GUIDANCE NOTES
GD 33-2020

CHINA CLASSIFICATION SOCIETY

GUIDELINES FOR APPLICATION OF SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEM ONBOARD SHIPS

2020

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PREFACE

The Marine Environment Protection Committee under the International Maritime Organization adopted, at its 66th session, the amendments to Annex VI and the NO_X Technical Code 2008 by the Resolution MEPC.251(66), which took effect on September 1st , 2015.

Through the review on the development status of the Tier III technology and repeated discussion, MEPC 66 finally decided on the time of implementation of Tier III NOx emission standards, which apply to:

(1) an engine installed on a ship constructed on or after 1 January 2016 and operating in the North American Emission Control Area or the United States Caribbean Sea Emission Control Area;

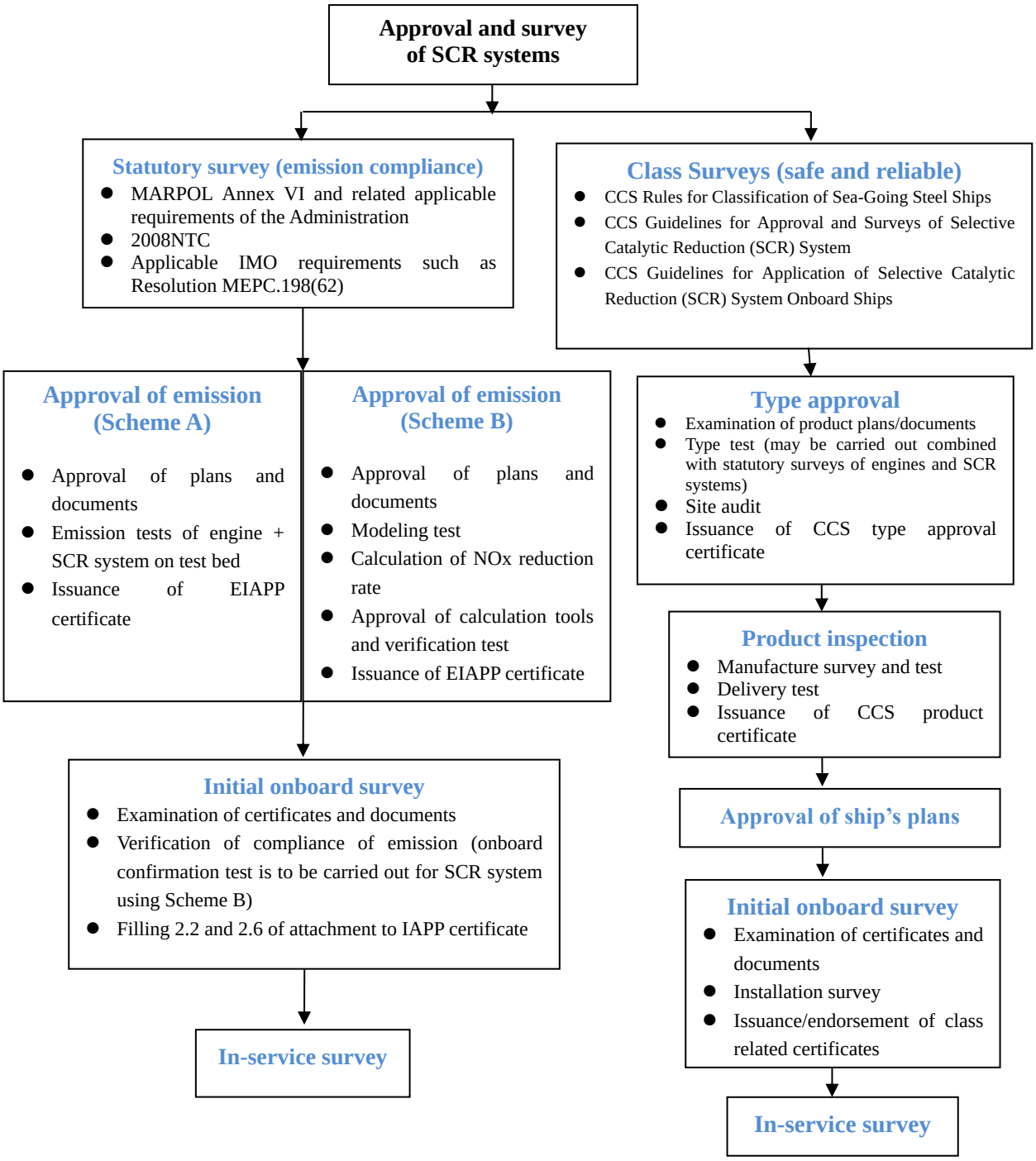
(2) an engine installed on a ship operating in an emission control area designated for Tier III NOx control, other than the North American Emission Control Area or the United States Caribbean Sea Emission Control Area, and constructed on or after the date of adoption of such an emission control area, or a later date as may be specified in the amendment designating the NOx Tier III emission control area, whichever is later.

Tier III emission limits reduced by around 80% compared to Tier I limits. Currently individual technologies that can meet Tier III emission standards and are relatively mature include SCR (selective catalytic reduction) technology, EGR (Exhaust Gas Recirculation) technology and low pressure injection LNG engines. SCR has a wide range of application and has little effect on safety of engine, thus it gained extensive attention in the industry.

On 15 July 2011, IMO MEPC 62 adopted the Guidelines Addressing Additional Aspects to the NOx Technical Code 2008 with Regard to Particular Requirements Related to Marine Diesel Engines Fitted with Selective Catalytic Reduction (SCR) Systems by MEPC.198(62), laying the foundation for the Administration or the organizations authorized by the Administration to carry out statutory inspection of Tier III engines.In the end of 2015, CCS Guidelines for Approval and Surveys of Selective Catalytic Reduction (SCR) System passed the review and officially entered into force on 1 March 2016, which is applicable to an SCR system applying for the product approval, inspection and certification by CCS. Technical requirements for the application of SCR systems onboard are to be further supplemented.

Based on the above needs, the Guidelines mainly specify the requirements for the design, arrangement, control and monitoring, and installation tests of SCR systems onboard ships. These requirements are class survey requirements aiming to provide guidance for the design, construction/conversion, survey and tests of the ship. The Guidelines are supplement to the rules and may not substitute the provisions of any conventions and regulations and operational requirements.

Since the inspection and onboard installation and application of SCR systems involve a lot of factors, the chart below illustrates major procedures of CCS approval of SCR systems for references by manufacturers, ship designers, shipyards, shipowners, plan approval and survey units. Approval of SCR systems mainly includes statutory surveys and class surveys and CCS may carry out statutory surveys separately as the organization authorized by the Administration.



Related Procedures for Approval and Survey of SCR Systems

CHAPTER 1 GENERAL

1.1 Scope of application

1.1.1 The Guidelines apply to the Selective Catalytic Reduction (hereinafter referred to as SCR) System installed for the reduction of NOx emission from onboard engines.

1.1.2 The Guidelines stipulate class requirements for onboard design, arrangement, control, monitoring and installation test of SCR systems. The Guidelines do not include detailed requirements for type approval and product inspection of SCR systems. For application for the type approval and product inspection of SCR systems by China Classification Society (hereinafter referred to as CCS), please refer to CCS Guidelines for Approval and Surveys of Selective Catalytic Reduction (SCR) System.

1.1.3 The Guidelines are only the supplement to the rules and SCR systems are also to comply with relevant requirements of CCS Rules for Classification of Sea-Going Steel Ships and CCSRules for Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk.

1.1.4 The Guidelines apply to an SCR system with reductant using urea solution or an SCR system with reductant using aqueous ammonia. SCR systems using liquid ammonia as reductant are to be subject to special consideration and approval.

1.2 Objective and functional requirements

1.2.1 The objective of the Guidelines is to provide standards for the design, manufacture, arrangement, installation, survey, tests and safe operation of SCR systems, so as to minimize the harm to the ship, crew and environment that may be caused by the installation and operation of SCR systems.

1.2.2 In order to achieve the above objective, an SCR system is to meet the following functional requirements:

(1) to be compatible with the environmental and working conditions of the ship’s operation;

(2) to effectively handle the NOx emission of the connected engine;

(3) to minimize the effect on engine due to the installation and operation of the SCR system, so as to ensure the continuous operation of the engine and ensure that operational parameters and output power are always within the designed limit;

(4) to prevent the accidental accumulation or spread of flammable, explosive and toxic gas;

(5) to prevent the harm to the crew, hull structure or other equipment and system due to the leakage and spread of chemicals;

(6) to prevent the harm to the crew or other equipment caused by low-temperature, high -temperature or equipment in operation or in motion;

(7) to set fire detection, fire protection and fire extinction measures for potential fire risks;

(8) to take into account the effect on hull structure and stability of the ship due to the installation and arrangement of SCR systems;

(9) to ensure the safe and reliable operation of the system by means of appropriate control, monitoring and safety protection system.

1.3 Definitions, abbreviations and symbols

1.3.1 Definitions

(1) *SCR system* means a system consisting of a reductant supply system, an SCR chamber, and an electric control system. If a separate compressed air system and a mixer are provided, they are also

regarded as a part of the SCR system.

(2) *Reductant injection system* means a system, which consists of the pump(s) to supply reductant to the nozzle(s), the nozzle(s) spraying reductant into the exhaust gas stream and control device(s) of the spray.

(3) *Reductant supply system* means a system consisting of reductant storage/preparation tank, reductant supply piping system and reductant injection system.

(4) *Catalyst block* means a block of certain dimension through which exhaust gas passes and which contains catalyst composition on its inside surface to reduce NOx from exhaust gas.

(5) *SCR chamber* means an integrated unit, which contains the catalyst block(s), and into which flows exhaust gas and reductant.

(6) *SCR electric control system* means a system to realize the function of reductant injection volume control, system status monitoring and safety protection, etc., which mainly consists of sensors, electronic control unit, actuator and external interface.

(7) *NOx reduction rate*，η，means a value deriving from the following formula, in %:

$$\eta = \frac{(C_{inlet} - C_{outlet})}{C_{inlet}} \times 100 \quad (\%)$$

where: C_{inlet} is NOx concentration (ppm) as measured at the inlet of the SCR chamber;

C_{outlet} is NOx concentration (ppm) as measured at the outlet of the SCR chamber.

(8) *Scheme B* means a survey method (refer to resolution MEPC.198(62)) to verify the emission compliance of the engine fitted with an SCR system through modeling calculation and initial onboard confirmation test (if necessary) in cases where the combined engine/SCR systems can neither be tested on a test bed due to some restrictions nor an on board test can be performed fully complying with the requirements of Chapter 5 of the NTC 2008.

1.3.2 Abbreviations and symbols

(1) SCR: Selective Catalytic Reduction;

(2) SCRS: Selective Catalytic Reduction Systems;

(3) 2008 NTC (NOx Technical Code 2008) refers to the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines as adopted by resolution MEPC.177(58);

(4) EIAPP (Engine International Air Pollution Prevention) certificate refers to the Engine International Air Pollution Prevention Certificate in relation to the emission of NOx;

(5) IAPP (International Air Pollution Prevention) certificate refers to the International Air Pollution Prevention Certificate;

(6) NOx: nitrogen oxide;

(7) MSDS: Material Safety Data Sheet.

1.4 Class notation

1.4.1 Where an SCR system is installed onboard (provided with CCS Marine Product Certificates) with its design, arrangement and installation in compliance with the requirements of the Guidelines and verification of the emission compliance is carried out in accordance with relevant provisions of CCS Guidelines for Testing and Survey of Emission of Nitrogen Oxides from Maine Diesel Engines in force and applicable IMO requirements including resolution MEPC.198(62) etc., the following class notation may be assigned after satisfactory survey:

NEC (SCRS)

1.4.2 The assignment, maintenance, suspension, withdrawal and reinstatement of the above class notation are to comply with the applicable requirements of Section 9, Chapter 2 of PART ONE of CCS Rules for Classification of Sea-Going Steel Ships.

1.5 Risk analysis

1.5.1 Analysis and assessment of the safety issues in relation to the design, arrangement and operation of SCR system are to be carried out using the recognized risk analysis/assessment methods (e.g. IEC/ISO31010) and consideration is to be given to appropriate measures for the control of the identified risks.

1.5.2 Appendix 1 of the Guidelines may be taken as reference for the factors to be considered, contents of report and the analysis table during risk analysis.

1.6 Operation and maintenance manual

1.6.1 Operation and maintenance manuals for SCR systems are to be kept onboard, covering the operations, safety, and maintenance requirements and occupational health hazards relevant to the SCR systems.

1.6.2 The manuals are to include, but not necessarily be limited to:

(1) procedures and schedules for operation, inspection, testing, and maintenance of SCR systems;

(2) the regular testing and maintenance procedures for the monitoring systems, safety shutoff systems, and the backup systems;

(3) special instructions for the bunkering, storage, and use of hazardous or non-hazardous chemicals that are intended to be used during system operation;

(4) system related working conditions and limits;

(5) identification of the relevant responsible parties.

1.7 Equivalence or alternatives

1.7.1 Any device, material, equipment or appliance installed onboard may substitute the device, material, equipment or appliance specified in the Guidelines, provided that it is verified through tests or other methods that such device, material, equipment or appliance is at least of equivalent efficiency as required by the Guidelines.

1.7.2 Where relevant test and theory basis, use experience or valid recognized standards may be provided for the calculation methods, assessment standards, manufacturing procedures, material, survey and test methods as required by the Guidelines, they may be taken as alternatives and equivalent methods as approved by CCS.

CHAPTER 2 SURVEY AND CERTIFICATION

2.1 Plans and documents

2.1.1 For a ship intended to install an SCR system (provided with CCS Marine Product Certificates), the following plans and documents are to be submitted to CCS for approval:

(1) Hull plans showing the foundation of SCR reaction chamber and attachments to the ship's structure, including scantlings, welding details, and foundation details of principal components;

(2) Arrangement details of the filling, storage, transportation and preparation of reductant, including the calculation of the capacity of reductant storage tank;

(3) Details of all piping systems, including scantlings of piping and associated components (pumps, reductant dosing systems, air supply systems, etc.), design pressures and temperatures, safety valve setting, and drip trays (if applicable);

(4) 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;

(5) Details of all electrical equipment installed for the SCR systems, including computer-based systems;

(6) Emergency shutdown arrangements of SCR systems;

(7) Testing procedures during commissioning trials.

2.1.2 The following plans and documents are to be submitted for information:

(1) general arrangement of SCR systems, including list of related equipment of SCR system;

(2) assessment information on the effects of the SCR system on the ship's stability (if applicable), including estimation of weight center of gravity of the SCR system and relevant hull structures, capacity plan/sheet (if applicable), calculation of loading condition (if applicable), damage stability calculations (if applicable);

(3) assessment information on the effects of the SCR system on the longitudinal strength of the ship (if applicable);

(4) detailed information verifying the compatibility of the SCR system with the engine;

(5) risk analysis report (refer to 1.5);

(6) operation and maintenance manual (refer to 1.6).

2.2 Surveys

2.2.1 In addition to statutory surveys, surveys of SCR systems generally include the following class surveys such as type approval and product inspection, initial survey and in-service survey.

2.2.2 Type approval and product inspection: the type approval and product inspection of an SCR system are to be carried out in accordance with CCS Guidelines for Approval and Surveys of Selective Catalytic Reduction (SCR) System and its system and components are to be certified in accordance with the requirements of Chapter 3 of PART ONE of CCS Rules for Classification of Sea-Going Steel Ships.

2.2.3 Initial survey: initial survey is to be carried out after the onboard installation of the SCR system and before it is put into service to confirm that certificates and relevant documents of each SCR system are well provided and the system is installed in accordance with the applicable requirements of the Guidelines and verification of the compliance of the performance of the system during operation is to be carried out in accordance with testing procedures during commissioning trials mainly including:

(1) to inspect and verify the foundations of SCR reaction chamber and attachments to the ship's structure in accordance with the approved plans;

(2) to carry out inspection of installation of piping system and tightness test in accordance with chapters 1, 2, 4 and 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships;

(3) inspection of continuity and proper workmanship of electrical wiring and connections;

(4) inspection of instrumentation of the system;

(5) inspection of pressure relief and safety valves;

(6) inspection of control system and emergency shutdown arrangements;

(7) tests of SCR system during sea trials (Integration test is to be carried out after the installation of the SCR system onboard ship, mainly to confirm the normal function and stable operation of relevant systems and equipment under operation condition and loads and major working parameters are controlled within the design scope, including the verification of control, alarm and safety protection in relation to the operation of the system. Where Scheme B is used, the integration test may be carried out in combination with the emission confirmation test of the SCR system.).

2.2.4 In-service survey: as a part of the surveys of the ship, in-service survey of the SCR system is carried out with the ship to ensure the emission and safety compliance of the SCR system during the service of the ship. Such survey includes annual survey, intermediate survey and special survey (the survey circles are to respectively meet the provisions of 5.2.1, 5.2.2 and 5.2.4 of Section 2, Chapter 5 of PART ONE of CCS Rules for Classification of Sea-Going Steel Ships).

(1) The annual and intermediate surveys include at least the following items:

①External Examination: External examination of all components, including SCR reaction chamber, injectors, dosing units, soot blowing equipment, piping (pumps and valves), tanks, insulation, drip trays, foundations and attachments of major component.

②Equipment Operation: Confirmation of correct operation of all rotating and reciprocating components, such as dosing pumps, ventilation fans, etc.

③Control Valves: Verify the correct operation of all remotely operated or automatically controlled valves in the exhaust, reductant dosing, or soot blowing systems.

④System Operation*:* Examination of working condition of the SCR system and confirmation of the normal operation of the SCR system.

(2) In addition to the items covered by the annual survey listed in 2.2.4(1), the special survey is to include:

①All bilge water pumps, water treatment pumps, and reductant pumps provided for the SCR system are to be opened for examination, as deemed necessary.

② Major fans provided for the SCR system are to be opened for examination, as deemed necessary.

③All remotely operated or automatically controlled valves are to be inspected and proven operable. Pressure relief valves are to be function-tested. A random selection of control valves is to be opened for examination and adjusted as necessary.

④ 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.

⑤ Electronic control system is to be subjected to dock trials to verify correct operation of the following automatic functions, alarms, and safety systems, including: function test of the monitoring and alarm systems, function test of safety systems (emergency shutdown arrangement), examination of manual control function, examination of automatic changeover function.

CHAPTER 3 DESIGN AND ARRANGEMENT OF SYSTEM

3.1 General requirements

3.1.1 An SCR system is to be installed as close to the engine as possible to obtain high reaction temperature, provided that there is enough time for the decomposition of urea solution or aqueous ammonia.

3.1.2 The SCR system is to be designed to enable continued operation of the engine in case the SCR system is under abnormal conditions such as equipment failure, damage or clogging or when the SCR system stops operation, e.g. designed with bypass arrangements or other equivalent measures.

3.1.3 Mechanical equipment, electrical equipment and control systems composing the SCR system are to be designed, selected and arranged under the environment condition/working environment specified in PARTs THREE, FOUR and SEVEN of the Rules for Classification of Sea-Going Steel Ships respectively.

3.1.4 Spaces where accumulation of flammable, toxic gases or steam is likely to occur are to comply with the requirements for ventilation in 1.3.4 of PART THREE of the Rules for Classification of Sea-Going Steel Ships.

3.1.5 Appropriate protective measures are to be provided in accordance with 1.3.6 of Chapter 1 of PART THREE of the Rules for Classification of Sea-Going Steel Ships to prevent the possible harm to the onboard personnel during the operation and maintenance of the SCR system.

3.1.6 If the SCR chamber or reductant storage tank is of a big size (e.g. in case of engineering ships long-termly operating within ECA area) which may affect the longitudinal strength and stability of the ship, the effect of SCR system on longitudinal strength and stability of the ship is to be assessed.

3.1.7 The installation and arrangement of SCR system are to facilitate the operation and maintenance.

3.2 Compatibility with the engine

3.2.1 Design and installation of the SCR system are 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.

3.2.2 The treatment capacity of the SCR system is to be consistent with the operation parameters of the engine and the SCR system intended to be installed is to effectively dispose the exhaust gas emission of the connected engine under the maximum continuous rate (MCR).

3.2.3 Where an SCR system is connected with several engines, the exhaust gas treatment capacity of the SCR system may be determined based on the sum of maximum possible exhaust gas emission during the actual operation if not all connected engines operate simultaneously during the actual operation.

3.2.4 Considering that the quality of the fuels used by the engine may have effect on the performance of SCR system, e.g. sulfur content, the range of fuel properties and other related parameters such as low exhaust gas temperature, reductant injection limits are to be indicated in the specifications of the SCR system or engine and the operation and maintenance manual.

3.3 Exhaust system

3.3.1 Material, design, manufacturing and installation of exhaust system (including valves, connections) of SCR systems are to comply with the applicable requirements of chapters 1, 2, 4 and 9 of PART THREE of Rules for Classification of Sea-Going Steel Ships.

3.3.2 The exhaust gas piping (including valves and connections) that are subjected to reductant (or

exhaust gas and reductant mixtures) and components of SCR reaction chamber are to be constructed of suitable corrosion resistant materials.

3.3.3 Normally, exhaust pipes from engines are to be routed separately and not interconnected. However, interconnected exhaust piping systems to a common SCR system may be accepted subject to the special consideration by CCS after the full consideration of potential risks are taken and the following conditions are met:

(1) The return of exhaust gas flow from a running engine to another stopped, or in operation, engine is to be prevented.

(2) Effective measures are to be taken to prevent the activation of the isolated engine when the isolation arrangement is closed.

(3) The isolation arrangement is to be reliable and ensure the safety operation of engine in the case of any failure.

(4) The connected engines are to comply with the applicable statutory requirements.

(5) The back pressure is never to exceed the limits specified by the manufacturer of each connected engine under all operation conditions. Fans installed for this purpose are to meet the requirements of 4.2.

3.4 Reductant supply system

3.4.1 General requirements

(1) Material, design, manufacturing and installation of reductant supply system (including piping, valves and connections) of an SCR system are to comply with the applicable requirements of chapters 1 and 2 of PART THREE of Rules for Classification of Sea-Going Steel Ships.

(2) The material of the piping system in relation to the storage, filling, disposal, transport of reductant, tanks, and other components which may come into contact with the reductant solution is to be of a suitable grade of alloyed steel,non-combustible plastic, carbon steel with anti-corrosion coating or other material established to be suitable for the application. Aluminium, aluminium alloy, copper, copper containing alloys, and zinc-coated steels are not to be used for reductant storage or piping systems.

(3) Reductant supply piping made of plastic material is to comply with the applicable requirements of Appendix 1 to Chapter 2 of PART THREE of Rules for Classification of Sea-Going Steel Ships.

(4) The reductant supply piping systems are to be independent of other ship service piping and are not to be located in accommodation, service, or control spaces.

(5) The reductant supply piping systems are not to be located over boilers or in close proximity to steam piping, exhaust systems, hot surfaces required to be insulated.

(6) Drip trays are to be provided in positions where possible leakage may occur in reductant storage/preparation tank and reductant supply piping systems so as to contain the possible leakage of reductant.

(7) Drainage arrangements are to be provided for the drip tray to drain the reductant in the tray to the overflow tank or other suitable tanks. The drain line is to be fitted with a non-return valve. Or as an alternative, leakage monitoring arrangement and fast closing valve is to be provided to cut off the supply of reductant swiftly when leakage occurs. Where this design is used, the volume of drip tray is to be enough to contain possible leakage.

3.4.2 Reductant storage tank

(1) The design volume of reductant storage tank is to be determined taking into account the intended voyage, concentration of reductant and the rated power of the connected engine.

(2) The reductant storage tank is not to be situated where spillage or leakage there from 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 and is not to be directly adjacent to any fuel oil tank and fresh water tank.

(3) For SCR system using urea solution as reductant, the reductant storage tank may be located within the engine room. Where a urea storage tank is located within an engine room a separate ventilation system is not required when the general ventilation system for the space is arranged so as to provide an effective movement of air in the vicinity of the storage tank and is to be maintained in operation continuously except when the storage tank is empty and has been thoroughly ventilated.

Where a urea storage tank is installed in a closed compartment, the area is to be served by an effective mechanical ventilation system of extraction type providing not less than 6 air changes per hour which is independent from the ventilation system of accommodation, service spaces, or control stations. The ventilation system is to be capable of being controlled from outside the compartment. A warning notice requiring the use of such ventilation before entering the compartment shall be provided outside the compartment adjacent to each point of entry. For SCR system using aqueous ammonia as reductant, requirements for ventilation as specified in 5.2 are to be complied with.

(4) Since excessively high or low temperatures may affect the properties of the reductant, necessary heating and/or cooling systems are to be provided for reductant storage tank depending on the voyage or operation area of the ship and the range of storage temperature of reductant (recommended by applicable recognized standards such as ISO 18611-3).

(5) Every pipe emanating from a tank containing reductant, which, if damaged, would allow reductant to escape from the tank, is to be provided with a fast closing valve located directly on the outlet of the tank. The fast closing valve is to be provided with means of closure both locally and from a readily accessible and safe position outside of the space. For the SCR system using urea aqueous solution as the reducing agent, manual closing valves are acceptable.

(6) Air pipes are to be fitted for reductant storage tank in accordance with section 10 of Chapter 3 of PART THREE of Rules for Classification of Sea-Going Steel Ships and the outlet is to be located at a not readily accessible position on open deck and effective measures are to be taken to prevent the entering of water into the tank. Air pipes are to be independent of other onboard piping or systems.

(7) Local temperature and level gauging are to be provided for reductant storage tank and indication is to be provided at the manned control station. For detailed requirements for temperature and level gauging indication and alarm of reductant storage tank, see 6.2.4.

(8) Where the reducing agent is stored in integral tanks, the following are to be considered during the design and construction:

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

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

3) These tanks are to be designed and constructed as per the structural requirements applicable to hull and primary support members for a deep tank construction.

4) These tanks are to be included in the ship’s stability calculation.

(9) The requirements specified in 3.4.2(3)also apply to closed compartments normally entered by persons:

1) when they are adjacent to the reductant integral tanks and there are possible leak points (e.g. manhole, fittings) from these tanks; or

2) when the reductant piping systems pass through these compartments, unless the piping system is made of steel or other equivalent material with melting point above 925 degrees C and with fully welded joints.

(10) Reductant tanks are to be of steel or other equivalent material with a melting point above 925 degrees C.

Pipes/piping systems are to be of steel or other equivalent material with melting point above 925 degrees C, except downstream of the tank valve, provided this valve is metal seated and arranged as fail-to-closed or with quick closing from a safe position outside the space in the event of fire; in such case, type approved plastic piping may be accepted even if it has not passed a fire endurance test.

(11) Reductant storage tanks are to be arranged so that they can be emptied of reductant and ventilated by means of portable or permanent systems.

3.4.3 Filters

(1) Filters are to be provided in the reductant supply system to minimize the entry of harmful foreign material that may affect valves or other essential system components.

(2) The design pressure of filters is to be greater than the maximum working pressure of the system.

3.4.4 Protective equipment

(1) For the protection of crew members, the vessel is to have on board suitable protective equipment consisting of large aprons, rubber gloves with long sleeves, rubber boots, coveralls of chemical-resistant material, and tight-fitting chemical safety goggles or face shields or both. For an SCR with reductant using urea solution, at least one set of protective equipment is to be provided onboard and the equipment is to be kept in a readily accessible locker outside the accommodation space. Eyewashes are to be provided near the reductant storage/preparation tank. For an SCR system with reductant using aqueous ammonia, equipment listed in 5.7 are to be provided.

(2) Safety instructions relating to precautions and corrective response actions are to be posted in the storage space containing reductant, and beside the entrance to the space, including MSDS of reductant.

CHAPTER 4 SYSTEM EQUIPMENT

4.1 SCR reaction chamber

4.1.1 Suitable manholes/inspection holes, passages or platforms are to be provided for the SCR reaction chamber and sufficient space around the SCR reaction chamber for replacement, service, maintenance and cleaning of catalyst blocks and other parts of the SCR reaction chamber is to be provided. Provision is to be made to indicate that catalyst elements have been removed from the reaction chamber.

4.1.2 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 NOx reduction rate, and a fire hazard. In general, this is expected to be achieved by control system limits on reductant injection strategies (prevention the formation of ammonia sulfates)and by the inclusion of soot blowing arrangements for the catalyst chamber.

4.1.3 Shell of SCR reaction chamber, catalyst block and supporting members are to be capable of sustaining all loads under normal working conditions.

4.1.4 The surface temperature of SCR reaction chamber is likely to hurt persons or fire hazards may occur due to contact with flammable liquid, therefore protection measures are to be taken in accordance with the requirements of 1.3.6.3 of Chapter 1 of PART THREE of Rules for Classification of Sea-Going Steel Ships.

4.2 Pumps and fans

4.2.1 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 SCR system at full rating.

4.2.2 Pumps and fans installed in the SCR system are to comply with the applicable requirements of Chapter 2 of PART THREE of Rules for Classification of Sea-Going Steel Ships.

4.3 Reductant

4.3.1 Where urea solution (e.g AUS 40) is used as the reductant, the requirements of ISO 18611-1 are to be complied with. Where aqueous ammonia is used as the reductant, the concentration is not to exceed 28% and common industrial standards are to be complied with, and it should be demonstrated that it is not practicable to use a urea based reductant, and the arrangements for its loading, carriage and use are to be derived from a risk based analysis. Where an application is made to use anhydrous ammonia as the reductant, it should be demonstrated that it is not practicable to use a urea based reductant and aqueous ammonia, and its use is to be agreed by the Flag Administration and CCS, and the arrangements for its loading, carriage and use are to be derived from a risk based analysis.

4.3.2 Where onboard reductant preparation device is used, the ingredient and properties of the prepared reductant are to comply with the requirements of ISO18611-1. The preparation capacity is to satisfy the operation demands of SCR system under maximum loads. The installation and arrangement of the device are to meet the requirements of the manufacturer of SCR system and comply with the applicable requirements of 3.4.

4.3.3 Reductant can be an eye, skin, and respiratory irritant, and hence there is a need for the provision of necessary protection measures (see 3.4.4 and 5.7) and reductant related equipment is to be identified definitely.

4.4 Pneumatic systems

4.4.1 Details of the pneumatic systems used for reductant injection, soot blowing, and any other associated SCR systems are to comply with the applicable requirements of Section 2, Chapter 2 of PART SEVEN of Rules for Classification of Sea-Going Steel Ships.

4.4.2 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 Section 5, Chapter 9 of PART THREE of Rules for Classification of Sea-Going Steel Ships.

4.4.3 Where the independent pneumatic systems and source of air supply of the manufacturer are used by SCR system equipment, the recognized industrial standards are to be met.

4.5 Electrical equipment

4.5.1 The electrical equipment of the SCR system is to comply with the applicable requirements of PART FOUR of Rules for Classification of Sea-Going Steel Ships.

(1) Motors and motor controllers are to be certified in accordance with Chapter 3 of PART ONE.

(2) In the event of failure of the pumps (such as reductant pump) or fans essential for the continuous operation of SCR system, the standby pump or fan required by 4.2.1, where provided, is to be automatically started and put into service.

(3) Suitable circuit breakers are to be installed for electrical equipment of the SCR system and the applicable requirements of Section 5, Chapter 2 of PART FOUR of Rules for Classification of Sea-Going Steel Ships are to be complied with.

CHAPTER 5 ADDITIONAL REQUIREMENTS IN CASES WHERE THE AQUEOUS AMMONIA IS USED AS REDUCTANT AGENT

5.1 Construction and arrangement

5.1.1 Compartments where independent aqueous ammonia storage tanks or aqueous ammonia injection systems, etc. are installed (hereinafter referred to as aqueous ammonia tank) are to be special compartments isolated by gastight bulkheads and decks from all other compartments so that leaked ammonia does not enter other compartments. The distance between aqueous ammonia storage tank and from the shell plating is not to be less than 760 mm.

5.1.2 The aqueous ammonia tank is to be provided with access doors which comply with the following requirements:

(1) At least two access doors are to be provided in the aqueous ammonia tank as far apart as possible from each other. At least one access door is to lead directly to the weather deck. Access doors not leading to weather deck are to be of a highly sealable and self-closing type.

(2) Access doors are to be capable of being operated easily and are to open outward.

5.1.3 Passages leading to the aqueous ammonia tank are to comply with the following requirements:

(1) The passage is to be isolated from passages to accommodation spaces.

5.1.4 Penetrations on gastight bulkheads and decks where cables and piping from the aqueous ammonia tank pass through are to be of a gastight construction.

5.1.5 An independent drainage system in the aqueous ammonia tank is to be provided so that the drainage of this compartment is not discharged into open bilge wells or the bilge ways of other compartments.

5.1.6 A system to lead the leaked aqueous ammonia from the drip trays to a drain tank is to be provided and a stop valve is to be fitted for the discharge line.

5.1.7 Piping for the supply, transfer, injection or discharge of aqueous ammonia storage tanks is not to pass through accommodation spaces, service spaces or control stations, unless reliable leakage prevention measures are taken, such as the use of double wall pipes.

5.1.8 The aqueous ammonia piping leading to the engine outside the aqueous ammonia tank is to be of double wall and at least 8 air changes of negative mechanical ventilation per hour is to be ensured within the double wall piping and the exhaust outlets are to be installed at a horizontal distance of more than 10m from the nearest air intake or openings of accommodation spaces, service spaces and control stations, and at a vertical distance of more than 4m from weather decks.

5.2 Ventilation systems

5.2.1 A negative ventilation system independent of other ship spaces and having a capacity of not less than 30 changes per hour is to be installed in aqueous ammonia tank. The ventilation system is to be close to the aqueous ammonia storage tank and to be capable of being operated from a readily accessible place outside the compartment. Exhaust outlets are to be installed at a horizontal distance of more than 10m from the nearest air intake or openings of accommodation spaces, service spaces and control stations, and at a vertical distance of more than 4m from weather decks.

5.2.2 Independent ventilation systems are to be installed in passages leading to the aqueous ammonia tank. However, if the ventilation system specified in 5.2.1 is provided with ducts so that it can be used for exhausting the air in the passages, then an independent ventilation system need not be installed.

5.3 Drain tanks

5.3.1 Drain tanks are to be installed at a lower position than aqueous ammonia tanks.

5.3.2 In cases where the drainage accumulated in the tank is to be discharged overboard, it is to be diluted or neutralized before discharge.

5.3.3 An appropriate drain trap is to be provided to prevent the reverse flow of the gas from the tank.

5.3.4 All the vent pipes of the tank are to be connected to the exhaust pipe of the negative ventilation system.

5.3.5 Aqueous ammonia supply line is to be equipped with a means to temporarily discharge aqueous ammonia remained in the pipes taking into consideration the need to remove aqueous ammonia in pipes for repairs to any leaking areas of the pipes. Therefore, a discharge line is to be installed from the bottom of ammonia supply line to a drain tank, and a stop valve is to be fitted for the discharge line. The capacity of the drain tank is to be enough for storing the maximum volume of aqueous ammonia which can remain in the pipes from the main valve of aqueous ammonia tank to the injection nozzle.

5.4 Air pipes of aqueous ammonia storage tanks

5.4.1 Air pipes are to be provided for aqueous ammonia storage tank and the positions of the vent outlets are to be arranged as follows:

(1) at a height of not less than 6m above the weather deck;

(2) at a distance of at least 10m measured horizontally from the nearest air intake or openings of accommodation, service spaces and control stations.

5.5 Aqueous ammonia filling system

5.5.1 Aqueous ammonia filling system is to be used exclusively for ammonia solution, and the open ends of the system are to be led to the open deck and to be provided with a shutoff valve and a blank flange. The open ends and filling pipes located in the open deck are to be identified. A fixed drip tray is to be installed below the open end of filling pipes and other position where potential leakage may occur.

5.5.2 The aqueous ammonia filling line is to be fitted on top of the aqueous ammonia storage tank or in close proximity to it. Arrangements are to be made to avoid the emission of gas remaining in the line after use or when not in use.

5.6 Gas detection and alarm systems

5.6.1 Fixed ammonia gas detectors are to be installed in each aqueous ammonia tank. The detectors are to activate an alarm when the gas concentration exceeds 25ppm. And when the gas concentration exceeds 300ppm, the detector is to automatically stop the aqueous ammonia supply pumps, automatically close the main valves of aqueous ammonia storage tanks, and activate the visual and audible alarm.

5.6.2 One portable ammonia gas detection instrument is to be provided for each aqueous ammonia tank. And a manually-operated transmitter for leakage warnings is to be provided at an outside location near the doors of aqueous ammonia tank.

5.6.3 Ammonia gas detection systems are to be provided in passages leading to the aqueous ammonia tank. The gas detectors are to generate visible and audible alarms in the passage and near the doors of the aqueous ammonia tank when the gas concentration exceeds 25ppm.

5.7 Safety and protective equipment

5.7.1 Three sets of protective equipment are to be stored at a readily accessible locker outside the

accommodation space(including large aprons, rubber gloves with long sleeves, rubber boots, coveralls of chemical-resistant material, and tight-fitting chemical safety goggles or face shields or both). And the following emergency equipment is to be provided at a readily accessible locker outside the aqueous ammonia tank:

(1) Self-contained breathing apparatus (capable of functioning for at least 30 minutes) x3;

(2) Eye lotion x 3;

(3) Boric acid, 250ml x 3;

(4) Stretcher x1.

5.7.2 Eyewash and safety showers are to be provided near the main aqueous ammonia filling pipe and pump.

CHAPTER 6 ELECTRONIC CONTROL SYSTEM

6.1 General requirements

6.1.1 In addition to the requirements of this chapter, SCR electronic control system is to comply with the requirements of chapters 1 and 2 of PART SEVEN of CCS Rules for Classification of Sea-Going Steel Ships. Ships with automation class notation are to comply with the applicable requirements of chapters 3 and 4 of PART SEVEN of CCS Rules for Classification of Sea-Going Steel Ships.

6.1.2 The control system for the SCR system may be connected to an integrated control system or may be a standalone system.

6.1.3 The computer system used for the control, monitoring, alarm and safety of the SCR system is to comply with the applicable requirements for computer system of category II in Section 6, Chapter 2 of PART SEVEN of CCS Rules for Classification of Sea-Going Steel Ships.

6.2 Control and monitoring system

6.2.1 Automatic control, alarm and safety functions are to be provided for the SCR system so that operations remain within preset parameters for all engine connected with the SCR system and arrangement for manual operation is to be provided.

6.2.2 A local control and monitoring system for the SCR system is to be provided in the event of an emergency or failure of any remote controls (where provided).

6.2.3 Indications of parameters necessary for the safe and effective operation of the system are to be provided at the local or remote control station(s) (where provided).

6.2.4 In addition to the monitoring parametersin4.5 of CCS Guidelines for Approval and Surveys of Selective Catalytic Reduction (SCR) System, monitoring, alarm and indication are to be provided in accordance with Table 6.2.4 to guarantee the safe, reliable and effective operation of the SCR system onboard ship.

Monitoring and Safety System Functions for SCR Systems Table 6.2.4

Monitored Parameters	Display	Alarm Activated	Automatic SCR Shutdown and Automatic SCR Bypass①
Exhaust fan motors, where provided	Running	Stop②	——
Exhaust bypass or isolation valves, where provided	Position	Failed	——
Control-actuating medium of the exhaust bypass or isolation valves	Running	Failed	Failed
Exhaust gas temperature before SCR chamber	Temperature	High	High-High
Exhaust gas temperature after SCR chamber	Temperature	High	High-High
Reductant system supply pressure	Pressure	Low	Low-Low
Reductant storage tank temperature	Temperature	Low/high	High-High
Reductant storage tank level	Level	Low/high	Low-Low
Reductant tank drip tray level, if applicable	——	High③	
Ventilation system of reductant storage tank	Running	Stop	——
Detection of concentration of ammonia in aqueous ammonia tank and passageway④	Concentration	High	High-High

Monitored Parameters	Display	Alarm Activated	Automatic SCR Shutdown and Automatic SCR Bypass①
Power supply for control, alarm and safety system	Working	Failed	——
SCR emergency shutdown	Applicable	Applicable	Applicable

Notes:

① Automatic bypass of the SCR unit is only applicable to those SCR units fitted with exhaust gas bypass arrangements.

② Failure of essential SCR system motors driving pumps or fans is to activate the standby units, where fitted.

③ In accordance with 3.4.1(7), alarm is to be activated once leakage of reductant is detected and the supply of reductant is to be cut off automatically.

④ Applicable to the SCR system using aqueous ammonia as reductant.

6.3 Emergency shutdown system

6.3.1 A shutdown system is to be provided for SCR system to stop the supply of reductant and open the exhaust gas bypass (where fitted). The shutdown of SCR system is not to influence the reliable operation of the engine.

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

APPENDIX 1 RISK ANALYSIS

1 The following potential risks are generally to be considered for risk analysis of SCR systems, but not limited to:

(1) adaptability to the environmental and working conditions;

(2) impacts on the safe operation of the engine;

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

(4) leakage and spread of chemical substances;

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

(6) potential fire risks.

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

(1) standards and methods for risk analysis;

(2) assumptions and prerequisites of the analysis;

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

(4) potential risks;

(5) causes for the risks;

(6) possible effects of the risks;

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

3 Reference may be taken to Table 1 for the format of risk analysis sheet.

Risk Analysis Sheet (example) **Table 1**

Items	Risk	Cause	Potential effects	Safety protection	Improvement measures