GUIDANCE NOTES
GD32-2020

CHINA CLASSIFICATION SOCIETY

GUIDELINES FOR APPROVAL AND SURVEY OF SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEM

2020

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Beijing

PREFACE

The Guidelines will, upon entry into force, replace GD04-2016 the Guidelines for Approval and Survey of Selective Catalytic Reduction (SCR) system (2016).

The main contents and structure of the Guidelines are as follows:

(1) Chapters 1 to 5 provide basic requirements for the SCR system, the requirements for the submission of plans and documents for approval, the technical requirements, the control, monitoring and safety protection requirement, and approval and survey requirements. These requirements apply to SCR system plan approval, approval and survey stage.

(2) Chapter 6 provides SCR System Technical Files and Parameter Checking Methods, applicable to approval of SCR systems, product survey and survey and certification for “diesel engine + SCR” EIAPP;

(3) Chapter 7 provides Procedures for Approval and Certification of Diesel Engines Fitted with SCR System, based on NTC2008 and MEPC.291(71). This chapter introduces the special requirements for survey of "diesel engine +SCR" for EIAPP, including the documents to be submitted, test requirements and certification procedures and requirements, thus providing guidance for approval of "diesel engine+SCR" for EIAPP and certificate issuance.

Compared with the 2016 version, the main revisions of the Guidelines include the following aspects:

(1) Based on the feedbacks collected after the release of the 2016 edition of the Guidelines, some provisions are revised after discussion, such as:

- In Chapter 3 on technical requirements, considering the existing bypass requirements, the suggestion to install safety valve on exhaust piping to prevent back pressure is deleted.
- In Chapter 3, for exhaust gas heating device, considering the safety of navigation, the requirements for diesel engine starting conditions are deleted.
- In Chapter 4, regarding electrical control system data recording, recording of all operational data is no longer a mandatory requirement, while the requirements for storing alarms and failure data are still kept.
- In Chapter 4, regarding interlocking mechanism for exhaust piping and bypass piping, mechanical interlocking valves are acceptable;
- In Chapter 5, considering actual installation of the SCR chamber onboard, the requirement for vibration test is changed into selecting applicable vibration test conditions according to actual installation.

(2) The items of approval survey and product inspection in Chapter 5 are sorted out in a list, which is easy to understand and implement. Some test requirements and descriptions are also improved.

(3) Paragraph 5.9 of the previous version on approval in principle is deleted, for which CCS has another guidance document.

(4) Chapter 7 is newly added, mainly including certification procedure for diesel engine with SCR system, including special requirements for family/group, certification procedure for scheme A and scheme B, EIAPP certificate completion requirements, project requirements for initial confirmation test onboard, etc.

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CHAPTER 1 GENERAL

1.1 Application

1.1.1 The Guidelines apply to Selective Catalytic Reduction (hereinafter referred to as SCR) systems applying for the approval and survey by China Classification Society (hereinafter referred to as CCS).

1.1.2 The Guidelines only apply to SCR systems using urea solution as reductant. SCR systems using aqueous ammonia or anhydrous ammonia as reductant are to be separately approved upon special consideration.

1.1.3 The Guidelines cover implementation of statutory requirements and class requirements.

1.2 Normative reference

1.2.1 IMO Resolution MEPC.291(71) "2017 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" and its amendments including MEPC.313(74).

1.2.2 IMO International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI

1.2.3 IMO Resolution MEPC.177 (58) on NO_X Technical Code and its amendments

1.2.4 CCS Rules for Classification of Sea-Going Steel Ships

1.3 Purposes

1.3.1 The purpose of type approval of SCR systems is to prove that the product design conforms to the requirements of the Guidelines, so that the SCR equipment can safely and continuously reach the declared NO_X treatment capacity.

1.3.2 Principles and significance of type approval of SCR systems

(1) Type approval of SCR systems is an approval of system security, function and purifying capacity. It does not include the preliminary survey of associated diesel engines. Diesel engines fitted with SCR are to be subject to after-matching test according to Scheme A and B, so as to ensure that it can meet the requirement of pre-certification survey.

(2) The application of SCR systems may bring unknown risks and type approval is helpful to verify the safety of newly-added equipment.

(3) Type approval of SCR systems may be regarded as the preliminary preparation of diesel engine emission test. After the performance of SCR system, on-board environmental suitability and possible modeling tools and model test are confirmed during the approval process, the classification of engine family/group fitted with SCR system and the selection of parent engine as well as the determination of system arrangement and control scheme are facilitated, so as to support the pre-certification survey of diesel engines fitted with SCR systems.

(4) An SCR system without CCS type approval is to be deemed as the main component of the diesel engine. During diesel engine pre-certification survey, plans and documents required in Chapter 2 of the Guidelines are to be submitted for approval and the SCR system is to be surveyed according to the requirements of type approval in the Guidelines, so as to ensure that the system is in compliance with the technical requirements of the Guidelines.

1.4 Terms and definitions

1.4.1 Terms and definitions

(1) *Selective catalytic reduction system* means a system consisting of an SCR chamber, reductant injection system, control device, exhaust pipe (if requested in design) and other necessary equipment.

(2) *SCR chamber* means catalytic converter. It is an integrated unit which contains the catalyst block that can facilitate the reaction action between NO_X in exhaust gas and reductant to generate N_2 and H_2O. It is the core part of the SCR system.

(3) *Engine system fitted with SCR* means a system consisting of a marine diesel engine, an SCR chamber and a reductant injection system. When a control device on NOx-reducing performance is provided, it is also regarded as a part of the 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 NO_x from exhaust gas.

(5) *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.
(6) *SCR electrical 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) *SV (Space velocity) value* means a value of the exhaust gas flow rate passing through the catalyst block(s) (m^3/h) per total volume of the catalyst block(s) in the SCR chamber (m^3). Therefore, unit of SV value is (1/h). The exhaust gas flow volume is the volume defined at 0°C and 101.3 kPa.
(8) *AV (Area velocity) value* means a value of the exhaust gas flow rate passing through the catalyst blocks (m^3/h) per total active surface area of the catalyst blocks in the SCR chamber (m^2). Therefore, unit of AV value is (m/h). The exhaust gas flow volume is the volume defined at 0°C and 101.3 kPa.
(9) *LV (Linear velocity) value* means a value of the exhaust gas flow rate passing through the catalyst blocks (m^3/h) per catalyst block's section (m^2) in a normal direction of exhaust gas flow. Therefore, unit of LV value is (m/h). The exhaust gas flow volume is the volume defined at 0°C and 101.3 kPa.
(10) *Total volume of the catalyst block* means the volume (m^3) based on outer dimensions of the catalyst block.
(11) *Block section* means the cross-sectional area (m^2) of the catalyst block based on the outer dimensions.
(12) *NO_X reduction rate* means a value η (%) deriving from the following formula:

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

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.
(13) *Catalyst block casing or frame* means a casing or frame of an assembly (module) of several catalyst blocks.
(14) *Total active surface area* means the total surface area of catalyst block measured with selective chemisorption method.
(15) *Reductant* means urea solution that can be hydrolyzed to produce NH_3.
(16) *Modeling tool* means a simulating calculation tool adopting diesel engine parameters and model test data to calculate the conversion efficiency of NO_X.
(17) *Model test* can provide data for modeling tool and it refers to the content in 6.1.1.3 of MEPC.291(71). It can be carried out with full-scale or scaled catalyst and the mixed gas can be diesel engine exhaust gas or simulated gas.
(18) *Scheme A* means a survey method to carry out, during pre-certification survey, test-bed testing in accordance with Chapter 5 of the NTC 2008 or onboard testing in accordance with the full test-bed requirements of Chapter 5 of the NTC 2008 for a diesel engine fitted with an SCR system to prove the compliance of its emission.
(19) *Scheme B* means a survey method to prove the emission compliance of a diesel engine through modeling calculation and on board initial confirmation test, etc. (refer to MEPC.291 (71)).
(20) *Open-loop control* means a system without feeding outlet parameter of an SCR chamber (for example NO_X concentration at the outlet) back to influence the supply of reductant.
(21) *Close-loop control* means the control mode adopted to correct the reductant supply according to outlet parameter of an SCR chamber (for example NO_X concentration at the outlet).
(22) *Catalyst MSDS (Material Safety Data Sheet)* means a sheet containing physical and chemical parameters and hazardous information about the catalyst for users' reference and to promote safe operation.

1.5 Abbreviations and symbol description
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(1) SCR: Selective Catalytic Reduction;
(2) SV: Space Velocity;
(3) CPSI: Channels Per Square Inch of catalyst cross section;
(4) PLC: Programmable Logic Controller;
(5) CPU: Central Processing Unit;
(6) NH_3: Ammonia;
(7) ANR: Ammonia to NO_X Ratio.

(8) NTC 2008 (NOX Technical Code 2008): NO_X Technical Code adopted by Resolution MEPC.177(58) and its ammendments.

CHAPTER 2 PLANS AND DOCUMENTS

2.1 Plans and documents submitted for approval

2.1.1 The following plans and documents are to be submitted for approval or for information:

(1) General arrangement plan of the SCR system, including the installation and arrangement of SCR chamber, bypass piping, soot blower, mixer, nozzles, sensors (especially control-related sensors), reductant supply pump, etc. The plan is to show the relative position of the SCR system and the diesel engine, for example, pre-turbo or post-turbo arrangement, exhaust branch piping or manifold arrangement, etc.;

(2) Schematic diagram of the SCR system;

(3) Materials and specifications of main components including shell of reaction chamber, soot blower, mixer, nozzles, supply pumps and pipelines;

(4) Drawings of SCR chamber, which is to include:

① SCR chamber structural drawing;

② Drawing of installation and arrangement of internal catalyst block, including quantity and arrangement of catalyst blocks and sealing between catalyst block and SCR chamber shell to prevent exhaust gas leakage;

③ Structural drawing of catalyst block, including sizes and meshes (CPSI)

(5) Electrical control system, including system specifications and software quality control plan, etc., for details, to comply with the requirements for plans and documents in Chapter 1, PART SEVEN of Rules for Classification of Sea-Going Steel Ships of China Classification Society. The serial number and version number of control software are to be stated explicitly in relevant documents.

(6) Reductant supply system, at least including:

① Schematic diagram of reductant supply system;

② Drawing of nozzles, including model and specification, nozzle diameter, aperture number and spray-cone angle (for information);

(7) Drawings and documents of auxiliary equipment (for information):

① Drawing of bypass system structure (if applicable);

② Drawing of soot blower and gas consumption calculations (if applicable);

③ Drawing of mixer structure (if applicable);

④ Drawing of exhaust gas heating device and power calculations (if applicable);

(8) Instructions of SCR system control strategy, at least including:

① Control strategy flow chart, in which control mode is specified (for example, open-loop or close-loop control,etc.);

② All input and feedback signals related to control;

(9) Specifications of main performance of the product:

① Performance Parameter Table, i.e. inlet and outlet boundary conditions and limits applicable to SCR chamber, at least including catalyst scaling range, exhaust gas flow range, AV and LV, NO_X concentration range, temperature range at the inlet of the chamber, pressure loss and other parameter ranges that may be applicable, such as ANR, SO_X, O_2, CO_2 and H_2O, etc.;

② Materials, composition/type of catalyst block;

③ Type/composition and concentration of reductant;

④ Applicable fuel quality, standard and maximum allowable sulphur content;

⑤ Factors related to SCR performance deterioration rate, including catalyst block replacement condition and suggested replacement time;

⑥ Maximum conversion efficiency of catalyst (corresponding to different temperatures and AVs and ammonia-nitrogen ratio and ammonia leakage amount is to be stated);

(10) Uniform distribution calculation of exhaust gas flow field. The mixing of reductant and exhaust gas and the uniform distribution of ammonia gas (or ANR) when the fluid passes through the cross section of the chamber is to be considered. The uniformity is not to be lower than 85% (for information);

(11) Failure Modes and Effects Analysis (FMEA) (for information);

(12) Catalyst Material Safety Data Sheet (MSDS) and protective measures to be taken during catalyst block installation and replacement, and waste recovery measures (for information);

(13) Type test program (it can be provided during application for type approval);
(14) SCR technical files (refer to the requirements in 6.1 of the Guidelines and can be provided during applying for type approval);
2.1.2 If the system is intended to be used in Scheme B, at least the following documents and information are to be added for approval:
(1) Model test plan;
(2) Instructions for modeling tools;
(3) Model test report;
(4) Modeling calculation report.

CHAPTER 3 TECHNICAL REQUIREMENTS FOR SCR SYSTEM APPROVAL

3.1 General requirements

3.1.1 Operating condition

(1) Designed operating condition of machinery installations is to comply with the requirements on environmental conditions in Section 2, Chapter 1, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

(2) Designed operating condition of electrical installations is to comply with the requirements in Section 2, Chapter 1, PART FOUR of CCS Rules for Classification of Sea-Going Steel Ships.

3.1.2 Piping system, valves and pipeline fittings are to comply with relevant requirements in Chapter 2, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

3.1.3 The structural strength and designed pressure of an SCR system installed in the upstream of the turbocharger, its SCR chamber shell and all equipment (e.g. the mixing device) and exhaust pipes in the upstream of the chamber is to be determined according to the design requirements for exhaust manifold of the matching diesel engine or the design requirements of pressure vessels of the corresponding grade. In addition, means are to be provided to prevent the broken catalyst block from entering the charger.

3.1.4 Back pressure rise of an SCR system during maximum exhaust gas flow is to meet the requirement of the diesel engine manufacturer.

3.1.5 The SCR system is to have enough capacity to reduce NO_X and the mean value of ammonia concentration (i.e. ammonia leakage amount) in the exhaust gas in the downstream of the chamber is to be limited. During the process of SCR system approval and survey, ammonia leakage is normally not to exceed 10ppm. If IMO has latest requirements on this limit value, then such IMO requirements shall prevail.

3.1.6 If an SCR system is intended to be used in a Tier III engine (i.e. the engine is to be certified in accordance with paragraph 5.1.1 of Regulation 13 in MARPOL Annex VI), the specific emission at each individual mode point is not to exceed the applicable NO_X emission limit value by more than 50% except as follows:

(1) The 10% mode point in the D2 test cycle;

(2) The 10% mode point in the C1 test cycle;

(3) The idle mode point in the C1 test cycle.

3.2 Raw materials and parts

3.2.1 Main components of an SCR system are to be supplied with CCS Marine Product Certificate or Manufacturer's document. For details, please refer to relevant requirements in Appendix 2B, Chapter 3, PART ONE of CCS Rules for Classification of Sea-Going Steel Ships. Information including the ID number or composition/type, structural formation (e.g. CPSI) and manufacturer of the catalyst block is not allowed to be changed without the permission of CCS.

3.2.2 The material used for equipment and parts of an SCR system is to be applicable to its intended temperature, pressure and media, especially structural components in contact with reductant, such as an SCR chamber, mixer, soot blower, supply pump and supply pipeline,etc.

3.3 SCR chamber

3.3.1 The design of the shell of an SCR chamber is to meet the requirements in 3.1.3 and 3.2.

3.3.2 Means for preventing or monitoring catalyst block from being removed deliberately, e.g. lead seal or other means, is to be provided for an SCR chamber.

3.3.3 When sealing catalyst block in the chamber, sealing means is to be provided to prevent exhaust gas leakage so as to guarantee sufficient contact between the exhaust and catalyst.

3.3.4 An SCR chamber is to be of sufficient strength that can withstand the vibration onboard.

3.3.5 An SCR system is to be fit for fuel oil of certain sulphur (S) content and clear description in this regard is to be given.

3.3.6 Deterioration rate of SCR performance such as replacement condition or replacement time of catalyst block is to be considered. The degradation curve or life of the catalyst is to be obtained through testing or engineering practice, or degradation resistance performance of the catalyst is to be verified through rapid aging test.

3.3.7 The applicable exhaust gas temperature range for SCR chamber is to be stated, which is to be compatible with the test cycle adopted by the matching diesel engine.

3.4 Electrical control system

3.4.1 The design, manufacturing and survey, including software design, of electronic equipment in the electrical control system is to comply with the relevant provisions in PART SEVEN of Rules for Classification of Sea-Going Steel Ships and in the Guidelines for Type Approval Test of Electric and Electronic Products.

3.4.2 In the control plan for SCR electrical control system, actual operating condition of on-board engine is to be fully considered. When engine operating condition deviates from the nominal curve (e.g. propulsion curve or constant-speed operation curve) as normal, the SCR system is not to stop injection of reductant. The operating condition range of the diesel engine is to be covered by the SCR system operation in plane, to be designed according to the operating range that may be reached during actual operation of diesel engine. However, the coverage area is not to be less than ±10% of the nominal curve. The actually measured NOx conversion efficiency value plus 5% is not to be lower than the conversion efficiency in the designed operating condition (or curve).

3.4.3 The NOx conversion efficiency value under any operating condition on the nominal curve plus 5% is not to be lower than the conversion efficiency interpolation at 2 cycle mode points near the operating condition.

3.4.4 The design of monitoring function and control function of the electrical control system for an SCR system is to comply with the relevant requirements in Chapter 4 of the Guidelines.

3.5 Reductant supply system

3.5.1 Generally, urea solution with a mass concentration of 32.5% or 40% is used for reductant.

3.5.2 The design of reductant supply system is to be able to guarantee the reductant atomization and injection pressure at the outlet of nozzle and the injection pressure is to be easily checked.

3.5.3 The supply pump is to have proper flow range which should cover the flow range of reductant supply and guarantee sufficient precision of pump within that range.

3.5.4 After the SCR system stops working, there will be reductant residue at the nozzle part. The evaporation or deterioration of the reductant may result in block of nozzle. The reductant supply system is to be provided with compressed air cleaning function or other equivalent measures to clean the residue in nozzle after the system stops working to prevent nozzle blocking.

3.5.5 For fluid supply pipeline, the maximum allowable relative height of the supply pump and storage tank and nozzle, and the maximum allowable length of fluid supply pipeline as well as other onboard installation requirements are to be specified to ensure effective operation of the system.

3.6 Auxiliary equipment

3.6.1 When a single diesel engine is used for main propulsion, bypass structure is to be provided for its SCR system. When multiple diesel engines are used for main propulsion or auxiliary engines for other purposes, bypass structure may not be provided for its SCR system. The bypass structure is to include at least bypass pipeline for the exhaust piping, valves and bypass status indicator, etc., and the following requirements are to be complied with:

(1) The valves on the bypass pipeline is to be able to be opened or closed manually or a set of independent power source is to be added to control the open and close of the valves.

(2) The design of the bypass structure is to be able to prevent simultaneous close of the access to SCR chamber and the bypass pipeline due to misoperation. One can be closed only after the other is opened.

(3) During bypassing, interlocking function is to be provided to keep the SCR system in the stopped state and unable to start.

3.6.2 A soot blower for an SCR system is to ensure that the SCR chamber can work continuously and effectively to prevent the particulate matter (PM) in diesel engine exhaust gas from gathering on the catalyst surface and result in rise of exhaust back pressure and reduction of system catalytic efficiency. If such a blower is fitted, the following requirements are to be met:

(1) The soot blower is to have sufficient blowing pressure and blowing frequency to ensure its efficiency;

(2) Gas consumption of the soot blower is to be listed in the technical specifications;

(3) Blowing pressure and operation state is to be monitored.

3.6.3 The design of an SCR system is to ensure that the reductant and exhaust gas will be mixed fully before entering the chamber and the rationality of the structural design will be verified through fluid simulating calculation. When the fluid passing the chamber section, the ammonia gas (or ANR) is to distribute evenly and its evenness is not to be lower than 85%. When necessary, a mixer can be installed, but the requirements for the arrangement of exhaust gas pipeline before and after the mixer including the requirement for the distance to the SCR chamber are to be specified.

3.6.4 The exhaust gas heating device installed to ensure sufficient reaction temperature for an SCR chamber is to meet the following requirements:

(1) When fuel oil is used to heat exhaust gas, the system is to be so designed that accumulation of combustible oil gas can be avoided as far as possible. When stop valves are installed on the fuel oil supply piping, its open-close state is to be indicated clearly.

(2) Regular pre-scavenging is to be carried out in gas flue before ignition of oil atomizer. The scavenging period is to be long enough to guarantee 4 air changes of furnace, and air regulator is to be opened fully during scavenging;

(3) Ignition is to be conducted after air enters the combustor and pre-scavenging is completed. The inlet valve of oil injector is be opened after ignition sparks appear. If it cannot be ignited, the ignition device and inlet valve of oil injector is to be closed automatically. The interval between the opening and closing of inlet valve is not to be longer than 1s;

(4) Flame monitor is to be provided, which can automatically close the inlet valve of oil injector in case of flameout due to failure. The time of close is not to b later than 6s after flameout;

(5) The fuel oil consumption of exhaust gas heating device is not to exceed 5% of the fuel consumption of the matching diesel engine under rated condition.

3.7 Redundancy

3.7.1 In the control system, machinery and electric equipment that may influence normal operation of an SCR system due to functional failure are to be equipped with dual systems or onboard spare parts, e.g. input signal sensor or the device that may influence reductant metering control.

3.7.2 At least two reductant supply pumps are to be provided for an SCR system, the configuration of which is to be such that in case of failure of one pump, the others can still supply sufficient reductant under maximum operating condition of the SCR system. All pumps are to be connected properly and be readily available or easy to be replaced.

CHAPTER 4 CONTROL, MONITORING AND SAFETY PROTECTION

4.1 General requirements

4.1.1 SCR electronic control system is to control reductant injection amount, SCR system operating status, bypass status and working status of soot blower and exhaust gas heating device (if any) and it can adjust SCR system parameter on the basis of the status of the engine and exchange data externally. SCR electronic control system consists of sensor, electronic control unit, actuator and external interface.

4.1.2 In addition to the requirements of this Chapter, the control, monitoring and safety system of an SCR system is also to meet relevant requirements in Chapter 3 of the Guidelines.

4.1.3 An SCR system is to have failure self-diagnosis and safety protection function. In case of failure, the system is to carry out failure diagnosis immediately and activate relevant safety protection function.

4.1.4 The electrical control system is to have data recording function to automatically storing the abnormal conditions including alarming and failure during operation of the SCR system. The storage record of abnormal condition can only be erased manually. The data are to be retained for at least 18 months from the date of recording.

4.1.5 Data recording and processing equipment of the SCR system is to be able to output the system status, data and alarms to the monitoring system of the ship through external interface.

4.1.6 Reliability and accuracy of the sensor and monitoring equipment are to be guaranteed and they are to be calibrated regularly. Calibration procedure of the designer or the equipment supplier may be accepted.

4.2 Control

4.2.1 An SCR system is to be capable of automatically controlling operation and its reductant injection amount may be adjusted automatically according to the change of diesel engine operating condition, so as to ensure the expected conversion efficiency and the minimum ammonia slip under different operating conditions.

4.2.2 A soot blower is to be capable of automatically controlling operation. When the pressure difference before and after the chamber exceeds the set value, it can operate automatically, or a reasonable starting frequency and continuous working period can be set to guarantee a reasonable pressure difference. In addition, manual control function is to be provided to facilitate continuous soot blowing.

4.2.3 An exhaust gas heating device is to be capable of automatically controlling operation. The exhaust gas temperature at operation and stopping is to be in consistency with that specified in the technical document.

4.2.4 When the flame of the exhaust gas heating device goes out, the heating device is to stop fuel oil injection.

4.3 Monitoring

4.3.1 The monitoring function of the electrical control system is to be capable of alarming for the main functional failure of the sensors, electronic control unit and actuator of the system.

4.3.2 In case of fault or failure of the sensors in the control system that may influence normal operation of the SCR system due to functional failure, especially the sensor affecting reductant metering control,

(1) an alarm signal is to be sent out;

(2) damaged parts are to be replaced or backup equipment is to be used in a timely manner to get back to normal control function;

4.3.3 The control unit of an SCR system is to be able to effectively monitor the working status of the essential components including the SCR chamber, reductant supply system, blowing device and exhaust gas heating device,etc. For details, please refer to the List of Monitoring Items in 4.5 of this Chapter.

4.4 Safety system

4.4.1 In case of breakdown of machinery and electronic equipment due to the action of safety system, alarming is to be sent out and the failure is to be displayed. The equipment is not allowed to be put into service automatically unless manual reset is made.

4.4.2 Interlocking mechanism is to be provided to prevent simultaneous close of the access to the SCR chamber and the bypass piping due to misoperation. The step for bypassing is to be such that the access to the SCR chamber is to be closed only after bypassing valve is fully opened. Mechanical interlocking

valves are also acceptable.

4.5 List of monitoring items for an SCR system

4.5.1 The monitoring items for an SCR system are to meet the requirements in Table 4.5.1.

4.5.2 SCR systems adopting different control strategies have different monitoring items. Monitoring items are to be added according to system characteristics.

List of Monitoring Items for an SCR System Table 4.5.1

Item	Control Station (Room)		Category of safety system action		Remarks
	Display	Alarm	SCR autostop	* Bypass	
1 SCR system operation status					
Operation of SCR system	Operation indication	—	—	—	
Bypass*	Status	Fail to open	—	—	
2 Chamber					
SCR chamber inlet & outlet pressure difference	Pressure difference	High	—	—	*Soot blower in operation
		Too high	X	X	
3 Reductant supply system					
Reductant injection amount	Injection amount	—	—	—	
Supply pump failure	—	Failure	—	—	To start or replace standby pump
Injection pressure	Pressure	Low	—	—	
Nozzle	—	Failure	—	—	
4 *Soot blower					
Operation of soot blower system	Operation indication	—	—	—	
Blowing pressure of soot blower	Pressure	Low	—	—	
5 * Exhaust gas heating device					
Operation of exhaust gas heating device	Operation indication	—	—	—	
Flame and ignition of heating device	—	flameout/failure	—	—	
Fuel oil pressure of heating device	Pressure	Low	—	—	
Power failure of burner blower	Voltage	Failure	—	—	Voltage can be replaced by indicator light
6 Control system					
Power failure of control unit	Voltage	Failure	—	—	Voltage can be replaced by indicator light
Communication failure of control system	—	Failure	X	X	
Main sensor failure (control-related)	—	Failure	X	X	

Note: The symbols and their meanings in the table above are as follows: (1) —: Not required; (2) X: Applicable; (3) *: If any.

CHAPTER 5 TECHNICAL REQUIREMENTS FOR SCR SYSTEM TEST

5.1 General requirements

5.1.1 For SCR systems in the same design but in different specifications, if it is designed based on scaling principle, the whole series can be approved after typical samples have been used for type test. Refer to Regulation 5.2 in this Chapter for scaling principle.

5.1.2 Before type test of SCR system, it should be confirmed that the plans and documents (according to the requirements in Chapter 2 of these guidelines) for the series within the range of approval has been approved by CCS.

5.2 Scaling principle

5.2.1 An SCR system adopting scaling principle and applicable to different diesel engine exhaust gas flow rate (rated condition) is to meet the following requirements:

(1) AV, SV and LV values of different systems are to be consistent or be in the range of application.

(2) Catalyst used for different systems: composition/type and catalyst block structural style are to be consistent.

(3) The rules for different system control strategies are to be consistent.

5.3 Selection of typical samples

5.3.1 During first approval, one set of equipment shall be selected for each series of SCR systems for type test. The sample selected is representative in terms of technical parameter, structure and manufacturing process and can embody the processing capability and manufacturing level of the factory.

5.3.2 The performance test for SCR system used in Scheme A or in both Scheme A and B shall be done by adopting diesel engine + SCR mode and test-bed mode in Scheme A or by combining pre-certification survey in diesel engine Scheme A.

5.3.3 The selection of diesel engine + SCR for performance test shall meet the following requirements:

(1) Diesel engine for test does not have to be the proposed matching diesel engine and the SCR system can be the equipment for design development.

(2) The selection of diesel engine + SCR for test shall ensure that the space velocity (SV) of SCR catalyst under rated condition of the diesel engine is no lower than the maximum space velocity applicable to the SCR system.

(3) If relevant diesel engine cannot be selected as sample due to the fixed size of catalyst block and condition restrictions and it can be proved through calculation or model calculation that the design of SCR system can meet the requirements of applicable maximum space velocity and the catalyst volume has allowance, consideration may be taken to lower the standard in (2) above.

(4) Considering that CPSI of catalyst varies from different manufacturers and types, the consistency of AV will be taken as a key consideration by the designer and SV varies. Maximum AV may be taken as the parameter when selecting the sample for the performance test.

5.4 SCR system type test items

5.4.1 Type test items listed in Table 5.4 shall be carried out for SCR system applying for type approval certificate and the test report shall be submitted.

SCR System Type Test Items **Table 5.4**

No.	Test Item	Survey requirement (Paragraph in the Guidelines)	Remarks
1	Visual inspection	5.5.1	
2	Sulphur resistance of catalyst	5.5.2	
3	Deterioration of catalyst	5.5.3	
4	Vibration test of SCR chamber or catalyst block	5.5.4	Sample inspection may be carried out for catalyst of same manufacturer, process, material and CPSI
5	Electrical control system test	5.5.5	
6	Function test of auxiliary equipment	5.5.6	

7	Performance test of SCR system	Capability of catalyst to reduce NO_X	5.5.7（1）	
		Rationality of control strategy design	5.5.7（2）	Generally applicable to open-loop control strategy
		Accuracy of the calculation by modeling tool and the rationality of scaling	5.5.7（3）	The same modeling tool may be used only once
8	Check of SCR technical files		5.5.8	The general technical file may only be used to confirm the completeness and rationality of structure

5.5 Type test requirements

5.5.1 Visual inspection. SCR system and its parts and components comply with the technical requirements in the approved drawings and Chapter 3 of the Guidelines.

(1) Survey requirements for SCR chamber

①The internal and external structure, including the compliance of packaging and structural size, number of units of catalyst block and its arrangement in the chamber;

② Tightness test is to be carried out under 1.1 times the design pressure or in accordance with the manufacturer's requirements;

(2) Catalyst supplying pump, nozzle and piping, etc.;

(3) Auxiliary equipment, including applicable equipment such as bypass line, soot blower, mixer, exhaust gas heating device.

5.5.2 Sulphur resistance of catalyst

(1) The manufacturer shall provide sufficient theoretical foundation of or test data on sulphur resistance of its catalyst as support.

(2) minimum and maximum working temperature of catalyst applicable to fuel oil of different sulphur content are to be provided.

5.5.3 Deterioration of catalyst

(1) Obtain degradation curve and catalyst age under common operating condition through test or engineering application; or

(2) Rapid aging test. The degradation rate of NO_X conversion efficiency due to SCR aged rapidly is not to exceed 10%. Rapid aging test is to be done on test-bed and test cycle is shown in Table 5.3.

(3) Chamber for test may be connected with engine or burner based on test-bed condition and proper size is to be selected.

Rapid Aging Test Condition **Table 5.5.3**

Inlet temperature (℃)	Space velocity (h^{-1})	Duration of aging (h)
550	50,000	200

5.5.4 SCR chamber or catalyst block vibration test

(1) Samples of catalyst or chamber with appropriate size may be selected as the vibration test samples based on the condition of vibration test-bed.

(2) Parameters for vibration test are shown in Table 5.5.4.

Parameters for Vibration Test **Table 5.5.4**

Means of installation onboard the ship	Frequency （Hz）	Amplitude （mm）	Acceleration （m/s^2）
With independent support or seat	2 (+3/0)~13.2	±1.0	——
	13.2~100	——	±6.9 (0.7g)
Installed on the diesel engine	2(+3/0)~25	±1.6	——
	25~100	——	±39 (4.0g)

(3) Test methods

① To check whether resonance phenomenon exists by scanning with the speed not greater than 1 oct / min according to the scope of frequency and amplitude specified in Table 5.5.4.

② A vibration resistance test lasting 90 minutes is to be carried out under the frequency of 30Hz if there is no obvious resonance point.
③ Vibration resistance test lasting 90 minutes is to be carried out under each resonance frequency recorded with $Q \geq 2$. If the tested resonance frequencies are close, frequency scanning test lasting 120 min may be taken for the vibration resistance test.
④ Measures to avoid the hazardous frequency or reduce the value of Q are allowed to be taken during the test provided that the resonance check and vibration resistance test are re-carried out.
⑤ Tests are to be carried out on three mutually perpendicular axes.

5.5.5 Electrical control system test
(1) In addition to the relevant requirements in CC *Guidelines for Type Approval Test of Electrical and Electronic Equipment*, the electrical control system is also to meet relevant requirements in this Section.
(2) For the control function test of electrical control system, the reaction of electrical control system is in line with that expected and control parameters are to be verified during SCR system working verification.
(3) The functional tests such as safety protection and failure monitoring alarm,etc. are be decided according to relevant requirements in Chapter 4 or are to be carried out by combined with the performance test.

5.5.6 Auxiliary equipment function test
(1) Functional verification of the following auxiliary equipment can be carried out by combined with the performance test.
(2) Bypass system (if any) function test, to verify the control, action and interlock function of bypass valve and indicator.
(3) Soot blower (if any) function test, to verify the control and action of soot blower system, as well as the soot blowing pressure and frequency, etc.
(4) Exhaust gas heating device (if any) function test, to verify the effectiveness of the device, so as to guarantee effective operation of SCR system under low-temperature condition.

5.5.7 SCR system performance test
(1) NOx reduction capability of catalyst
① Verification of the maximum conversion efficiency of catalyst. Select at least one diesel engine condition and manually control the SCR system or to temporally change the injection volume of reductant. At this time, the injection volume of reductant is to be determined according to the temperature and space velocity value under this condition, referring to the corresponding ammonia nitrogen ratio in 2.1.1(9) ⑥ in Chapter 2 of the Guidelines. Compare the measured NOx conversion rate and ammonia slip with 2.1.1(9) ⑥ in Chapter 2 of the Guidelines to verify the maximum conversion efficiency of catalyst.
② The leakage volume of ammonia is to be measured to comply with the requirements of 3.1.5 of the Guidelines.
(2) Rationality verification of the control strategy design
① Random check of condition. One operation condition (excluding the original mode points in E3 or D2) is to be additionally selected from diesel engine propeller characteristic curve (E3 cycle condition curve) or D2 cycle condition curve (or nearby, a deviation about 5% is suggested). The NOx conversion efficiency value under this point plus 5% is not to be lower than the conversion efficiency interpolation at 2 cycle mode points nearby during the cycle. If the verification test is carried out in conjunction with pre-certification survey (EIAPP certification survey) for Scheme A, one operation condition is to be randomly selected and checked on each curve of test cycle.
② The leakage volume of ammonia is to be measured to comply with the requirements of 3.1.5 of the Guidelines.
(3) Verification of calculation accuracy of modeling tool and rationality of scaling
① For an SCR system intended to be used in Scheme B, no matching test of diesel engine and SCR system is carried out on test-bed and the initial confirmation test onboard is a simplified validation mode. Therefore, verification of the applicant's scaling scheme and modeling tool accuracy is be completed before matching onboard, so as to reduce the possibility of unsatisfacotry initial IAPP survey.

② The applicant is to submit the SCR chamber test report and modeling calculation report of the sample engine first and verify the rationality of scaling and the accuracy of modeling calculation through test. The verification process is shown in Figure 5.5.7.

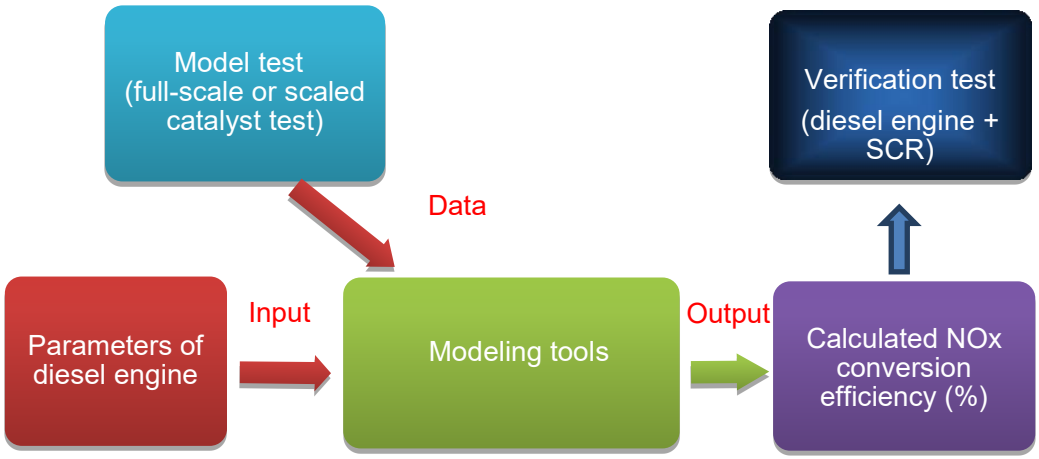

Figure 5.5.7 Process of modeling tool calculation and scaling verification test

③ Relevant requirements of SCR chamber test and modeling tool may be referred to in resolution MEPC.291(71).

④ The leakage volume of ammonia is to be measured to be in compliance with the requirements of 3.1.5 of the Guidelines.

(4) During verification test, the test data in Appendix 2 are to be recorded at least.

(5) Performance test is to comply with the test-bed NO_X emission measurement procedure in Chapter 5 of NTC 2008.

5.5.8 General technical files are to be approved according to the requirements of Chapter 6 of the Guidelines during the phase of approval of SCR.

5.6 Survey of single piece/single batch

5.6.1 After obtaining CCS type approval, the factory can apply for CCS' single piece/single batch survey for SCR systems manufactured in accordance with the approved condition.

5.6.2 The approved single piece/single batch survey items are to comply with the requirements of Table 5.6.2 and relevant test report is to be submitted once the survey is completed.

SCR System Single Piece/Batch Item Table 5.6.2

No.	Test item	Survey requirement
1	Visual inspection	5.5.1 of the Guidelines
2	Edition of control software	To check the information such as the edition No. of control software
3	Check of IMO identification of emission related parts	For emission related parts, refer to 6.2 of the Guidelines
4	Approval of SCR technical files	1) To confirm whether it is applicable to the diesel engine to be matched; 2) To comply with the requirements of Chapter 6 of the Guidelines

5.6.3 After the completion of single piece/single batch survey, CCS will issue marine product certificate or equivalent documentary evidence and approve the SCR technical file before the certificate is issued.

5.7 Certificate

5.7.1 After the SCR system is satisfactorily surveyed according to the Guidelines, relevant certificate is to be issued and SCR technical file is to be approved before the issuance of certificate.

5.7.2 The scope of application is to be specified in the approval certificate and product certificate of SCR system.

(1) For an SCR system only applicable to Scheme A, the following is to be indicated: "Applicable to

Scheme A, not including the approval of Scheme B (modeling tool, etc.); if it is to be applied to Scheme B, it is to be confirmed that the system is in compliance with the relevant requirements ofResolution MEPC.291(71)".

(2) For an SCR system applicable to both Scheme A and Scheme B, the following is to be indicated: "Applicable to Scheme A and Scheme B".

5.7.3 The approval certificate and product certificate of an SCR system are to include the information listed in "List of Boundary Parameters of SCR System Function" of Appendix 1 of the Guidelines.

5.7.4 The SCR system approval certificate and product certificate are to include a list of parts (details of components) to specify the composition of the system. The list of parts of approval certificate is to include: name of component, type, specifications or material, IMO identification. The list of parts of product certificate is to include: name of component, specifications or material, IMO identification, component product No.

5.7.5 The SCR system product certificate is to indicate that: for a diesel engine fitted with an SCR system, the installation and arrangement of its exhaust gas piping is to comply with the relevant requirements in technical files.

5.7.6 Survey and certification of an SCR system by CCS is to be requested after the whole system is installed. If the system is supplied in pieces, and a complete system is not formed at the survey location when applying for single piece/single batch survey, then the required additional surveys and tests together with the reference document No. are to be indicated in the product certificate.

CHAPTER 6 SCR SYSTEM TECHNICAL FILES AND PARAMETER CHECKING METHODS

6.1 Technical file of SCR system

6.1.1 Each SCR system is to be provided with a technical file and the technical file is to at least include the following content:

(1) Reductant: component/type and concentration;

(2) Reductant injection system, including critical dimensions, supply volume, and type and specification of supply pump;

(3) Design features of SCR specific components in the exhaust duct from the engine exhaust manifold to the SCR chamber. The design features are to be specified by the applicant and may include, but are not limited to:

① any restrictions specified by the applicant relating to exhaust duct configuration/design, including the position and number of bends in exhaust duct along with orientation and geometry, exhaust duct changes of diameter and arrangements fitted to manipulate exhaust flow;

②minimum distance between reductant injection point(s) and SCR chamber;

③position of reductant injection equipment within duct and the direction of reductant injection, e.g. counter flow or parallel flow;

④reductant mixing arrangements;;

⑤Nozzle and atomization arrangement;

⑥inlet plenum design,, bottom entry or top entry;

⑦where an SCR by-pass arrangement is stipulated by the applicant, the control specifications, identification of the by-pass valve and its control device;

⑧ where an integrated reductant injection and SCR chamber arrangement is supplied as a packaged item to be fitted into an exhaust duct, the parameters of such a unit which may affect NOx emissions;

(4) Catalyst block specification and arrangement in the SCR chamber. The details of the catalyst block specification and the arrangement of catalyst blocks within the SCR chamber may include, but are not limited to:

① installation of blocks within the SCR chamber, including the number of blocks, number of layers and the SCR chamber casing and frame to prevent exhaust gas slip;

② catalyst block geometry;

③ limiting characteristics such as CPSI (cells per square inch) and ranges for physical parameters such as the space velocity (SV), area velocity (AV) and linear velocity (LV), or a part number or specification number specified by the applicant on the catalyst block;

④ catalyst material: this may be identified by means of a part number or specification number. The means to ensure a correct catalyst block installed on board against the Technical File, where a part number or specification number specified by the applicant on the catalyst block casing or frame is acceptable;

⑤ arrangement of soot blowing equipment;

⑥ inspection and access arrangements. The inspection of the SCR chamber should be limited to ensuring that the correct catalyst blocks are fitted during assembly of the SCR and the inspection of spare catalyst blocks can be accepted to demonstrate compliance at surveys other than at the initial assembly of the SCR ;

⑦ any baffle plates or other devices fitted within the SCR chamber for exhaust gas and reductant flow distribution;

(5) Inlet parameters including allowable exhaust gas temperature (maximum and minimum) at the inlet of the SCR chamber;

(6) Cross-unit parameters: cross-unit parameters: allowable pressure loss (Δp) between inlet and outlet of SCR chamber and in the exhaust duct caused by SCR components. Where there is any element of the SCR system upstream and/or downstream of the SCR chamber which affects the allowable pressure loss, then this allowable pressure loss (Δp) is to be based on the entire SCR system.

(7) Aspects related to the fuel oil quality resulting in continued compliance of the engine with the applicable NOx emission limit to assure continued NOx reduction may include, but not be limited to:

① the maximum allowable sulphur content of fuel oil;
② guidance on applicable fuel oil composition and fuel oil contaminants under operational conditions;
(8) Factors related to the deterioration rate of SCR performance, e.g. exchange condition for SCR catalyst blocks and recommended exchange time of SCR catalyst blocks:
① where a feedback or a feed forward reductant control strategy is incorporated with a NOx measurement device, this is acceptable as a means of monitoring catalyst condition/degradation. The exchange criteria of catalyst blocks against the reading of the NOx measurement device is to be specified by the applicant as well as the maintenance, service, and calibration requirements for the NOx measurement device;
② where a feed forward reductant control strategy is adopted without a NOx measurement device, the application is to provide the details of:

- the expected deterioration curve under expected operating conditions or the life of catalyst under expected operating conditions;
- factors which can influence catalyst NOx reduction efficiency; and
- guidance on how to assess catalyst NOx reduction efficiency based on periodical spot checks or monitoring as specified by the applicant, if applicable; records are to be kept for inspection during annual, intermediate and renewal surveys. The frequency of periodical spot checks is to be defined by the applicant considering the expected deterioration of the catalyst. The frequency for spot-checks should be at least after installation and once every 12 months; and

③ other strategies on monitoring the catalyst condition/degradation are subject to the approval.
(9) Controlling arrangements and settings of the SCR, e.g. model, specification of control device. This is to include, but not be limited to:
① the reductant injection control strategy which may be a feed forward reductant injection control or feedback reductant injection control strategy;
② instrumentation and sensors which are part of the SCR control arrangement, as applicable;
③ crew instructions for allowable adjustment of control parameters including details of how to prevent unauthorized alteration of the system configuration parameters, programmable logic controller (PLC) data, and central processing units (CPU) as applicable;
④ where a NOx measurement device is used, the following details should be included:

- type/model (identification number);
- calibration, zero and span check procedures and the periodicity of such checks, if applicable;
- calibration gases to be carried on board if applicable; and
- maintenance and/or exchange requirements.

⑤ where the engine system fitted with SCR has different operating modes (e.g. modes for Tier II and Tier III compliance separately), details of the control philosophy for selecting different modes of operation and recording the mode of operation together with means of changing between modes; and
⑥ auxiliary control devices, as mentioned in regulation 13.9 and defined in regulation 2.4 of MARPOL Annex VI, respectively, may be used on engine systems fitted with SCR, covering starting and stopping, low load operation and reversing operation, subject to the approval;
(10) Measures to minimize reductant slip. The maximum reductant slip may be specified by the applicant. Supporting information, including reductant injection rates under certain engine loads, the catalyst temperature or exhaust gas temperature when reductant injection occurs, etc. may be included in order to prevent reductant slip from exceeding the specified maximum level. Reductant slip monitoring in the exhaust duct downstream of the SCR or an equivalent means may be accepted as a means to minimize reductant slip. Alternatively, means of alleviating reductant slip (for example through the use of an ammonia slip catalyst or active catalyst thermal management) may be accepted as a means to minimize reductant slip;
(11) Parameter check method of SCR system (referring to Section 6.2 of the Guidelines)
(12) Other parameters specified by the applicant.
(13) Technical files for EIAPP certification of diesel engines fitted with SCR are also to include:
① information on Tier III family/group of diesel engines and information on member engine in family/group and its supporting SCR system;

② information on Tier II or Tier I family/group and information on member engine in family/group and its supporting SCR system.

6.2 SCR Parameter check method of SCR system

6.2.1 Parameter inspection method of SCR system mainly includes the following 4 aspects:
(1) Inspection of identification number of emission related components (see 6.2.2 of this Chapter);
(2) Load related reductant mass flow rate inspection (see 6.2.3 of this Chapter);
(3) NO_X measurement (periodical spot checks, see 6.2.4 of this Chapter);
(4) Parameter record sheet is used to record the change of emission related components and set value.

6.2.2 Component identification number of all emission related components is to be identified and the position of identification number on component is to be specified in technical files. Emission related parts and components of SCR system are:
(1) SCR chamber;
(2) Catalyst block;
(3) Mixing device;
(4) Reductant nozzle;
(5) NOx measurement device (control related);
(6) Software version of SCR control system.

6.2.3 Inspection of load related reductant mass flow rate mainly includes:
(1) Load related reductant mass flow rate of SCR system is to be monitored timely according to the requirements in Table 4.5.1.
(2) The reductant injection at each mode point is to be recorded regularly and compare it with that during pre-certification survey of diesel engine.
(3) The reductant filling volume, components and concentration onboard are to be recorded.
(4) The time and position of ECA-NO_X coming in and out from the ship are to be recorded.
(5) Total reductant consumption of SCR system is to be checked and recorded regularly and is to be compared with reductant filling volume.
(6) It is easy to determine whether the applicable purpose of NO_X limitation can be met through reductant consumption by providing judgment standard.
6.2.4 NO_X measurement, mainly including:
(1) periodical checks(at least once after installation and once every 12 months) or monitoring on NO_X concentration at downstream of SCR under each mode point.
(2) provision of the judgement standard which may facilitate the judgement of the consistency of SCR efficiency with that when the certificate is issued.

CHAPTER 7 PROCEDURES FOR APPROVAL AND CERTIFICATION OF DIESEL ENGINES FITTED WITH SCR SYSTEM

7.1 Special requirements for family/group

7.1.1 The family/group of diesel engines fitted with SCR system is to comply with the requirements of Chapter 4 of NTC 2008 and resolution MEPC.291(71).

7.1.2 For diesel engines fitted with SCR system, the basic characteristics, which may be shared among the diesel engines in the group, may be composed by space velocity, catalyst block geometry and catalyst material. Some basic characteristics and parameters specified by 4.3.8 (particularly 4.3.8.3 and 4.3.6.4) and 4.4.6.2 (excluding 4.6.2.1 'bore and stroke') of NTC 2008 may not be shared by diesel engines in the group (as per MEPC.1/Circ.865).

7.1.3 For diesel engines fitted with SCR system, the diesel engine with the highest NOx emission in the group/family is to be selected as the parent engine. If engines with the same level of NOx emission exist, the parent engine is the system with the highest raw NOx value emitted from the engine + SCR.

7.1.4 The parent engine for Tier II compliance is not necessarily the same parent engine for Tier III compliance.

7.1.5 Scheme B is only applicable to the concept of group, which means the concept of family is not applicable to Scheme B.

7.2 Procedures for approval and certification of Scheme A

7.2.1 Certification process of Scheme A is shown in Figure 7.2.1.

Figure 7.2.1 Certification process of Scheme A

7.2.2 The diesel + SCR test of Scheme A is to comply with the test requirements in Chapter 5 of NTC2008. Bypass system may not be installed during the test, but any effect to the fluid dynamics or reductant distribution caused by the absence of the by-pass arrangement is to be presented by the applicant.

7.2.3 For diesel engine + SCR test of Scheme A, ammonia slip at each mode point is not to exceed 10ppm in general and other recognized standards adopted by the applicant may also be accepted.

7.2.4 For diesel engine + SCR test bed of Scheme A, the distance between reductant injection position to SCR chamber is not to be greater than that required by the technical file, which means the arrangement of the distance is not to be looser than the actual arrangement onboard the ship.

7.2.5 The initial certification survey of diesel engines fitted with SCR system is to comply with the requirements of NTC2008 and resolution MEPC.291(71). Therefore, the information listed in Table 7.2.5 is at least to be submitted for EIAPP certification survey of Scheme A.

List of Information for EIAPP Certification of Scheme A Table 7.2.5

No.	Information submitted		Basis (regulation)		Remarks
			MEPC. 291(71)	NTC 2008	
1	Application of the concept of family or group		4	4	In the meantime, refer to Section 7.1 of the Guidelines
	1.1	Effective control of the consistency of product	——	4.3.7	
	1.2	Division of family/group	4	4.3.8/4.4.6	
	1.3	Guidance for selection of parent engine	4.2,4.3	4.3.9/4.4.8	
2	Test program		5	5	
3	Explanation for not installing the bypass pipes (if applicable)		5.1.2	——	When bypass pipes are not installed on

				test bed
4	Test report	5.2.2	5.10	
5	Technical files and onboard NOx checking procedures	3.1.3，3.2	6	Chapter 6 of the Guidelines

7.2.6 Before the diesel engine +SCR test of Scheme A, the contents of Table 7.6 are to be checked to confirm the consistency of SCR system with the technical file and plans and drawings.

7.3 Approval and certification procedures of Scheme B

7.3.1 The certification process of Scheme B is shown in Figure 7.3.1 and for detailed requirements, refer to resolution MEPC.291(71). The "Parameters of Diesel Engine (6.1.1.3&6.2)" used in the calculation as shown in the flow chart are to be the parameters of the parent engine of group.

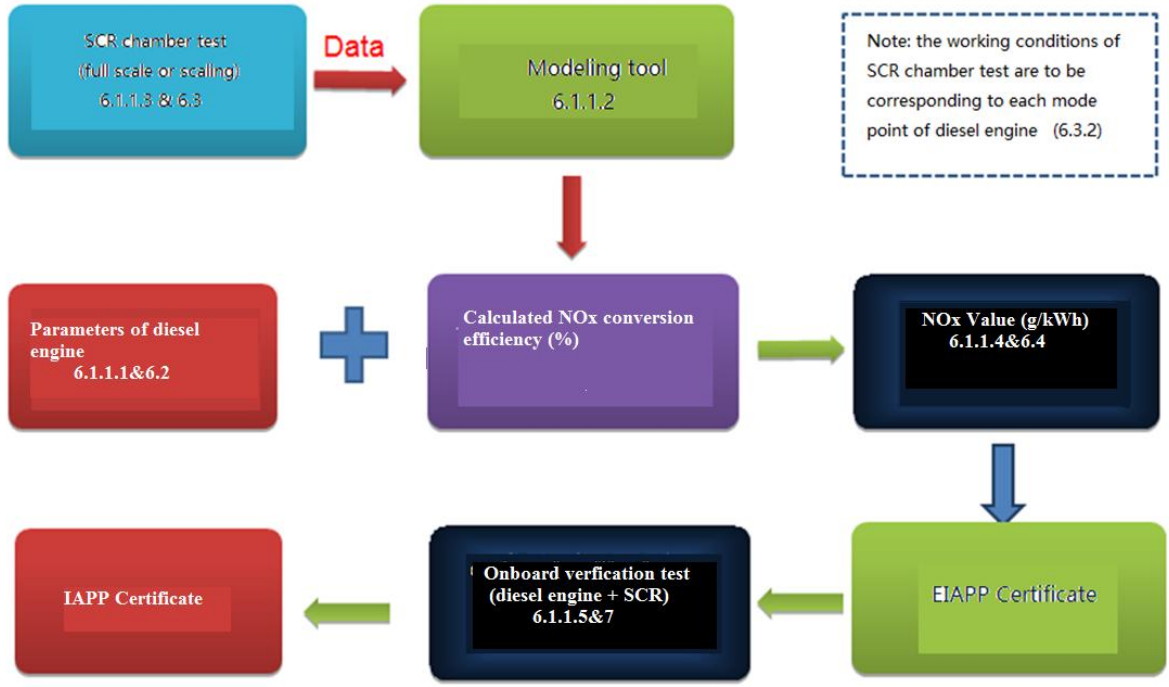

Figure 7.3.1 Certification Process of Scheme B (Note: the paragraphs in the Figure are those in MEPC.291(71))

7.3.2 If satisfactory confirmation is not achieved through theoretical analysis or calculation (considering the complexity of SCR chamber, such as air speed and homogeneity of reductant) for scaling procedure of SCR chamber test, verification test is to be carried out in the form of Scheme A. For process of verification test, refer to 5.5.7(3) of Chapter 5 of the Guidelines.

7.3.3 The initial certification survey of diesel engines fitted with SCR system is to comply with relevant requirements of NTC2008 and MEPC.291(71). Therefore, the information listed in Table 7.3.3 is at least to be submitted when applying for EIAPP certification survey of Scheme B.

List of EIAPP Certification information of Scheme B Table 7.3.3

No.	Information submitted	Basis (regulation)		Explanation
		MEPC. 291(71)	NTC 2008	
1	Application of the concept of group	4	4.4	In the meantime, refer to Section 7.1 of the Guidelines.
	1.1 Effective control of consistency of product	——	4.4.5	
	1.2 Division of group	4	4.4.6	
	1.3 Guidance on selection of parent engine	4.2,4.3	4.4.8	

2	Test plan of Scheme B	6	——	Including the specifications of test procedures listed in 6.1
3	Specifications of modeling tool	6.1	——	
4	Specifications of scaling procedures	6.3.1	——	
5	Scaling verification test report (if applicable)	6.3.1.2	——	
6	Scheme B test report	6.5	——	
	6.1 Raw engine emission data	6.2.2	——	
	6.2 SCR chamber test report	6.3.5	——	
	6.3 NOx emission calculation report	6.4.1	——	
7	Onboard confirmation of test program	3.1.3，7	——	7.3.4 of the Guidelines
8	Technical file and onboard NOx checking process	3.1.3，3.2	6	The onboard confirmation of test report is to be incorporated into the technical file

7.3.4 The initial onboard verification test is only required for parent engine in the group. If onboard verification tests are not carried out for parent engines or member engines with the same emission as that of the parent engines, onboard verification test is to be carried out for each diesel engine in the group.

7.4 EIAPP certificate

7.4.1 Certificate applicant

(1) EIAPP certificate applicant is the subject responsible for the compliance of emission by diesel engines fitted with SCR system. Information of applicant is to be indicated in EIAPP certificate.

(2) For EIAPP certification survey of Scheme B, the initial IAPP survey is deemed completed after a satisfactory initial onboard confirmation test report is provided. Therefore, the applicant is the responsible subject until the final approval of the system.

7.4.2 A piece of certificate and a technical file

(1) An EIAPP certificate will be issued to diesel engine complying with both Tier II and Tier III standards and a technical file including Tier II and Tier III information is to be approved,

7.4.3 Issuance and filling of certificate

(1) For diesel engine fitted with SCR system, the type and specifications of diesel engines (parent engine and member engines) in the family/group and the type and specifications of supporting SCR system will be listed in the NOx emission approval certificate in the form of attached page.

(2) If there is no change of the engine's existing Tier II family/group, relevant Tier II information is to be filled based on the existing approval.

(3) Tier III parent engine emission value.

① for diesel engine approved by Scheme A, the measured emission value is to be filled and indicated with Scheme A;

② for diesel engine approved by Scheme B, the calculated value is to be filled and indicated with Calculated Value in Scheme B.

7.5 Initial onboard confirmation test

7.5.1 For diesel engines fitted with SCR system, the initial onboard confirmation test is to be completed before the initial IAPP survey certificate is issued if the early certification survey is applied for with Scheme B.

7.5.2 The initial onboard confirmation test is to be carried out according to the 'onboard confirmation test program' mentioned in Table 7.3.3 of the Guidelines and the contents in Table 7.5.2 must be confirmed

during the test.

Initial Onboard Confirmation Test Items and Descriptions Table 7.5.2

No.	Item	Description
1	**Analytical instrument and standard gases**	
1.1	Specifications of analytical instrument	1) NOx analytical instrument. Chemiluminescent detector (CLD) or heated chemiluminescent detector (HCLD) is required. If HCLD is used, the sampled gas temperature is to be maintained from 55℃to 200℃. 2) Ammonia analytical instrument
1.2	Calibration of analytical instrument	1) Check the calibration records or calibration certificate in the recent three months
1.3	Standard gas	1) Check the qualification certificate of standard gas 2) Types of standard gases are complete so as to meet the calibration of analytical instrument
2	**Installation and arrangement of sampling probe**	
2.1	Position of sampling probe	1) Probe at the upper stream of SCR (NOx): Installed at the upper stream of all components of SCR system, normally the upper stream of mixer. 2) Probe at the lower stream of SCR (NOx and NH3) Distance of the diameter of at least 10 exhaust gas ducts at the lower stream of SCR, Distance of 0.5 m at the exit of exhaust system or diameters of 3 exhaust gas ducts (whichever is greater)
2.2	Sampling temperature	1) The exhaust gas temperature in way of sampling probe is normally to be over 190℃; if HC is not measured, the temperature is at least to be 70℃ 2) Heating and thermal protection treatment are to be carried out for sampling pipes.
3	**Preparation before the test**	
3.1	Pre-heating of analytical instrument	1) Generally not less than 2h or set according to the recommendation of manufacturer of the analytical instrument
3.2	Leakage test of sampling system	1) The probe is separated with the exhaust and the end was choked up; the sampling flow was zero after the analytical instrument was started
3.3	Zero and span values of analytical instrument	1) Before and after the test, the zero and span values are to be tested with standard gases 2) The difference between the zero and span responses results is less than 2% of the initial span gas concentration before and after the test
4	**Test requirements and acceptance index**	
4.1	Test mode point	1) Three mode points, 75%、50%、25% of the rated power (as close as possible) 2) NOx in way of the entry and exit of SCR system is measured after the working condition of engine is stabled, to be measured at least after the NOx measurement curve stables
4.2	Acceptance index	1) The conversion efficiency of NOx at each mode point is not to be lower than 5% of the conversion efficiency value in emission technical file Calculation of conversion efficiency $\eta=\frac{(C_{inlet}-C_{outlet})}{C_{inlet}}\times 100$ 2) The ammonia slip at each mode point is normally not to exceed 10 ppm or other recognized standards adopted by the applicant may be accepted 3) Reductant injection volume at each mode point. To compare with the reductant supply at each mode point in the emission technical file
5	**Records and reports**	
5.1	Data records	Check the field data records, which are to be maintained
5.2	Onboard confirmation test report	Check and sign the onboard verification test report

7.5.3 After the SCR system is installed onboard the ship, contents listed in Table 7.6 are to be checked to confirm the consistency of SCR system with the approved technical file and approval requirements.

7.6 SCR system check items and descriptions

7.6.1 For diesel engines fitted with SCR system, items listed in Table 7.6 are to be checked no matter for diesel engine + SCR test-bed testing of Scheme A or onboard verification test of Scheme B.

SCR system check imes and Descriptions **Table 7.6**

No.	Item	Description (confirmation of the consistency with technical file and approval requirements)
1	**SCR chamber**	
1.1	Main structure	Arrangement, sealing, vertical or horizontal type of observation hole
1.2	Internal arrangement	1) Structural size, element number of catalyst block and the arrangement in the chamber 2) To confirm the compliance of overall volume and space velocity (taking into account the calculation of exhaust gas volume in the file) of catalyst with the requirements of technical file
2	**Control strategy**	
2.1	Open-loop or close-loop	To be consistent with technical file
2.2	NOx monitoring	Whether the NOx monitoring device is installed
2.3	Key input signal	Source of control signal, such as rotate speed, power rate, accelerator.
2.4	Pressure difference protection	The value set for pressure difference alarm and suspension of operation
2.5	Beginning injection temperature control	Whether the working temperature window is consistent with the technical file
3	**Reductant supply**	
3.1	Reductant concentration	40% or 32.5%, whether consistent with the technical file
3.2	Redundancy of supply pump	Generally there are two pumps acting as mutual backup with each other or the spare part is provided
3.3	Arrangement of nozzles	Relative distance between injection position and SCR chamber (e.g.: minimum distance or position in front of the mixer)
3.4	Auxiliary air	Auxiliary air is provided to assist the atomization of reductant in the position of nozzles. To check whether the air pressure is consistent with the technical file
4	**Auxiliary equipment (applicable items are selected based on the provision of equipment)**	
4.1	Bypass pipe	Whether interlocked by bypass pipes and valves as required
4.2	Soot blower	Soot blowing pressure, blowing arrangement
4.3	Mixer	Arrangement of mixer
4.4	Exhaust gas heating device	Function confirmation
5	**IMO ID**	
5.1	SCR chamber	Identification No. and position
5.2	Catalyst block	Identification No. and position
5.3	Mixer	Identification No. and position
5.4	Reductant nozzle	Identification No. and position
5.5	NOx measurement device (control related)	Identification No. and position
5.6	Version of control software and CRV	To check through control system operation interface

APPENDIX 1 LIST OF BOUNDARY PARAMETERS FOR SCR SYSTEM FUNCTION

1. Catalyst		
Type		
Process (honeycomb, finned or other forms)		
Major material (vanadium-base or other)		
Visual number (CPSI of catalyst block)		
Manufacturer		
2. System parameter		
Maximum allowable pressure different before and behind the SCR chamber	kPa	
Applicable fuel oil quality and standard, and maximum sulphur content in fuel oil and corresponding beginning injection temperature of SCR system	% ℃	
Catalyst block replacement cycle	h	
Reductant concentration and specifications	%	
Minimum blowing pressure of soot blower	kPa	
Minimum reductant injection pressure	kPa	
Applicable maximum space velocity	1/h	
Applicable maximum surface velocity	m/h	
Applicable maximum linear velocity	m/h	
ANR application		

APPENDIX 2 VERIFICATION TEST DATA RECORD SHEETS

Mode		1	2	3	4	5	6	7	8
Power/Torque %									
Speed %									
Time at beginning of mode									
Environmental data									
Relative humidity %									
Ambient temperature °C									
Atmospheric pressure kPa									
Engine data									
Fuel mass flow kg/h									
Exhaust mass flow (q_{mew}) kg/h									
Charge air coolant temperature in °C									
Charge air temperature °C									
Charge air reference temperature °C									
Charge air pressure kPa									
SCR data									
Exhaust gas temperature SCR inlet °C									
Exhaust gas temperature SCR outlet °C									
Pressure SCR inlet kPa									
Pressure SCR outlet kPa									
Pressure drop over SCR (ΔP) kPa									
Reductant flow L/h									
Reductant inject pressure kPa									
Reductant concentration m/m %									
Soot blow pressure kPa									
Emission data									
SCR inlet	NO_X Concentration dry/wet ppm								
SCR outlet	NO_X Concentration dry/wet ppm								
	O_2 Concentration dry/wet %								
	CO Concentration dry/wet ppm								
	CO_2 Concentration dry/wet %								
	HC Concentration dry/wet ppm								
	NH_3 slip concentration ppm								