

RESOLUTION MEPC.198(62)

Adopted on 15 July 2011

2011 GUIDELINES ADDRESSING ADDITIONAL ASPECTS TO THE NO<sub>x</sub> TECHNICAL  
CODE 2008 WITH REGARD TO PARTICULAR REQUIREMENTS RELATED TO MARINE  
DIESEL ENGINES FITTED WITH SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEMS

## ANNEX 6

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#### **2011 GUIDELINES ADDRESSING ADDITIONAL ASPECTS TO THE NO<sub>x</sub> TECHNICAL CODE 2008 WITH REGARD TO PARTICULAR REQUIREMENTS RELATED TO MARINE DIESEL ENGINES FITTED WITH SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEMS**

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

RECALLING Article 38(a) of the Convention on the International Maritime Organization concerning the functions of the Marine Environment Protection Committee (the Committee) conferred upon it by international conventions for the prevention and control of marine pollution,

RECALLING ALSO that, at its fifty-eighth session, the Committee adopted, by resolution MEPC.176(58), a revised MARPOL Annex VI (hereinafter referred to as "MARPOL Annex VI") and, by resolution MEPC.177(58), a revised Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines (hereinafter referred to as "the NO<sub>x</sub> Technical Code 2008"),

NOTING regulation 13 of MARPOL Annex VI which makes the NO<sub>x</sub> Technical Code 2008 mandatory under that Annex,

NOTING ALSO that the use of NO<sub>x</sub>-reducing devices is envisaged in the NO<sub>x</sub> Technical Code 2008 and that selective catalytic reduction systems (hereinafter referred to as "SCR systems") are such NO<sub>x</sub>-reducing devices for compliance with the Tier III NO<sub>x</sub> limit,

HAVING CONSIDERED, at its sixty-second session, the guidelines addressing additional aspects to the NO<sub>x</sub> Technical Code 2008 with regard to particular requirements related to marine diesel engines fitted with SCR systems, developed by the Sub-Committee on Bulk Liquids and Gases at its fifteenth session,

1. ADOPTS the 2011 Guidelines addressing additional aspects to the NO<sub>x</sub> Technical Code 2008 with regard to particular requirements related to marine diesel engines fitted with Selective Catalytic Reduction (SCR) Systems, as set out at annex to the present resolution;
2. INVITES Administrations to take the annexed Guidelines into account when certifying engines fitted with SCR systems;
3. REQUESTS Parties to MARPOL Annex VI and other Member Governments to bring the annexed Guidelines related to the NO<sub>x</sub> Technical Code to the attention of shipowners, ship operators, shipbuilders, marine diesel engine manufacturers, and any other interested groups; and
4. AGREES to keep these Guidelines under review in light of the experience gained.

## ANNEX

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## **1 INTRODUCTION**

1.1 The use of NO<sub>x</sub>-reducing devices is envisaged in the NO<sub>x</sub> Technical Code 2008 (NTC 2008) as given in section 2.2.5 and a Selective Catalytic Reduction (SCR) system is one of such devices.

1.2 NTC 2008 contains two ways for pre-certification of engine systems fitted with NO<sub>x</sub>-reducing devices:

- .1 engine fitted with SCR: Approval in accordance with paragraph 2.2.5.1 of the NTC 2008. Test according to chapter 5 of the NTC 2008; and
- .2 the simplified measurement method in accordance with section 6.3 of the NTC 2008 as regulated in paragraph 2.2.5.2 (Primary failure case) of the NTC 2008.

1.3 According to paragraph 2.2.5.1 of the NTC 2008 the engine system fitted with SCR should be tested on a test bed (Scheme A). Where that is not appropriate, given reasons as outlined under paragraph 3.1.1 of these guidelines; the provisions of Scheme B as set out in these guidelines should be applied.

1.4 Administrations are invited to take these guidelines into account when certifying engines fitted with SCR.

## **2 GENERAL**

### **2.1 Purpose**

2.1.1 The purpose of these guidelines is to provide guidance in addition to the requirements of the NTC 2008 for design, testing, surveys and certification of marine diesel engines fitted with an SCR system to ensure its compliance with the requirements of regulation 13 of MARPOL Annex VI.

### **2.2 Application**

2.2.1 These guidelines apply to marine diesel engines fitted with SCR for compliance with regulation 13 of MARPOL Annex VI.

### **2.3 Definitions**

2.3.1 Unless provided otherwise, the terms in these guidelines have the same meaning as the terms defined in regulation 2 of MARPOL Annex VI and in section 1.3 of the NTC 2008.

2.3.2 "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 NO<sub>x</sub>-reducing performance is provided, it is also regarded as a part of the system.

2.3.3 "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<sub>x</sub> from exhaust gas.

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

2.3.5 "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.

2.3.6 "AV (area velocity) value" means a value of the exhaust gas flow rate passing through the catalyst blocks (m<sup>3</sup>/h) per total active surface area of the catalyst blocks in the SCR chamber (m<sup>2</sup>). Therefore, unit of AV value is (m/h). The exhaust gas flow volume is the volume defined at 0°C and 101.3 kPa.

2.3.7 "SV (space velocity) value" means a value of the exhaust gas flow rate passing through the catalyst block(s) (m<sup>3</sup>/h) per total volume of the catalyst block(s) in the SCR chamber (m<sup>3</sup>). Therefore, unit of SV value is (1/h). The exhaust gas flow volume is the volume defined at 0°C and 101.3 kPa.

2.3.8 "Total volume of the catalyst block" means the volume (m<sup>3</sup>) based on outer dimensions of the catalyst block.

2.3.9 "LV (linear velocity) value" means a value of the exhaust gas flow rate passing through the catalyst blocks (m<sup>3</sup>/h) per catalyst block's section (m<sup>2</sup>) 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.

2.3.10 "Block section" means the cross-sectional area (m<sup>2</sup>) of the catalyst block based on the outer dimensions.

2.3.11 "NO<sub>x</sub> reduction rate  $\eta$ " means a value deriving from the following formula. Unit of  $\eta$  is (%):

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

Where:  $c_{inlet}$  is NO<sub>x</sub> concentration (ppm) as measured at the inlet of the SCR chamber;  
 $c_{outlet}$  is NO<sub>x</sub> concentration (ppm) as measured at the outlet of the SCR chamber.

### 3 PRE-CERTIFICATION PROCEDURE

#### 3.1 General

3.1.1 Engine systems fitted with SCR should be certified in accordance with chapter 2 of the NTC 2008. In cases where combined engine/SCR systems can neither be tested on a test bed due to their size, construction and other restrictions nor an on board test can be performed fully complying with the requirements of chapter 5 of the NTC 2008 the procedures provided by Scheme B of these guidelines should be applied.

3.1.2 The applicant for certification should be the entity responsible for the complete system "Engine system fitted with SCR", e.g., the engine manufacturer.

3.1.3 The applicant should supply all necessary documentation, including the Technical File for the complete system, a description of the required on board NO<sub>x</sub> verification procedure and, where applicable, the description of the confirmation test procedure.

### **3.2 Technical File and on board NO<sub>x</sub> verification procedures**

3.2.1 In addition to the information supplied in paragraph 3.1.3 of these guidelines and items in section 2.4 of the NTC 2008, engine systems fitted with SCR should include the following information in its 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;
- .4 catalyst block specification and arrangement in the SCR chamber;
- .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 ( $\Delta p$ ) between inlet and outlet of SCR chamber and in the exhaust duct caused by SCR components;
- .7 aspects related to the fuel oil quality resulting in continued compliance of the engine with the applicable NO<sub>x</sub> emission limit;
- .8 factors related to the deterioration rate of SCR performance, e.g., exchange condition for SCR blocks and recommended exchange time of SCR blocks;
- .9 controlling arrangements and settings of the SCR, e.g., model, specification of control device;
- .10 measures to minimize reductant slip;
- .11 parameter check method as the verification procedure: with regard to the application of the parameter check method, requirements given in paragraph 2.3.6 of the NTC 2008 and guidance given in appendix VII, paragraph 2 of the NTC 2008 should be taken into account in assessing the adequacy of a proposed procedure with analysers meeting or exceeding the requirements of appendix III of the NTC 2008; and
- .12 any other parameter(s) specified by the manufacturer.

### **3.3 Measures to minimize reductant slip**

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

### **3.4 Pre-certification procedure**

3.4.1 Test and pre-certification of an engine system fitted with SCR should be conducted either by Scheme A (as given in section 5 of these guidelines), or by Scheme B (as given in sections 6 and 7 of these guidelines), as appropriate.

### **3.5 EIAPP certificate**

3.5.1 An Engine International Air Pollution Prevention (EIAPP) Certificate (see appendix I of the NTC 2008) should be issued by the Administration after approval of the Technical File.

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

## **4 FAMILY AND GROUP CONCEPTS FOR ENGINE SYSTEMS FITTED WITH SCR**

4.1 Requirements in chapter 4 of the NTC 2008 apply equally to engine systems fitted with SCR.

## **5 TEST PROCEDURES FOR SCHEME A**

### **5.1 General**

5.1.1 A test for a combined system of an engine fitted with an SCR in Scheme A is to ensure compliance with the applicable NO<sub>x</sub> emission limits of MARPOL Annex VI, as required. The test bed measurement procedures of chapter 5 of the NTC 2008 should apply.

### **5.2 Calculation of gaseous emissions**

5.2.1 The calculation method in section 5.12 of the NTC 2008 is also applied 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 NTC 2008). The NO<sub>x</sub> correction factor for humidity and temperature (equations (16) or (17), paragraphs 5.12.4.5 and 5.12.4.6, respectively, of the NTC 2008) should not be applied.

5.2.2 For an engine system fitted with SCR, the following parameters should be measured and recorded in the engine test report in accordance with section 5.10 of the NTC 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  $\Delta p$ . If the manufacturer sets an allowable limit of  $\Delta p$ , it should be confirmed; and
- .4 other parameter(s) as specified by the Administration.

## **6 TEST PROCEDURES FOR SCHEME B**

### **6.1 General**

6.1.1 A test for an engine system fitted with SCR in Scheme B is to ensure that the system complies with the applicable NO<sub>x</sub> emission limits in MARPOL Annex VI, as required. The test procedures in Scheme B are as follows:

- .1 an engine is tested to obtain the NO<sub>x</sub> emission value (g/kWh) in accordance with paragraph 6.2.1 of these guidelines;

- .2 the SCR NO<sub>x</sub> reduction rate may be calculated by modelling tools, taking into account geometrical reference conditions, chemical NO<sub>x</sub> conversion models as well as other parameters to be considered;
- .3 an SCR chamber, not necessarily to full scale, is to be tested in accordance with section 6.3 of these guidelines in order to generate data for the calculation model as that used in paragraph 6.1.1.2 of these guidelines;
- .4 the NO<sub>x</sub> emission from the engine system fitted with SCR, which is calculated in accordance with section 6.4 of these guidelines using the NO<sub>x</sub> emission value from the engine and the NO<sub>x</sub> reduction rate of SCR chamber. At this point the Technical File will be completed and this NO<sub>x</sub> emission value will be entered into the supplement of the EIAPP certificate; and
- .5 the NO<sub>x</sub> emission performance of the engine combined with the SCR is verified by a confirmation test in accordance with the procedure in paragraph 7.5 of these guidelines.

## **6.2 Verification test procedures for an engine**

6.2.1 The purpose of the test of an engine is to establish the emission values for use in section 6.4 of these guidelines. These measurements should be in accordance with chapter 5 of the NTC 2008.

6.2.2 Paragraph 5.9.8.1 of the NTC 2008 requires engine conditions to be measured at each mode point, for an engine system. 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 NTC 2008.

## **6.3 Test procedures for SCR chambers**

### **6.3.1 General**

6.3.1.1 The SCR chamber for validation testing may be either a full scale SCR chamber or a scaled version. A SCR chamber should demonstrate the reduction in NO<sub>x</sub> concentrations (ppm) expected in exhaust gas measured in section 6.2 of these guidelines. Therefore, NO<sub>x</sub> reduction rate of the SCR chamber should be determined for each individual mode point. Where undertaken on a scaled version of the SCR chamber the scaling process should be validated to the satisfaction of the Administration.

### **6.3.2 Test conditions at each mode point**

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

- .1 Exhaust gas flow  
Exhaust gas flow rate for the test should be scaled accordingly to account for the dimension 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 should correspond, in terms of concentrations, to the exhaust gas in section 6.2 of these guidelines, in terms of NO<sub>x</sub>, O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>O, and SO<sub>2</sub> (±5% of the required concentration for each emission species).

Where simulated gas is used it should correspond, in terms of concentrations, to the exhaust gas in section 6.2 of these guidelines, in terms of NO, NO<sub>2</sub>, O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>O, and SO<sub>2</sub> (±5% of the required concentration for each emission species) balance N<sub>2</sub>.

.3 Exhaust gas temperature

The temperature of exhaust gas used for the test should correspond to the temperatures obtained from testing in section 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 NTC 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 should be representative of the catalyst blocks to be used in the SCR chamber in service. AV,SV or LV value should, in the case of full scale tests, be within a range of ±20% of the required value as obtained in testing from section 6.2 of these guidelines. In the case of scaled tests it should correspond to the above.

.5 Reductant

The reductant concentration should be representative of the reductant concentration in the exhaust gas during actual operation.

### 6.3.3 Stability for measurement

6.3.3.1 All measurements should be recorded after they have stabilized.

### 6.3.4 List of data to be derived from the model

6.3.4.1 Operating data which is to be given in the Technical File should be derived from the modelling process or otherwise justified.

6.3.4.2 Exhaust gas analysers should be in accordance with appendix III and appendix IV of the NTC 2008 or otherwise to the satisfaction of the Administration.

### 6.3.5 Test report for SCR chamber

6.3.5.1 Data recorded under paragraph 6.3.1.1 of these guidelines should be recorded in the test report as required by section 5.10 of the NTC 2008.

## 6.4 Calculation of the specific emission

6.4.1 The NO<sub>x</sub> emission value of the engine system fitted with SCR should be calculated as follows:

$$\text{gas}_x = \frac{\sum_{i=1}^{i=n} ((100 - \eta_i)/100) \cdot q_{m\text{gas}_i} \cdot W_{F_i}}{\sum_{i=1}^{i=n} (P_i \cdot W_{F_i})}$$

Where:  $\eta_i$  = NO<sub>x</sub> reduction rate (%) derived in accordance with section 6.3 of these guidelines;  
 $q_{\text{mgas}_i}$  = Mass flow of NO<sub>x</sub> gas measured in accordance with section 6.2 of these guidelines;  
 $W_{F_i}$  = Weighting factor;  
 $P_i$  = Measured power at individual mode points in accordance with section 6.2 of these guidelines.

The weighting factors and number of modes (n) used in above calculation shall be according to the provisions of section 3.2 of the NTC 2008.

6.4.2 The NO<sub>x</sub> emission value (g/kWh) calculated in accordance with paragraph 6.4.1 of these guidelines should be compared to the applicable emission limit. This emission value is entered into 1.9.6 of the Supplement to the EIAPP certificate (appendix I of the NTC 2008).

## 6.5 Test report to be submitted to the Administration

6.5.1 The test report referenced under paragraphs 6.2.2 and 6.3.5.1 of these guidelines, together with the data from section 6.4 of these guidelines should be consolidated into the overall documentation to be submitted to the Administration.

## 7 ON BOARD CONFIRMATION TEST FOR SCHEME B

7.1 After installation on board of an engine system fitted with SCR and before entry into service an initial confirmation test should be performed on board.

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

7.3 The confirmation test should be undertaken as close as possible to 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 should be verified.

7.5 NO<sub>x</sub> emission concentrations should be measured at the inlet and outlet of the SCR chamber. The NO<sub>x</sub> reduction rate should be calculated. Both values should either be dry or wet. The value obtained for NO<sub>x</sub> reduction rate should 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 should not be less than the corresponding values as given in the Technical File by more than 5%.

7.6 The NO<sub>x</sub> analyser should meet the requirements of chapter 5 of the NTC 2008.

7.7 When an engine system fitted with SCR is in a group defined in chapter 4 of these guidelines, the confirmation test should be conducted only for the parent engine system of the group.

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