RULES

PUBLICATION 98/P

GUIDELINES REGARDING THE REQUIREMENTS FOR MARINE DIESEL ENGINES FITTED WITH NO_X SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEMES

July
2022

Publications P (Additional Rule Requirements) issued by Polski Rejestr Statków complete or extend the Rules and are mandatory where applicable.

GDAŃSK

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1 INTRODUCTION

1.1 The present *Publication* is based on the requirements of *Resolution MEPC.291(71)* adopted on 7 July 2017 as amended by MEPC.313 (74) adopted on 17 May 2019. Additionally, in Appendix the requirements for the storage and use of reductants for selective catalytic reduction (SCR) have been specified in accordance with IACS UR M77.

1.2 The use of NO_X-reducing devices is envisaged in *Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines, 2008* (*NO_X Technical Code, 2008)* as given in section 2.2.5 and a Selective Catalytic Reduction (SCR) system is one of such devices.

1.3 *NO_X Technical Code, 2008* contains two ways for pre-certification of engine systems fitted with NO_x-reducing devices:

.1 engine fitted with SCR: approval in accordance with paragraph 2.2.5.1 and test in accordance with chapter 5 of the *NO_X Technical Code, 2008:*

„Where a NO_X-reducing device is to be included within the EIAPP certification, it must be recognized as a component of the engine and its presence shall be recorded in the engine Technical File. The engine shall be tested, at the pre-certification test, with the NO_X-reducing device fitted…" [1)]

The tests shall be carried out in accordance with Chapter 5 of the *NO_X Technical Code, 2008*; and

.2 the simplified measurement method in accordance with section 6.3 of the *NO_X Technical Code, 2008* as regulated in paragraph 2.2.5.2 of the *NO_X Technical Code:*

„In those cases where a NO_X-reducing device has been fitted due to failure to meet the required emission value at the pre-certification test, in order to receive an EIAPP Certificate for this assembly, the engine, including the reducing device, as installed, must be re-tested to show compliance with the applicable NO_X emission limit. However, in this case, the assembly may be re-tested in accordance with simplified measurement method in accordance 6.3. In no case shall the allowances given in 6.3.11 be granted."

1.4 According to paragraph 2.2.5.1 of the *NO_X Technical Code, 2008,* where a NO_X-reducing device is to be included within the EIAPP certification, it must be recognized as a component of the engine, and its presence shall be recorded in the engine's Technical File.

2 GENERAL

2.1 Purpose

The purpose of the present *Publication* is to provide guidance in addition to the requirements of the *NO_X Technical Code, 2008,* for design, testing, surveys and certification of marine diesel engines fitted with SCR system to ensure their compliance with the requirements of regulation 13 of *MARPOL Annex VI.*

2.2 Application

The present guidelines apply to marine diesel engines fitted with SCR for compliance with regulation 13 of *MARPOL Annex VI.*

[1)] With effect from 1 August 2013, the paragraphs 2.2.4 and 2.2.5.1 of the *NO_X Technical Code, 2008* have been amended by Resolution MEPC.217(63).

2.3 Definitions

Unless provided otherwise, the terms used in the present *Publication* have the same meaning as the terms defined in regulation 2 of *MARPOL Annex VI* and in section 1.3 of the *NO_X Technical Code, 2008.*

A gas fuelled engine installed on a ship constructed on or after 1 March 2016 or a gas fuelled additional or non-identical replacement engine installed on or after that date is also considered as a marine diesel engine.[1)]

Engine system fitted with SCR – a system consisting of a marine diesel engine, a SCR chamber and a reductant injection system. When a control device on NO_X reducing performance is provided, it is also regarded as a part of the system.

Catalyst block – a block of certain dimensions through which exhaust gas passes and which contains catalyst composition on its inside surface to reduce NO_X from exhaust gas.

Catalyst block casing or frame – a casing or frame of an assembly (module) of several catalyst blocks.

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

Reductant injection system – 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.

NO_X (η) reduction rate, [%] – a value derived from the following formula:

$$\eta = 100\ (c_{inlet} - c_{outlet})\ /\ c_{inlet}$$

where:

c_{inlet} – NO_X concentration as measured at the inlet of the SCR chamber, [ppm];

c_{outlet} – NO_X concentration as measured at the outlet of the SCR chamber, [ppm].

Area velocity (*AV*), [m/h] – a value of the exhaust gas flow rate passing through the catalyst block(s) [m^3/h] per total active surface area of the catalyst blocks in the SCR chamber [m^2]. The exhaust gas flow volume is the volume defined at 0°C and 101.3 kPa.

Linear velo city (*LV*), [m/h] – 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. The exhaust gas flow volume is the volume defined at 0°C and 101.3 kPa.

Block section, [m^2] – the cross-sectional area of the catalyst block based on the outer dimensions.

Space velocity (*SV*), [1/h] – 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]. The exhaust gas flow is the volume defined at 0°C and 101.3 kPa.

Total volume of catalyst block, [m^3] – the volume based on outer dimensions of the catalyst block.

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1) With effect from 1 September 2017, the paragraphs 1.3.10 of the *NO_X Technical Code*, *2008* have been amended by Resolution MEPC.272(69).

3 PRE-CERTIFICATION PROCEDURE FOR ENGINES FITTED WITH SCR SYSTEM

3.1 General

.1 Engine systems fitted with SCR shall be certified in accordance with Chapter 2 of the NO_X Technical *Code, 2008*. The procedures provided by Scheme A or Scheme B of these Guidelines should be applied.

.2 The applicant for certification should be the entity responsible for the complete engine system fitted with SCR.

.3 The applicant shall supply all necessary documentation, including the *Technical File* for the complete system, a description of the required on board NO_X verification procedures and, where applicable, the description of the confirmation test procedure (NO_X limits should be met).

3.2 Technical File and On Board NOX Verification Procedures

In addition to the information given in 3.1.3 of these guidelines and the items in section 2.4 of the *NO_X Technical Code, 2008*, engine systems fitted with SCR shall include the following information in the engine *Technical File:*

.1 reductant: component/type and concentration;

.2 reductant injection system including critical dimensions and supply volume;

.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, where applicable;
2) minimum distance between reductant injection point(s) and SGR chamber;
3) position of reductant injection equipment within duct and the direction of reductant injection, e.g. counter flow or parallel flow;
4) reductant mixing arrangements;
5) reductant lances, nozzles, atomizing arrangement;
6) inlet plenum design, top entry or bottom entry;
7) where an SCR by-pass arrangement is stipulated by the applicant, the control specifications, identification of the by-pass valve and its control device; and
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 NO_X 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; and
7) any baffle plates or other devices installed within the SGR 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: allowable pressure loss (Δp) between inlet and outlet of the SCR chamber and in the exhaust duct caused by SCR system 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 NO_X emission limit to assure continued NO_X reduction may include, but not limited to:
1) the maximum allowable sulphur content of fuel oil which can be combusted, while maintaining compliance; and
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 NO_X 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 NO_X measurement device;
2) where a feed forward reductant control strategy is adopted without a NO_X 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 NO_X reduction efficiency; and
   – guidance on how to assess catalyst NO_X 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 of the Administration;
   Notice: Interpretations to par.3.2.8 is given in MPC 112 (Rev.1 Nov.2019)

.9 controlling arrangements and settings of the SCR, e.g. model, specification of control device. This is to include, but not 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 NO_X 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;
   - 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
5) 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 of the Administration;

.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 as the verification procedure: with regard to the application of the parameter check method, the requirements given in 2.3.6 and guidance given in paragraph 2 of appendix VII shall be taken into account in assessing the adequacy of a proposed procedure with analysers meeting or exceeding the requirements of *Appendix III* of the *NO_X Technical Code, 2008;* and

Notice: Interpretations to par. 3.2.11 are given in MPC 115 (Corr.1 May 2020).

.12 any other parameter(s) specified by the applicant.

Notice: Interpretations to par. 3.2.12 are given in MPC 116 (Rev.1 Nov.2019).

3.3 Measures to Minimize Reductant Slip

When SCR uses urea solution, ammonia solution or ammonia gas as reductant, measures to prevent reductant slip shall be provided to avoid the supply of an excessive amount of reductant in the system. The reductant injection system shall be designed to prevent emissions of any harmful substance from the system.

3.4 Pre-certification Procedure for an Engine System Fitted with SCR

Tests and pre-certification of an engine system fitted with SCR shall be conducted either by *Scheme A* (as given in Chapter 5 of these guidelines) or by *Scheme B* (as given in Chapters 6 and 7 of these guidelines), as appropriate.

In cases, when engines which, due to their size, construction and delivery schedule, cannot be pre-certified on a test-bed the engine manufacturer, shipowner or shipbuilder shall make application to the Administration requesting an onboard test (see 2.1.2.2, *NO_X Technical Code, 2008*). The applicant must demonstrate to the Administration that the onboard test fully meets all of the requirements of a test-bed procedure as specified in chapter 5 of *NO_X Technical Code, 2008*. In no case shall an allowance be granted for possible deviations of measurements if an initial survey is carried out on board a ship without any valid pre-certification test. For engines undergoing an onboard certification test, in order to be issued with an Engine International Air Pollution Prevention (EIAPP) Certificate, the same procedures apply as if the engine had been pre-certified on a test-bed, subject to the limitations given in paragraph 2.2.4.2 of *NO_X Technical Code, 2008*.

Engines undergoing an onboard certification test should have a preliminary approved *Technical File*, pending the results of the emission test.

If the result of the emission test does not comply with the applicable NOX regulation, the engines should be re-adjusted to the compliance condition originally approved, if any, or the applicant should apply to the flag Administration for acceptance of further testing.

3.5 EIAPP Certificate

An *Engine International Air Pollution Prevention (EIAPP) Certificate* for NO_X emission (see *Appendix I* to the *NO_X Technical Code, 2008*) should be issued by the Administration after approval of the *Technical File*.

When an applicant chooses the *Scheme B* for pre-certification, the *International Air Pollution Prevention (IAPP) Certificate* initial survey should be not be completed until on board initial confirmation test provides compliant results. The applicant remains the responsible entity until the final acceptance of the system.

When the engine is to be certified to both Tier II and Tier III, the EIAPP Certificate should be completed for both Tier II and Tier III with a single Technical File covering both Tier modes.

4 FAMILY AND GROUP CONCEPTS FOR ENGINE SYSTEMS FITTED WITH SCR

The requirements specified in Chapter 4 *Approval for serially manufactured engines: engine family and engine group concept* of the *NO_X Technical Code, 2008* apply equally to engine systems fitted with SCR – *see MEPC.1/Circ.895*.

For engines fitted with an SCR system to reduce NO_X emissions, it is recognized that some of the parameters provided may not be common to all engines within a group, in particular paragraphs of Chapter 5 of the *NO_X Technical Code, 2008* it is state that:

.1 individual cylinder displacement to be within a total spread of 15%

.2 number of cylinders and cylinder configuration applicable in certain cases only, e.g. in combination with exhaust gas cleaning devices.

When bore and stroke dimensions should remain common to all engines within the group, the parameters listed below may be replaced by alternative SCR parameters, provided that the applicant is able to demonstrate that these alternative parameters are suitable for defining the engine group.

.1 method and design features of pressure charging and exhaust gas system:

- constant pressure;
- pulsating system;

.2 method of charge air cooling system:
- with/without charge air cooler

.3 design features of the combustion chamber that affect NO_X emission;

.4 design features of the fuel injection system, plunger and injection cam that may profile basic characteristics that affect NO_X emission; and

.5 rated power at rated speed. The permitted ranges of engine power (kW/cylinder) and/or rated speed are to be declared by the manufacturer and approved by the Administration

For engines fitted with an SCR system to reduce NO_X emissions, the number and arrangement of cylinders may not be common to all members of the engine group. These parameters may be replaced with new parameters derived from the SCR chamber and catalyst blocks, such as the SCR space velocity (SV), catalyst block geometry and catalyst material.

The applicant remains responsible for selecting the parent engine and demonstrating the basis of this selection to the satisfaction of the Administration.

5 TEST PROCEDURES FOR ENGINES FITTED WITH SCR IN SCHEME A

5.1 General

Tests of a combined system of an engine fitted with SCR in *Scheme A* shall ensure compliance with the applicable NO_X emission limits of *MARPOL Annex VI*. The test bed measurement procedures of Chapter 5 of the *NO_X Technical Code, 2008* shall apply.

Notwithstanding the above provision, the applicant may choose to test the combined system of an engine fitted with an SCR with a by-pass arrangement without that by-pass installed for the purpose of test bed measurement. 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.

5.2 Calculation of Gaseous Emission

5.2.1 The calculation method, presented in section 5.12 of the *NO_X Technical Code, 2008*, is also applicable to engine systems fitted with SCR. No allowance is made for the reductant solution injected into the exhaust gas stream in respect of its effect on exhaust gas mass flow rate calculation (*Appendix VI*) or dry/wet correction factor (equation (11), paragraph 5.12.3.2.2 of the *NO_X Technical Code, 2008).* The NO_X correction factors for humidity and temperature (equations (16) or (17), paragraphs 5.12.4.5 and 5.12.4.6, respectively, of the *NO_X Technical Code, 2008*) should not be applied.

Note:
The calculation method presented in subchapter 5.12 of *NO_X Technical Code* applies to both certification methods A and B for engines with fitted SCR system.

5.2.2 For an engine system fitted with SCR, the following parameters shall be measured and recorded in the engine test report in accordance with 5.10 of the *NO_X Technical Code, 2008:*

.1 injection rate of reductant at each load point, [kg/h];

.2 exhaust gas temperature at the inlet and outlet of the SCR chamber, [°C];

.3 pressure loss, [kPa]: it is necessary to measure the pressure at inlet and at outlet of the SCR chamber and to calculate pressure loss (Δp). It would also be permissible to measure the pressure loss (Δp) of the SCR chamber with a differential pressure sensor. The allowable Δp limit shall be confirmed; and

.4 other parameter(s) as specified by PRS.

5.3 Test report

For every Individual Engine or Parent Engine tested to establish an Engine Family or Engine Group, the engine manufacturer shall prepare a test report which shall contain the necessary data to fully define the engine performance and enable calculation of the gaseous emissions including the data as set out in section 1 of appendix 5 of *NO_X Technical Code, 2008*. The original of the test report shall be maintained on file with the engine manufacturer and a certified true copy shall be maintained on file by the Administration.

The "necessary data to fully define the engine performance and enable calculation of the gaseous emissions" should be incorporated, in accordance with 5.12 of *NO_X Technical Code, 2008*, from the raw data units to the cycle weighted NO_X emission value in g/kWh. The data set given under appendix 5 of *NO_X Technical Code, 2008*. should not be considered definitive and any other test data (i.e. engine performance or setting data, description of control devices) relevant to the approval of a specific engine design and/or on-board NO_X verification procedures should also be given. For the engine fitted with SCR, under scheme A, the parameters listed in sub-paragraphs of paragraph 5.2.2 of IMO resolution MEPC. 291(71) should be measured and recorded in the engine test report. Under scheme B, the exhaust gas temperature at the intended inlet of the SCR chamber should be determined and recorded in the test report. For dual fuel engines, the ratio of liquid-to-gas, gas fuel temperature and its measurement point position should be recorded during the testing.

With reference to appendix 5 of *NO_X Technical Code, 2008*. it should be further interpreted that:

.1 the term "Deviation" as given under "Sheet 3/5, Measurement equipment, Calibration" refers to the deviation of the analyser calibration and not the deviation of the span gas concentration; and

.2 the "Fuel properties" as given under "Sheet 3/5, Fuel Characteristics, Fuel properties" should, include sufficient data to justify the ISO 8217:2017 grade (i.e. DMA, DMB, etc.) as given on EIAPP Certificate Supplement 1.9.4 by considering other additional analysis results for the fuel oil characteristics, i.e. Cetane index (ISO 4264:2018), carbon residue (ISO 10370:2014).

6 TEST PROCEDURES FOR ENGINES FITTED WITH SCR IN SCHEME B

6.1 General

Tests of a combined system of an engine fitted with SCR in *Scheme B* shall ensure that the system complies with the applicable NO_X emission limits of *MARPOL Annex VI*. The test procedures in *Scheme B* are as follows:

.1 an engine shall be tested to obtain the NO_X emission value, [g/kWh], in accordance with 6.2.1 of these guidelines;

.2 the SCR NO_X reduction rate may be calculated by modelling tools, taking into account geometrical reference conditions, chemical NO_X, conversion models, as well as other parameters to be considered;

.3 for every type of catalytic element, an SCR chamber, not necessarily to full-scale, shall be tested in accordance with 6.3 of these guidelines in order to generate data for the calculation model as that used in 6.1.2 of these guidelines;

.4 the NO_X emission from the engine system fitted with SCR shall be calculated in accordance with 6.4 of these guidelines using the NOX emission value from the engine and the NO_X reduction rate of SCR chamber. The *Technical File* shall be completed and the NO_X emission value entered into the Supplement to EIAPP Certificate; and

.5 the NO_X emission performance of the engine combined with the SCR shall be verified by a confirmation test in accordance with the procedure specified in 7.5 of these guidelines.

Note: The calculation of gaseous emissions in 6.1.1 should be undertaken in accordance with 5.2.1.

6.2 Verification Test Procedures for an Engine

6.2.1 The purpose of the tests of an engine is to establish the emission values for use in 6.4 of these guidelines. The measurements shall be in accordance with Chapter 5 of the *NO_X Technical Code, 2008.*

6.2.2 Paragraph 5.9.8.1 of the *NO_X Technical Code, 2008* requires engine conditions to be measured at each mode point only after the engine has been stabilized. This equally applies in the case of an engine fitted with SCR. Additionally, exhaust gas temperature at the intended inlet of the SCR chamber should be determined and recorded in the test report as required by section 5.10 of the *NO_X Technical Code, 2008.*

6.3 Test Procedures for SCR Chambers

6.3.1 General

The SCR chamber for validation testing may be either a full-scale SCR chamber or a scaled version. A SCR chamber shall demonstrate the reduction in NO_X concentrations [ppm] expected in exhaust gas measured in 6.2 of these guidelines. Therefore, NO_X reduction rate of the SCR chamber shall be determined for each individual mode point. Where undertaken on a scaled version of the SCR chamber, the scaling process shall be approved by PRS.

The scaling process is to correspond with the modelling tool of 6.1.1.2 of these guidelines, and take into account geometrical reference conditions, and chemical NO_X conversion modes, and other parameters which have influence on NO_X conversion rate in the modelling tool. If the scaling process could not be validated satisfactorily by theoretical analysis or calculations taking into consideration the complex conditions in the SCR chamber, such as uniformity of gas speed, reductant, a combined engine and SCR system validation test in accordance with Scheme A shall be undertaken.

The modelling tool of 6.1.1.2 of these guidelines is acceptable for use in other engine groups which operate within the same defined boundary conditions.

6.3.2 Test Conditions at Each Mode Point

Exhaust gas, catalyst, reductant and an injection system shall satisfy the following conditions at each mode point:

.1 Exhaust gas flow

Exhaust gas flow rate for the test shall be scaled accordingly to account for the dimensions of the catalyst model.

.2 Exhaust gas component

Exhaust gas for the test should either be diesel engine exhaust gas or simulated gas. Where diesel exhaust gas is used, it shall correspond, with regard to concentrations, to the exhaust gas as specified in 6.2 of these guidelines in terms of NO_X, O_2, CO_2, H_2O and SO_2 (±5% of the required concentration for each emission species).

Where simulated gas is used, it shall correspond, with regard to concentrations, to the exhaust gas as specified in 6.2 of these guidelines in terms of NO, NO_2, O_2, CO_2, H_2O and SO_2 (±5% of the required concentration for each emission species) balance N_2.

An exemption for one or more of the above-mentioned gas species concentrations requirements may be allowed subject to a demonstration test showing that the gas or gases do not affect the NOx reduction rate by more than 2%.

.3 Exhaust gas temperature

The temperature of exhaust gas used for the test shall correspond to the temperature obtained from testing according to 6.2 of these guidelines, ensuring that the SCR chamber is activated at every load point, other than as provided for by 3.1.4 of the *NO_X Technical Code, 2008* and that no ammonia bisulphate formation or reductant destruction takes place.

.4 Catalyst blocks and AV, SV value

The catalyst blocks used in the test shall be representative of the catalyst blocks to be used in the SCR chamber in service. *AV*, *SV* or *LV* value shall, in the case of full-scale tests, be within – 5% or above of the required value as obtained in testing according to 6.2 of these guidelines. In the case of scaled test, it shall correspond to the above.

.5 Reductant

The reductant concentration on the surface of the tested catalyst shall be representative of the reductant concentration on the surface of the catalyst during actual engine operation. Ammonia gas may be used as a reductant for the SCR chamber test, provided that it results in an equivalent concentration on the catalyst surface.

6.3.3 Stability for Measurement

All measurements shall be recorded after they have stabilized.

6.3.4 List of Data to be Derived from the Model

.1 Operating data, to be given in the Technical File shall be derived from the modelling process or otherwise justified.

.2 Exhaust gas analysers shall be in accordance with *Appendix III and Appendix IV* of the *NO_X Technical Code, 2008* or otherwise to the satisfaction of PRS.

6.3.5 Test Report for SCR Chamber

Data recorded in accordance with 6.3.1 of these guidelines shall be entered into test report as required in section 5.10 of the *NO_X Technical Code, 2008* and 5.3 of these Rules.

6.4 Calculation of the Specific Emission

6.4.1 The NO_X emission value of the engine system fitted with SCR shall be calculated as follows:

$$gas_x = \frac{\sum_{i=1}^{i=n} \left((100 - \eta_i)/100 \right) \cdot q_{mgas\ i} \cdot W_{F\,i}}{\sum_{i=1}^{i=n} \left(P_i \cdot W_{F\,i} \right)} \qquad (6.4.1\text{-}1)$$

where:

η_i – NO_X reduction rate derived in accordance with 6.3 of these guidelines, [%];
$q_{mgas\,i}$ – mass flow of NO_X gas measured in accordance with 6.2 of these guidelines;

W_{Fi} – weighting factor;
P_i – measured power at individual mode points in accordance with 6.2 of these guidelines, [kW].

The weighting factors and the number of modes used in the above calculation shall be according to the provisions of section 3.2 of the *NO_X Technical Code, 2008.*

6.4.2 The NO_X emission value [g/kWh] calculated in accordance with 6.4.1 of these guidelines, shall be compared to the applicable emission limit. The emission value is entered into item 1.9.6 of the *Supplement* to the *EIAPP Certificate* (*Appendix I* of the *NO_X Technical Code, 2008).*

6.5 Test Report

The test report, referred to in paragraphs 6.2.2 and 6.3.5 of these guidelines, together with the data given in 6.4 of these guidelines, shall be consolidated into the overall documentation to be submitted to PRS for approval.

7 ON BOARD CONFIRMATION TEST FOR SCHEME B

7.1 After installation on board of an engine fitted with SCR and before entry into service, an initial confirmation test shall be performed on board (NO_X limits should be met).

7.2 The engine system fitted with SCR shall be verified as corresponding to the description given in the *Technical File*.

7.3 The confirmation test shall be conducted, as far as practicable, for 25%, 50% and 75% of rated power, independent of test cycle.

7.4 At each mode point of the confirmation test, the operating values as given in the *Technical File* shall be verified.

7.5 NO_X emission concentrations shall be measured at the inlet and outlet of the SCR chamber. The NO_X reduction rate shall be calculated. Both values should be measured for either dry or wet conditions. The value obtained for NO_X reduction rate shall be compared to the initial confirmation test required value at each mode point as given in the *Technical File*. Reduction efficiency values obtained at each of the test points shall be not less than the corresponding values given in the *Technical File* by more than 5%.

7.6 The NO_X analyzer shall comply with the requirements specified in Chapter 5 of the *NO_X Technical Code, 2008.*

7.7 When an engine system fitted with SCR is in a group defined in Chapter 4 of the present *Publication,* the confirmation test shall be conducted only for the parent engine system of the group.

Where the parent engine system of the group is not the first one to complete the onboard confirmation test as required by Chapter 7 of these guidelines, the onboard confirmation test is to be done for all installed engine systems within the engine group unless it is an identical NO_X specification member engine or the parent engine system has been installed and tested successfully. Where the parent engine system is not available to be installed on board, the first installed member engine system of the engine group can be chosen and adjusted to the worst case NO_X emission for confirmation test on board instead. The test results shall be verified as described in the *Technical File*.

Appendix

Storage and use of SCR reductants

1 General

The *NO_X Technical Code*, in 2.2.5 and elsewhere, provides for the use of NO_X Reducing Devices of which Selective Catalytic Reduction (SCR) is one option. SCR requires the use of a reductant which may be a urea/water solution or, in exceptional cases, aqueous ammonia or even anhydrous ammonia. These requirements apply to the arrangements for the storage and use of SCR reductants which are typically carried on board in bulk quantities.

2 Reductant using urea based ammonia (e.g. 40%/60% urea/water solution)

2.1 Where urea based ammonia (e.g. AUS 40 – aqueous urea solution specified in ISO 18611-1:2014) is introduced, the storage tank shall be arranged so that any leakage will be contained and prevented from making contact with heated surfaces. All pipes or other tank penetrations shall be provided with manual closing valves attached to the tank. Tank and piping arrangements shall be approved by PRS.

2.2 The storage tank may be located within the engine room.

2.3 The storage tank shall be protected from excessively high or low temperatures applicable to the particular concentration of the solution. Depending on the operational area of the ship, this may necessitate the fitting of heating and/or cooling systems. The physical conditions recommended by applicable recognized standards (such as ISO 18611-3:2014) shall be taken into account to ensure that the contents of the aqueous urea tank are maintained to avoid any impairment of the urea solution during storage.

2.4 If a urea storage tank is installed in a closed compartment, the area shall 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 shall 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.

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

2.5 Each urea storage tank shall be provided with temperature and level monitoring arrangements. High and low level alarms together with high and low temperature alarms shall also be provided.

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

- These tanks may be designed and constructed as integral part of the hull, (e.g. double bottom, wing tanks).
- These tanks shall be coated with appropriate anti-corrosion coating and cannot be located adjacent to any fuel oil and fresh water tank.
- These tanks shall be designed and constructed as per the structural requirements applicable to hull and primary support members for a deep tank construction.
- These tanks shall be included in the ship's stability calculation.

2.7 The requirements specified in 2.4 also apply to closed compartments normally entered by persons:

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

2.8 The reductant piping and venting systems shall be independent of other ship service piping and/or systems. Reductant piping systems shall not be located in accommodation, service spaces, or control stations. The vent pipes of the storage tank shall terminate in a safe location on the weather deck and the tank venting system shall be arranged to prevent entrance of water into the urea tank.

2.9 Reductant tanks are to be of steel or other equivalent material[2] 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. Reductant tanks and pipes/piping systems are to be made with a material compatible with reductant or coated with appropriate anti-corrosion coating.

2.10 For the protection of crew members, the ship shall have on board suitable personnel protective equipment. Eyewash shall be provided, the location and number of these eyewash stations and safety showers shall be derived from the detailed installation arrangements.

2.11 Urea storage tanks shall be arranged so that they can be emptied of urea, and ventilated by means of portable or permanent systems.

3 Reductant using aqueous ammonia (28% or less concentration of ammonia)

Aqueous ammonia shall not be used as a reductant in a SCR except where it can be demonstrated that it is not practicable to use a urea based reductant. Where an application is made to use aqueous ammonia as the reductant then the arrangements for its loading, carriage and use shall be derived from a risk based analysis.

4 Reductant using anhydrous ammonia (99.5% or greater concentration of ammonia by weight)

Anhydrous ammonia shall not be used as a reductant in a SCR except where it can be demonstrated that it is not practicable to use a urea based reductant and where the Flag State Administration agrees to its use. Where it is not practicable to use a urea reductant then it is also to be demonstrated that it is not practicable to use aqueous ammonia. Where an application is made to use anhydrous ammonia as the reductant then the arrangements for its loading, carriage and use are to be derived from a risk based analysis.

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[2] Material requirement "to be of steel or other equivalent material with a melting point above 925 degrees C" is not applicable for integral tanks on FRP vessels such as those listed below, provided that the integral tanks are coated and/or insulated with a self-extinguishing material.

1) FRP vessels complying with Regulation 17 of SOLAS Chapter II-2 based upon its associated IMO guidelines (MSC.1/Circ.1574), and
2) FRP vessels exempted from the application of SOLAS e.g., yachts, fast patrol, navy vessels, etc., generally of less than 500 gross tonnage, subject to yacht codes or flag regulations.

List of amendments effective as of 1 July 2022

Item	*Title/Subject*	*Source*
3.4	Pre-certification Procedure for an Engine System Fitted with SCR	MEPC.1/Circ.895
5.3	Test Report	MEPC.1/Circ.895
6.3.5	Test Report for SCR Chamber	MEPC.1/Circ.895
Appendix 2.1, 2.3	Date of ISO standards' added	IACS UR M77 Rev.2
Appendix 2.9	Footnote added	IACS UR M77 Rev.3