazardous chemicals used in the SCR exhaust gas cleaning system
- Testing procedures during installation and commissioning trials

3. SCR Operation and Maintenance Manuals

Detailed instruction manuals are to be provided onboard, covering the operations, safety, and maintenance requirements and occupational health hazards relevant to the SCR exhaust gas cleaning 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 gas cleaning 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.

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

4. SCR System Configuration and Vessel Integration

4.1 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 B. 6.1.3).

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 Guideline are supplementary to, and to be applied in association with, the requirements for diesel engines under **TL**, Part B, Chapter 4, Machinery, Section 2. The integration of a SCR system to an already approved diesel engine is not considered an engine type defining parameter change as per **TL**, Part B, Chapter 4, Machinery, Section 2, A 2.1.

It is to be noted that exhaust gas cleaning 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 Recognized Organizations 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 Section A.8 of this Guideline.

4.2 Compatibility with the Engine

i) Installation and operation of an exhaust gas cleaning 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 fuel oil combustion unit 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 gas cleaning systems, together with other regulatory aspects, are to be detailed in the approved IMO Annex VI Regulation 13 Technical Files by the Administration or Recognized Organizations 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 sections B.2 and B.3 of this Guideline.

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.

4.3 Redundancy

Redundancy of equipment is to be provided for those rotating and reciprocating components that form part of the exhaust gas cleaning unit essential supplementary systems, such as pumps, fans, blowers, etc. (see B. 5.1 and A.5.6.3 of this Guideline).

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 gas cleaning 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 **TL** as meeting this objective and should be justified with reference to the FMEA required by B.7.1ii) of this Guideline.

4.4 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 **TL**, Part B, Chapter 5, Electrical Installation, Section 1, B, 2.3.2.

4.5 Inclinations

Exhaust gas cleaning systems are to be designed for proper operation at the inclination requirements of **TL**, Part B, Chapter 4, Machinery, Section 1, C, Table 1.1.

4.6 Inspection and Maintenance

Exhaust gas cleaning 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.

5. SCR System Equipment

5.1 Pumps/Fans

i) Unless alternative means of compliance in accordance with B.4.3 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 gas cleaning system at full rating see also B.5.6.3.

For vessels fitted with two or more identical exhaust gas cleaning 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 B.4.3 are applicable and where exhaust fans form part of the SCR system and are essential for continual operation of the exhaust gas cleaning 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.

5.2 Heat Exchangers

Where provided, heat exchangers are to be designed, constructed, and certified in accordance with **TL**, Part B, Chapter 4, Machinery, Section 14. Suitability of the heat exchanger materials for the intended media is to be demonstrated.

5.3 SCR Reductant System

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 B 6.2.

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

5.4 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

5.5 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 **TL**, Part B, Chapter 4, Machinery, Section 16.

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 **TL**, Part B, Chapter 4, Machinery, Section 2, H.

5.6 Electrical System

The electrical system and electrical equipment requirements in this Guideline are to be applied in association with the requirements of **TL**, Part B, Chapter 5, Electrical Installation.

5.6.1 Electrical Motors and Controllers

Motors and motor controllers of 100 kW (135 hp) and over are to be certified in accordance with **TL**, Part B, Chapter 5, Electrical Installation.

5.6.2 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 **TL**, Part B, Chapter 5, Electrical Installation, Section 3, B 1.1, 1.2.

5.6.3 Standby Pump/Fan Arrangements

i) In the event of failure of the essential exhaust emission cleaning system pumps or fans, the standby pump or fan required by B 5.1 of this Guideline, 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.

5.6.4 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.

6. SCR System Piping

6.1 Exhaust Gas Piping Systems

6.1.1 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 gas cleaning systems are to meet the applicable requirements **TL**, Part B, Chapter 4, Machinery, Section 16.

6.1.2 Exhaust Gas Piping Valves

i) Valves used in the exhaust system of gas cleaning systems are to meet the requirements of **TL**, Part B, Chapter 4, Machinery, Section 16 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.

6.1.3 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 gas cleaning 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 A. 5.1ii).

6.1.4 Exhaust Gas Piping and SCR Reaction Chamber Insulation

Hot surfaces of exhaust gas cleaning 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.

6.2 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.

6.2.1 Piping and Connections

i) In general, pipe fittings and joints are to meet the requirements of **TL**, Part B, Chapter 4, Machinery, Section 16 for certification.

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 **TL**, Part B, Chapter 4, Machinery, Section 16 (in particular B 2.6). For the purpose of these Rules, “plastic” means both thermoplastic and thermosetting plastic materials, with or without reinforcement, such as PVC and FRP. Plastic piping is to meet Level 3 fire endurance testing requirements (see **TL**, Part B, Chapter 4, Machinery, Section 16, B 2.6.9).

vii) Flexible hoses are to comply with the requirements of of **TL**, Part B, Chapter 4, Machinery, Section 16 (in particular D.10, and U).

6.2.2 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.

6.2.3 Arrangement of the Urea Storage Tank

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 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.

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.

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 **TL**, Part B, Chapter 4, Machinery, Section 16, R and the outlets are to terminate in a safe location (Vent outlets are to be situated where possibility of ignition of the gases issuing therefrom is remote) 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.

v) The urea storage tank is to be provided with temperature and level monitoring arrangements.

6.2.4 Spill Trays

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

6.2.5 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, dust respirator, and tight-fitting chemical safety goggles or face shields or both. An eyewash and safety shower should be nearby.

6.2.6 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.

7. Control, Monitoring, and Safety Systems

7.1 General

i) The control system for the SCR exhaust gas cleaning 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 Subsection B of this Guideline.

7.2 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 gas cleaning system operating conditions. For vessels with AUT or AUT-C notations, the alarm and monitoring systems are to be integrated in the vessel's centralized monitoring systems that conform to the requirements for AUT or AUT-C 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.

c) Indications of parameters necessary for the safe and effective operation of the exhaust gas cleaning process are to be provided at the local and, as applicable, remote control station(s), as per Table A.1 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 B.5.4vi)], and control strategies are to minimize ammonia slip.

e) The computer-based control systems are to comply with the applicable requirements of **TL**, Part B, Chapter 5, Electrical Installation, Section 10 as a Category III.

iii) The power supply arrangements for the control and monitoring system are to meet the requirements of **TL**, Part B, Chapter 4-1, Automation .

7.3 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 Table B.1.

8. 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 B.7.1ii).

9. Surveys During Construction

9.1 General

This Subsection pertains to surveys during fabrication at the manufacturer's facility and installation and testing of SCR units onboard. These surveys may be incorporated with the certification, shop test, and shipboard tests required by the applicable aspects of **TL**, Part B, Chapter 4, Machinery, Section 02, E. 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.

9.2 Surveys at Manufacturer's Facility

See Table B.2 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/Guidelines.

9.3 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 unit and associated systems are in accordance with the approved plans and particulars.

ii) Piping systems are to be visually examined and pressure-tested. Pressure tests conducted on Class I piping systems (see **TL**, Part B, Machinery, Chapter 4, Section 16, Table 16.1) should preferably be recorded on test charts for the duration of their tests.

iii) Electrical wiring and connections are to be in accordance with **TL**, Part B, Chapter 5, Electrical Installation 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 **TL** approved installation test procedure.

9.4 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 **TL** approved testing procedure during sea trials.

Table B.1 Monitoring and Safety System Functions for SCR Systems

Monitored Parameters	Display	Alarm Activated	Automatic SCR Shutdown and Automatic SCR bypass
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 B.4.1).*

(2) *Failure of essential SCR system motors driving pumps or fans is to activate the standby units, where fitted (see B.5.6.3 of this Guideline).*

(3) *Urea storage tanks of 500 liters and above only (see B.6.2.4).*

Table B.2 Certification of SCR Systems at the Manufacturer's Facility

This Table has been prepared for guidance only and annotated to agree with the **TL** Classification and Construction 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 **TL** Classification and Construction Rules. This list is not to be considered as substitutive or integrative of the content of the **TL** Classification and Construction Rules and/or other applicable Regulations. In case of conflict between the content of this list and the applicable **TL** Classification and Construction 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 **TL** not required, acceptance based on manufacturers documentation and guarantee (see A 5.6.1).*

C. EGCS-SO_x

1. General

This subsection provides requirements on the arrangements and system design for exhaust gas cleaning systems designed primarily for the removal of SO_x emissions, or 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 Guideline, the applicable Guidelines for SO_x exhaust gas cleaning systems are *2015 Guidelines for Exhaust Gas Cleaning Systems*, adopted by IMO Resolution MEPC.259(68).

2. Plans and Data to be Submitted

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

- General arrangement of the scrubber installation, layout, and systems

- Documentation detailing the scrubber specification

- Analyses demonstrating compatibility of the scrubber with the fuel oil combustion units (see C.4.2 of this Guideline)

- 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 gas cleaning system (see C.4.8 of this Guideline)

- 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 gas cleaning system

- Arrangement and capacity of tanks for storage, chemicals, process washwater, exhaust gas cleaning residues, etc.

- Details of all piping systems, including details of piping and associated components, design pressures, temperatures, insulation, and drip trays, where applicable

- Descriptions and schematic diagrams for the control and monitoring systems, including set points for abnormal conditions and details of the location and positions where exhaust emission monitoring and washwater monitoring systems are to be located

- Details of all electrical equipment installed for the scrubber 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 C.7.1 of this Guideline]

- Emergency shutdown arrangements

- SOx scrubber unit FMEA integration test report (see 2/15 of this Guideline)

- Operating and maintenance instruction manuals, including MSDSs and details for handling of hazardous and non-hazardous chemicals used in the SO_x exhaust gas cleaning system

- Testing procedures during installation and commissioning trials.

3. SO_x System Operation and Maintenance Manuals

In accordance with A.6 of this Guideline, 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 gas cleaning 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 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 nonhazardous chemicals that may be used in the exhaust gas cleaning 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 subsection.

4. SO_x System Configuration and Vessel Integration

4.1 General

i) Exhaust gas cleaning systems are to be designed to enable continued operation of the fuel oil combustion unit at the times the EGC system is not in operation, either through operational selection, equipment failure, or system deterioration through partial blocking/clogging.

ii) The exhaust systems from a number of fuel oil combustion units may be led to a common scrubber , sometimes known as an integrated scrubber (see C..6.1.3 of this Guideline).

iii) The response of the mechanical and electrical systems of the first scrubber unit in a particular design series is to be demonstrated by the FMEA integration test of C.8 of this Guideline.

4.2 Compatibility with Fuel Oil Combustion Units

i) Installation and operation of an exhaust gas cleaning system is to be compatible with the fuel oil combustion unit(s) and is not to cause any adverse effects on the fuel oil combustion unit performance such as excessive back pressures or high temperatures during operation.

ii) Details are to be submitted demonstrating the exhaust flow compatibility of the EGC unit with the connected fuel oil combustion units 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 fuel oil combustion unit operating parameters within the approved design limits.

It is to be noted that exhaust gas cleaning systems that cause diesel engines to operate outside the exhaust backpressure limits detailed in the approved IMO Annex VI Regulation 13 Technical Files may nvalidate the emissions certification and will require a re-approval of the engine NOx certification by the Administration or Recognized Organizations responsible for the original certification.

4.3 Redundancy

Redundancy of equipment is to be provided for those rotating and reciprocating components that form part of the exhaust gas cleaning unit essential supplementary systems, such as pumps, fans, blowers, etc. (see C.5.1 and C.5.9.3 of this Guideline).
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 gas cleaning 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 **TL** as meeting this objective and should be justified with reference to the FMEA required by C.7.1 of this Guideline.

4.4 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 **TL** Rules, Chapter 5, Section 1,B.

4.5 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 gas cleaning washwater system is not in operation, either through operational selection or equipment failure. As applicable, evidence of material suitability is to be submitted for dry running of scrubbers.
All EGC units fitted to single main propulsion engines are to be installed with an exhaust bypass arrangement unless arranged for unrestricted flow of exhaust gas and with no risk of causing failure of the main propulsion engine.

4.6 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 fuel oil combustion unit.

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

4.7 Inclinations

Exhaust gas cleaning systems are to be designed for proper operation at the inclination requirements of **TL** Rules, Part B, Chapter 4, Machinery, Section 1,C.

4.8 Vessel Stability

i) For those existing ships fitting an exhaust gas cleaning system as a retrofit conversion, a revision of the stability calculations may be required based on the additional weights of the EGC system and increased wind profile. In general, if the change in lightship displacement exceeds 2 % (excluding any certified weights, if any) of the lightship displacement from the most recent approved lightship data and/or the change in lightship Longitudinal Center of Gravity (LCG), relative to the most recent approved lightship data, exceeds 1,0 % of the Length Between Perpendiculars (LBP), a stability test may be required on the vessel and stability calculations would need to be revised to indicate the changes. Where a ship is within these limits, immediate update of the Stability Booklet may not be required if there is sufficient margin in the conditions contained in the booklet. In this case, the principal particular page would need to be updated, and the ship would be required to use the latest lightship properties when assessing new conditions.

ii) Documentation detailing the effect on Load Line and Stability of the exhaust gas cleaning system, in accordance with the guidance of C.4.15.i of this Guideline, is to be submitted.

4.9 Inspection and Maintenance

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

5. SO_x System Equipment

5.1 Pumps/Fans

i) Where provided, scrubber washwater, circulation, discharge, etc., pumps, essential for the continual operation of the EGC system, are to be tested and certified in accordance with **TL** Rules, Part B, Chapter 4, Machinery, Section 16, D.7. This is applicable to exhaust gas cleaning systems connected to fuel oil combustion units rated at 2250 kW and above or internal combustion engines having cylinders of more than 300 mm bore.

ii) Unless alternative means of compliance in accordance with C.4.5 of this Guideline 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 gas cleaning system at full rating. See also C.5.9.3 of this Guideline. For vessels fitted with two or more identical exhaust gas cleaning 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 C.4.5 of this Guideline are applicable and where exhaust fans form part of the EGC system and are essential for continual operation of the exhaust gas cleaning 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.

5.2 Exhaust Plume Heaters

i) Where provided, heat exchangers within the exhaust are to be designed, constructed, and certified in accordance with **TL** Rules, Part B, Chapter 4, Machinery, Sections 12 to 14.

ii) Where the introduction of hot air to the exit exhaust gases is used on exhaust gas cleaning systems, the details of this auxiliary system are to be submitted for review and approval on a case-by- case basis.

5.3 Chemical Treatment System

The specific requirements for chemical treatment system components are given under C.6.5 of this Guideline.

5.4 Dry Scrubber Consumable Handling Equipment

i) For dry type exhaust gas cleaning systems, details of the granulate supply and discharge systems are to be submitted.

ii) Unless alternative means of compliance in accordance with C.4.5 of this Guideline are applicable, drive arrangements for the exhaust cleaning reductant consumable are to be arranged in a redundant arrangement.

5.5 Electrical System

The electrical system and electrical equipment requirements in this paragraph are to be applied in association with the requirements of **TL** Rules, Part B, Chapter 5, Electric Installations.

5.5.1 Electrical Motors and Controllers

Motors and motor controllers of 100 kW (135 hp) and over are to be certified in accordance with **TL** Rules, Part B, Chapter 5, Electric Installations.

5.5.2 Electrical Load Analysis

i) The number and capacity of generators are to be sufficient under normal seagoing conditions with one generator in reserve to carry those loads for essential services and for minimum comfortable conditions of habitability as per **TL** Rules, Part B, Chapter 5, Electric Installations, Section 3, B.1.

ii) The electrical loads associated with the SO_x exhaust gas cleaning system are to be included in the electric-plant load analysis required by **TL** Rules, Part B, Chapter 5, Electric Installations, Section 3, A.1.

5.5.3 Standby Pump/Fan Arrangements

i) In the event of failure of the essential exhaust gas cleaning system pumps or fans, the standby pump or fan required by C.5.1 of this Guideline, 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.

5.5.4 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.

6. SO_x System Piping

6.1 Exhaust Gas Piping Systems

6.1.1 Exhaust Gas Piping/Scrubber Materials and Installation

i) Exhaust gas piping materials located before the 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 scrubber unit are to be of a corrosion resistant material such as stainless steel.

iv) The exhaust piping systems for exhaust gas cleaning systems are to meet the applicable requirements of **TL** Rules, Part B, Chapter 4, Machinery, Section 16, D.3 and M.1.

v) Exhaust gas piping and piping components constructed of non-metallic materials are to comply with **TL** Rules, Part B, Chapter 4, Machinery, Section 16, B. and to be specifically approved for the intended application.

6.1.2 Exhaust Gas Piping Valves

i) Valves used in the exhaust system of gas cleaning systems are to meet the requirements of **TL** Rules, Part B, Chapter 4, Machinery, Section 16, B. 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 scrubber unit are provided, the isolation and bypass valves are to be arranged in an interlocked, fail safe manner, such that free flow of exhaust gases to the atmosphere is possible at all times, either through the scrubber unit or through the bypass. Bypass valves are to be provided with a local position indicator.

iii) Valves are to be installed in accessible locations, clear of or protected from obstructions, moving equipment, and hot surfaces, in order to permit regular inspection and/or periodic servicing.

6.1.3 Interconnections of Exhaust Gas Piping

i) Normally, exhaust pipes from internal combustion engines and flue gas pipes from oilfired boilers are to be routed separately and are not to be interconnected. However, interconnected exhaust piping systems to a common exhaust gas cleaning 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 between a running fuel oil combustion unit to another stopped, or in operation, fuel oil combustion unit 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 C./5.1.iii of this Guideline.

6.1.4 Exhaust Gas Scrubber and Scrubber Piping Insulation

Hot surfaces of exhaust gas cleaning 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 noncombustible 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.

6.2 Washwater Piping

6.2.1 Piping and Connections

i) In general, pipe fittings and joints are to meet the requirements of the **TL** Rules for certification in Part B, Chapter 4, Machinery, Section 16, B.3, materials in Part B, Chapter 4, Machinery, Section 16, B.2, and design in Part B, Chapter 4, Machinery, Section 16, D.2
Molded non-metallic expansion joints, where used, are to be of an approved type (see **TL** Rules, Part B, Chapter 4, Machinery, Section 16, D.11, Part B, Chapter 4, Machinery, Section 16, B.2.3 for Cu and Cu Alloy and Part B, Chapter 4, Machinery, Section 16, Table 16.9 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 **TL** Rules, Part B, Chapter 4, Machinery, Section 16, B.2.6. 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 **TL** Rules, Part B, Chapter 4, Machinery, Section 16, B.2.6.8).

iv) Flexible hoses are to comply with the requirements of **TL** Rules, Part B, Chapter 4, Machinery, Section 16, D.10.

6.2.2 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 means to manually 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.

6.2.3 Overboard Discharges

i) Overboard discharges of any exhaust gas cleaning 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, propellers or to prevent any discharge of water onto survival craft during abandonment.

6.3 Chemical Treatment Piping Systems

The requirements for the washwater chemical treatment system detailed in this Subsection are based on the use of Caustic Soda (Sodium Hydroxide, NaOH) solution. If other chemicals are used, the requirements are to be consistent with the intent of the requirements for NaOH, but are 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 C.6.5 of this Guideline and the requirements for the residue tank in C.6.7 of this Guideline.

6.3.1 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.

6.3.2 Bunkering of NaOH

i) The bunker station(s) for NaOH is/are 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 have means of drainage to the EGC residue/ NaOH overflow tank, are to be provided.

6.3.3 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.

6.3.4 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 **TL** Rules, Part B, Chapter 4, Machinery, Section 16, R, and the outlets are to terminate in a safe location in the weather.

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.

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 **TL** Rules, Part B, Chapter 4, Machinery, Section 16, G. and R. 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.

6.3.5 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/NaO overflow tanks, and

are to comply with the sounding requirements applicable to fuel oil tanks of **TL** Rules, Part B, Chapter 4, Machinery, Section 16, R.2.

ii) A sight glass is not to be used unless the materials of construction are compatible with the concentration of NaOH solution involved, it is well protected from mechanical damage, and the arrangements are equivalent to that required in **TL** Rules, Part B, Chapter 4, Machinery, Section 16, R.2. (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.

6.3.6 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.

6.3.7 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) 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, or in close proximity to, boilers, steam piping, exhaust systems, hot surfaces required to be insulated, or other sources of ignition.

6.3.8 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.

6.3.9 Personnel Protection

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 chemicalresistant material, and tight-fitting chemical safety goggles or face shields or both. The protective clothing and equipment is to cover all skin so that no part of the body is left unprotected. The quantities of personel protective equipment carried onboard is to be appropriate for the number of personnel engaged in regular handling operations or that may be exposed in the event of a failure; but in no case is there to be less than two sets available onboard.

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. As a minimum, the following stations are to be provided:

i) In the vicinity of transfer or treatment pump locations. If there are multiple transfer or treatment pump locations on the same deck then one eyewash and safety shower station may be considered for acceptance provided that the station is easily accessible from all such pump locations on the same deck.

ii) An eyewash station and safety shower is to be provided in the vicinity of a chemical bunkering station on-deck. If the bunkering connections are located on both port and starboard sides, then consideration is to be given to providing two eyewash stations and safety showers, one for each side.

iii) An eyewash station and safety shower is to be provided in the vicinity of any part of the system where the potential for a person to come into contact with the chemicals exists (e.g., openings such as filling/drainage or system connections/components that require periodic maintenance).

Depending on the specific arrangements (e.g., vessel type, size, layout of deck, machinery space, etc.), consideration may be given so that the personnel protection arrangements required by this section may be shared with those required by B.6.3.5 of this Guideline.

6.3.10 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.

6.4 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 **TL** Rules, Part B, Chapter 4, Machinery, Section 16, O.2.

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 C.6.5 of this Guideline 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 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 **TL** Rules, Part B, Chapter 4, Machinery, Section 16, R.

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 **TL** Rules, Part B, Chapter 4, Machinery, Section 16, R.2.2.

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 C.6.7 i) through vi) of this Guideline, EGC residue record logs satisfy the requirements of MEPC.259(68), 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 **TL** Rules, Part B, Chapter 4, Machinery, Section 16, V.5.2 plus the capacity requirements for EGC residue tanks of C.6.4.iii of this Guideline.

7. Control, Alarm, and Monitoring System

7.1 General

i) The control system for the exhaust gas cleaning 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 Subsection D of this Guideline.

7.2 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 gas cleaning system operating conditions. For vessels with AUT or AUT-C notations, the alarm and monitoring systems are to be integrated in the vessel's centralized monitoring systems that conform to the requirements for AUT or AUT-C 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.

c) Indications of parameters necessary for the safe and effective operation of the exhaust gas cleaning process are to be provided at the local and, as applicable, remote control station(s), as per C.9.7 Table C.1 of this Guideline, 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 **TL** Rules, Part B Chapter 4-1, Automation, Section 3, B as a Category II system based on **TL** Rules, Part B, Chapter 5, Electric Installations, Section 10.

iii) Where power supply is electric, each of the control, monitoring and safety systems is to be supplied by a separate circuit. Each of these circuits is to be protected for short circuit and monitored for voltage failure.

7.3 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 C.9.7 Table C.1 of this Guideline.

8. 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 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 C.7.1 of this Guideline.

9. Surveys During Construction

9.1 General

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

9.2 Surveys at Manufacturer's Facility

See C.9.7 Table C.2 of this Guideline for certification requirements of EGC 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.

9.3 Surveys During Installation

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

i) Inspection and verification that the foundations and attachments of the principal components of the EGC 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 **TL** Rules. Pressure tests conducted on Class I piping (see **TL** Rules, Part B, Chapter 4, Machinery, Section 16, Table 16.1) 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 **TL** Rules, Part B, Chapter 5, Electric Installations 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 unit is to be checked for proper operation in accordance with the **TL** approved installation test procedure.

9.4 Surveys During Trials

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

Table C.1 Monitoring and safety system functions for SO_x scrubber systems

Monitored parameters (5)	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 fuel oil combustion 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 or alkali system valves	Running	Failed	
EGC system washwater and alkali system supply pressure	X	Low	X (Low-Low)
EGC system washwater and alkali system supply temperature **(6)**	X	High	X (High-High)
Water level in wet EGC unit	X	High	X (High-High) **(3)**
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) **(3,4)**
EGC residue tank level	X	High	X (High-High)
Control and safety system 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 C.4.9 of this Guideline) and to EGC units fitted to single main propulsion engines.*

(2) *Failure of essential EGC system motors driving pumps, fans or feed systems is to activate the standby units, where fitted (see C.5.9.3 of this Guideline).*

(3) *Safety shutdown system as required by C.7.5 of this Guideline.*

(4) *Automatic shutdown is to activate the close coupled alkali storage tank valves required by C.7.5.7.iii of this Guideline.*

(5) *As applicable.*

(6) *Not applicable to open loop scrubbers (scrubbers that do not recircultae sea water).*

Table C.2 Certification of Scrubber Systems at the Manufacturer's Facility

This Table has been prepared for guidance only and annotated to agree with the **TL** Classification and Construction 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 **TL** Classification and Construction Rules. This list is not to be considered as substitutive or integrative of the content of the **TL** Classification and Construction Rules and/or other applicable Regulations. In case of conflict between the content of this list and the applicable **TL** Classification and Construction 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*
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 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 **TL** not required, acceptance based on manufacturer's documentation and guarantee (see C.5.9.1 of this Guideline).*

(2) *Applicable to pumps fitted to EGC systems connected to fuel oil combustion units rated at 2250 kW and above or internal combustion engines having cylinders of more than 300 mm bore [see C.5.1.i of this Guideline].*

D. Exhaust Emission Monitoring Systems

1. General

The requirements in this subsection provide guidance on the arrangements and system design for permanently installed EEMONS 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.

The intent is that these requirements supplement the statutory specification, calibration, testing, and survey requirements of the applicable IMO Regulations and Guidelines. NO_x emissions monitoring systems may be installed for the purpose of monitoring exhaust gas cleaning 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 **TL** approval of the exhaust emission monitoring system in accordance with the requirements of this Guideline.

2. 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

• 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 EEMONS 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 EEMONS control and monitoring equipment

• Operating and maintenance instruction manuals

• Testing procedures during installation and commissioning trials

3. EEMONS Operation and Maintenance Manuals

In accordance with A.6 of this Guideline, 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 EEMONS 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 subsection.

4. Exhaust Emission Monitoring Systems

4.1 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 after treatment system.

ii) Alternative emissions monitoring system design principles are permitted provided analyzer equivalency is demonstrated [see also D.5.7i)]. Accordingly, the requirements for certain design features, such as sample

handling and pneumatic systems detailed under D.5.3 and D.5.6, respectively, may not be applicable to all exhaust emissions monitoring systems.

iii) An exhaust emissions monitoring system may be assigned to a vessel fitted with, or without, an exhaust gas cleaning system.

4.2 Inclinations

Exhaust emission monitoring systems are to be designed for proper operation at the inclination requirements of **TL**, Part B, Chapter 4, Machinery, Section 1, C, Table 1.1.

5. EEMONS Equipment

5.1 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.

5.2 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.

ii) A sample probe connection flange designed in accordance with Section 5 of Appendix 8 of the NO_x Technical Code and D.5.3 is to be provided for each engine or fuel oil combustion unit 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.

5.3 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.

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.

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 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.

5.4 Analyzer Specifications and Calibration

i) The EEMONS 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 **TL**.

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

5.5 Data Recording and Processing Device

i) The EEMONS is to be capable of recording calibration and emissions monitoring data. This capability may be incorporated within the EEMONS 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.

5.6 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 **TL**, Part B, Chapter 4, Machinery, Section 16.

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 **TL**, Part B, Chapter 4, Machinery, Section 2, H.

6. Monitoring System

6.1 General

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

6.2 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 **TL**, Part B, Chapter 5, Electrical Installation, Section 10 as a Category III.

iv) The electronic control equipment is to be performance tested in the presence of the Surveyor or by a recognized testing laboratory.

v) The power supply arrangements for the monitoring system are to meet the requirements of **TL**, Part B, Chapter 4-1, Automation.

Monitoring is to be in accordance with Table D.1.

7. Surveys During Construction

7.1 General

This subsection pertains to surveys during installation and testing of EEMONS units onboard.

7.2 Surveys During Installation

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

i) Piping systems are to be visually examined and pressure-tested, as required by **TL** Rules. Pressure tests conducted on Class I piping systems (see **TL**, Part B, Machinery, Chapter 4, Section 16, Table 16.5) should preferably be recorded on test charts for the duration of their tests.

ii) Electrical wiring and connections are to be in accordance with **TL**, Part B, Chapter 5, Electrical Installation 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 EEMONS unit is to be checked for proper operation in accordance with the **TL** approved installation test procedure.

7.3 Surveys During Trials

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

Table D.1 Monitoring System Functions for EEMONS Systems

Monitored	Display	Alarm
Analyzer/EEMONS 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

E. Surveys After Construction and Maintenance of Class

1. General

This subsection pertains to periodical surveys after construction for the systems described in Section A to D of this Guideline.

1.1 Definitions

For definitions related to the surveys of equipment covered refer to **TL** Classification and Surveys Rules.

1.2 Modifications

When it is intended to carry out any modifications to the exhaust gas cleaning 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 **TL** 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 Guideline.

2. Survey Intervals

2.1 Annual Survey

An Annual Survey of a vessel fitted with exhaust gas cleaning equipment, monitoring equipment, and installed classed systems covered by this Guideline is to be carried out within three (3) months before or after each annual anniversary date of the crediting of the previous Class Renewal 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.

2.2 Class Renewal Survey

A Class Renewal Survey of exhaust gas cleaning 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 Class Renewal Survey. The fifth Annual Survey must be credited as a requirement of the Class Renewal Survey.

The Class Renewal Survey may be commenced at the fourth Annual Survey and be continued with completion by the fifth anniversary date. Where the Class Renewal 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 Class Renewal Survey.

A Class Renewal 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 Class Renewal Survey. If the Class Renewal Survey is completed within three (3) months prior to the due date, the Class Renewal will be credited to agree with the effective due date. Special consideration may be given to Class Renewal Survey requirements in unusual cases. Consideration may be given for extensions of Rule-required Class Renewal Surveys under exceptional circumstances.

2.3 Continuous Class Renewal Surveys

At the request of the Owner, and upon approval of the proposed arrangements, a system of Continuous Surveys may be undertaken, whereby the Class Renewal Survey requirements are carried out in regular rotation to complete all of the requirements of the particular Class Renewal 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.

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

2.4 Survey Based upon Preventive Maintenance Systems

A properly conducted approved program of preventive-maintenance/condition-monitoring plan may be credited as satisfying the requirements of Class Renewal Survey. This plan must be in accordance with **TL**, Classification and Surveys, Section 3, A 4.5 and A 4.6.

3. Surveys

3.1 Annual Surveys

3.1.1 General

The following should be carried out during each Annual Survey of the exhaust gas cleaning equipment, associated systems, and monitoring equipment:

i) General: The logbooks are to be examined with regard to correct functioning of the exhaust gas cleaning systems, emissions monitoring, and washwater monitoring systems, etc. The hours per day of the prime movers, scrubbers, SCR 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 gas cleaning 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 gas cleaning 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 gas cleaning 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 gas cleaning systems is to be examined for continued suitability for its intended service and installation area.

viii) Personal Protective Equipment: The required personnel protective 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.

3.1.2 EGCS – SO_x

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 gas cleaning system during working condition. Multi-mode scrubbers are to be tested in all operational modes as far as practicable.

3.1.3 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, heating, 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 gas cleaning system during working condition.

3.1.4 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 EEMONS during calibration and exhaust gas sampling conditions; verification of the emissions monitoring and data logging functions is to be undertaken.

3.2 Class Renewal Survey

In addition to the items covered by the Annual Survey listed in E. 3.1, the Class Renewal of the exhaust gas cleaning 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, 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 gas cleaning 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 gas cleaning equipment.