RUSSIAN MARITIME REGISTER OF SHIPPING

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GUIDELINES

ON THE APPLICATION OF PROVISIONS OF THE TECHNICAL CODE ON CONTROL OF EMISSION OF NITROGEN OXIDES FROM MARINE DIESEL ENGINES

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GUIDELINES ON THE APPLICATION OF PROVISIONS OF THE TECHNICAL CODE ON CONTROL OF EMISSION OF NITROGEN OXIDES FROM MARINE DIESEL ENGINES

The Guidelines on the Application of Provisions on the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines set the regulations for survey of ship's diesel engines for their compliance with international nitrogen oxides (NO_x) emission standards both at the firms (manufacturers) and on ships in service, have been approved in accordance with the established procedure and come into force on 1 July 2022.

The Guidelines have been developed on the basis of the Guidelines on the Application of Provisions of the Technical Code on Control of Emission, 2020, taking into account the requirements of the above Technical Code, adopted by IMO resolution MEPC.177(58) as amended, and the revised Annex VI to MARPOL 73/78 adopted by IMO resolution MEPC.176(58) as amended.

In case of discrepancies between the Russian and English versions, the Russian version shall prevail.

REVISION HISTORY

(purely editorial amendments are not included in the Revision History)

Amended paras/chapters/sections	Information on amendments	Number and date of the Circular Letter	Entry-into-force date
Section 3, para 3.1.1	Para has aligned with the NO_x Technical Code	313-04-1917c of 03.04.2023	15.04.2023
Section 3, para 3.1.2	Para has aligned with the NO_x Technical Code	313-04-1917c of 03.04.2023	15.04.2023
Section 3, para 3.1.3	Para has aligned with the NO_x Technical Code	313-04-1917c of 03.04.2023	15.04.2023
Section 3, para 3.3.9.4	Para has been amended considering IMO Circular MEPC.1/Circ.895/Rev.1	313-04-1917c of 03.04.2023	15.04.2023
Section 6, para 6.3.1.6	Requirements have been specified	313-04-1917c of 03.04.2023	15.04.2023
Appendix 5, Table 1	Table has been aligned with the NO_x Technical Code	313-04-1917c of 03.04.2023	15.04.2023

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ABBREVIATIONS, SUBSCRIPTS AND SYMBOLS

Tables 1 — 3 contain the abbreviations, subscripts and symbols used throughout the Guidelines on the Application of Provisions of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines[1].

Table 1

Symbols for the chemical components of diesel engine emissions

Symbol	Chemical component	Symbol	Chemical component
C_3N_8	Propane	NO_x	Oxides of nitrogen
NO	Nitric oxide	HC	Hydrocarbons
CO	Carbon monoxide	O_2	Oxygen
NO_2	Nitrogen dioxide	H_2O	Water
CO_2	Carbon dioxide		

Table 2

Abbreviations for analysers for measurement of diesel engine gaseous emissions

Abbreviation	Term	Abbreviation	Term
CLD	Chemiluminescent detector	(H)FID	(Heated) flame ionization detector
ECS	Electrochemical sensor	NDIR	Nondispersive infrared detector
FID	Flame ionisation detector	PMD	Paramagnetic detector
FTIR	Fourier transform infrared detector	UVD	Ultra-violet detector
HCLD	Heated chemiluminescent detector	ZRDO	Zirconium dioxide detector

Table 3

Symbols and subscripts for terms in the formulae used at measurements

Symbol	Term	Dimension
conc	Concentration	ppm; vol %
EAF	Excess air factor (kg dry air per kg fuel)	kg/kg
EAF_{Ref}	Excess air factor (kg dry air per kg fuel) at reference conditions	kg/kg
f_a	Laboratory atmospheric factor	–
F_{FCB}	Fuel specific factor for the carbon balance calculation	–
F_{FH}	Fuel specific factor used for the calculations of wet concentrations from dry concentrations	–
F_{FD}	Fuel specific factor for exhaust flow calculation on dry basis	–
F_{FW}	Fuel specific factor for exhaust flow calculation on wet basis	–
G_{AIRW}	Intake air mass flow rate on wet basis	kg/h
G_{AIRD}	Intake air mass flow rate on dry basis	kg/h
G_{EXHW}	Exhaust gas mass flow rate on wet basis	kg/h
G_{FUEL}	Fuel mass flow rate	kg/h
GAS_x	Average weighted NO_x emission value	g/kW·h
H_{REF}	Reference value of absolute humidity (10,71 g/kg; for calculation of NO_x and particulate humidity correction factors)	g/kg
H_a	Absolute humidity of the intake air	g/kg
HTCRAT	Hydrogen-to-carbon ratio	mol/mol
i	Subscript denoting an individual mode	–
K_{HDIES}	Humidity correction factor for NO_x for diesel engines	–

[1] Hereinafter referred to as "the Guidelines".

Symbol	Term	Dimension
$K_{W,\,a}$	Dry to wet correction factor for intake air	–
$K_{W,\,r}$	Dry to wet correction factor for the raw exhaust gas	–
L	Percent torque related to the maximum torque for the test engine speed	%
M_{GAS}	Emission mass flow rate	g/h
P_a	Saturation vapour pressure of the engine intake air	kPa
P_B	Total barometric pressure	kPa
P_s	Dry atmospheric pressure	kPa
P	Power, brake uncorrected as per ISO 3046	kW
P_{AUX}	Declared total power absorbed by auxiliaries fitted for the test only, but not required onboard	kW
P_m	Maximum measured or declared power at the test engine speed under test conditions	kW
R_a	Relative humidity of the intake air	%
S	Dynamometer setting	kW
T_a	Intake air temperature determined at the engine intake	K
T_{Dd}	Absolute dewpoint temperature	K
T_{sc}	Temperature of the interceded air	K
T_{ref}	Reference temperature (of combustion air: 298 K)	K
T_{SCRef}	Intercooled air reference temperature	K
V_{AIRD}	Intake air volume flow rate on dry basis	m^3/h
V_{AIRW}	Intake air volume flow rate on wet basis	m^3/h
V_{EXHD}	Exhaust gas volume flow rate on dry basis	m^3/h
V_{EXHW}	Exhaust gas volume flow rate on wet basis	m^3/h
W_F	Weighting factor	–

1 GENERAL

1.1 PURPOSE

1.1.1 The Guidelines set procedures, methods and scope of surveys performed by Russian Maritime Register of Shipping[1] to ensure the compliance of marine diesel engines with the international standards of the nitrogen oxides (NO_x) emissions. The technical supervision of marine diesel engines comprises both the process of their manufacture and service on board ships. The NO_x emission standards are specified by regulation 13 of Annex VI to the International Convention for Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto[2], and are given in Appendix 1. On the basis of satisfactory results of survey the Register shall issue an Engine International Air Pollution Prevention (EIAPP) Certificate with Supplement (forms 2.4.40 and 2.4.41).

1.1.2 The requirements of the Guidelines comply with the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines[3] adopted on 10 October 2008 by IMO resolution MEPC.177(58), as amended.

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1 Hereinafter referred to as "RS", "the Register".
2 Hereinafter referred to as "MARPOL 73/78".
3 Hereinafter referred to as "the NO_x Technical Code".

1.2 APPLICATION

1.2.1 The Guidelines apply to the following:

.1 marine diesel engines with a power output of more than 130 kW installed on board ships;

.2 marine diesel engines with a power output more than 130 kW, which were subjected to "substantial modifications" on or after 1 January 2000 except when demonstrated that such engine is an identical replacement to the engine which it is replacing.

1.2.2 The Guidelines do not apply to the following:

.1 emergency diesel engines;

.2 life boat diesel engines;

.3 diesel engines driving the equipment used in emergency situations only;

.4 diesel engines installed on the ships engaged in voyages only within the waters under the jurisdiction of the state, which flag the ship is flying, provided that these diesel engines are subject to alternative control of the NO_x emissions specified by the Register.

1.3 DEFINITIONS AND EXPLANATIONS

Administration means the government of the State, under whose authority the ship is operating (refer to MARPOL 73/78, Article 2 (5)).

Parent marine diesel engine for determining the NO_x emissions is the marine diesel engine with a set of similar features specific within the family or the group (refer to 3.3 and 3.4) and having the largest NO_x emissions.

Weighting factor (W_F) in tests means a conditional value reflecting a statistical time part of operation of given diesel engine application, on a given mode in service, and adopted in ISO 8178. Values of W_P are stated in Tables 2.2, 2.4, 2.5 and 2.6 of Appendix 1.

Exhaust gases on wet basis mean exhaust gases, the moisture content of which corresponds to the complete composition of fuel combustion.

Wet air means atmospheric air used for fuel combustion, moisture content of which corresponds to atmospheric conditions during the tests.

Nitrogen oxide (NO_x) emissions mean the total emission of nitrogen oxides air-emitted together with the exhaust gases per time unit.

Engine system fitted with the SCR reducing NO_x emissions means a system consisting of a marine diesel engine, an 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.

Record Book of Engine Parameters means the document in connection with the Engine Parameter Check method used for recording all diesel engine parameter changes, including components and engine settings, which may influence the NO_x emission of the engine.

Substantial modification of marine diesel engine means:

.1 for engines installed on ships the keels of which were laid or which were at a similar stage of construction on or after 1 January 2000, substantial modification means any modification to an engine that could potentially cause the engine to exceed the emission standards set out in Appendix 1 (regulation 13 of Annex VI to MARPOL 73/78). Routine replacement of engine components by parts specified in the Technical File (refer to 2.1.11) that do not alter emission characteristics shall not be considered a substantial modification, regardless of whether one part or many parts are replaced;

.2 for engines installed on ships the keels of which are laid or which were at a similar stage of construction before 1 January 2000 – the alterations of which at the engine modifications after 1 January 2000 may 10 % increase the existing NO_x emission characteristics as specified in 6.3.11.1.

These changes include, but not limited to, changes in its operations or in technical parameters: changing camshafts of high pressure fuel pumps; fuel injection systems, air systems, combustion chamber configuration, timing calibration of the engine, and other changes influencing the NO_x emissions. The Installation of a surveyed approved method pursuant to regulation 13.7.1.1 of Annex VI to MARPOL 73/78 or survey in compliance with regulation 13.7.1.2 of Annex VI to MARPOL 73/78 is not considered to be a substantial modification for the purpose of the application of regulation 13.7.1.2 of Annex VI to MARPOL 73/78.

Any modification made on or after 1 January 2000 to such an engine involving alternative duty cycle, rating, components or settings that were available, but not necessarily utilised, prior to 1 January 2000 shall not be considered as representing a "substantial modification" to that engine.

Test cycle means aggregate, measured power at the test diesel engine speed set as per diesel engine application and realised in tests (as stated in Appendix 1) for the calculation of average weighted NO_x emission.

Components are those parts, which influence the NO_x emissions performance identified by their design (parts number).

Concentration of nitrogen oxides NO_x (equated to NO_2) means exhaust gas volume content of all nitrogen oxides, which they would constitute when changing (transforming) into the equivalent volume of nitrogen dioxide, NO_2, in vol %.

The EIAPP Certificate is the Engine International Air Pollution Prevention Certificate. The IAPP Certificate is the International Air Pollution Prevention Certificate.

Electronic Record Book means a device or system, approved by the Administration, used to electronically record the entries required under the NO_x Technical Code, 2008, in lieu of a hard copy record book. The definition is applied in compliance with IMO resolution MEPC.317(74).

Rated power means the maximum continuous rated power output, as specified on the nameplate and in the Technical File of Marine Diesel Engine.

Rated speed is the crankshaft revolutions per minute, at which the rated power occurs, as specified on the nameplate and in the Technical File of Marine Diesel Engine.

Approved method is a method for a particular engine, or a range of engines, which, when applied to the engine, will ensure that the engine complies with the applicable NO_x limit as detailed in regulation 13.7 of Annex VI to MARPOL 73/78. Approved methods may be the necessary engine settings or the installation of the set of equipment for the engine modernization.

Nitrogen oxides mean the mixture of different nitrogen oxides, which have formed as a result of fuel combustion in the diesel cylinder, and symbolized as NO_x.

Exhaust gases (EG) mean a mixture of products of complete combustion of fuel, excess air and various micro impurities (both gaseous and liquid, or solid particulates) emitted from diesel engine cylinders to its intake system and further to the atmosphere.

On-board NO_x verification procedures mean procedures, which shall be used during initial or periodical surveys to verify compliance with the requirements of the Guidelines, as specified by the marine diesel engine manufacturer and approved by the Register.

Operating values are engine data from the engine log, which are related to the NO_x emissions performance. These data are load-dependent.

Setting means adjustment of an adjustable feature influencing the NO_x emission performance of an engine within allowances, as set out in the Technical File of Marine Diesel Engine.

Marine diesel engine means any reciprocating internal combustion diesel engine operating on liquid or dual fuel, to which regulation 13 of Annex VI to MARPOL 73/78 applies, including booster/ compound systems, if applied. in addition, 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.

Where an engine is intended to be operated normally in the gas mode, i.e. with the main fuel gas and only a small amount of liquid pilot fuel, the requirements of regulation 13 of Annex VI to MARPOL 73/78 shall be met only for this operation mode. Operation on pure liquid fuel resulting from restricted gas supply in cases of failures shall be exempted for the voyage to the next appropriate port for the repair of the failure.

Exhaust gases on dry basis mean exhaust gases, moisture content of which is less or corresponds to the balance, where T = 298 K and atmospheric pressure = 101 kPa.

Dry air means atmospheric air used for fuel combustion, where water vapours are absent.

Existing engine is an engine which is subject to regulation 13.7 of Annex VI to MARPOL 73/78. Technical File of Marine Diesel Engine is a record containing all details of parameters, including components and settings of an engine, which may influence the NO_x emissions of the engine, in accordance with the requirements, as prescribed in 2.1.11.

Approved method file is a document which describes an approved method and its means of survey.

Average weighted nitrogen oxide (NO_x) emission means the total emission of nitrogen oxides air-emitted together with EG per 1 kW·h of diesel brake power in any of the test cycles according to diesel engine application (calculated using Formula (4.12.1.1-1)).

On-board conditions mean that an engine is:

.1 installed on board and coupled with the actual equipment, which is driven by the engine;

.2 under operation to perform the purpose of the equipment.

Installed engine means a marine diesel engine that is or is intended to be fitted on a ship, including a portable auxiliary marine diesel engine, only if its fueling, cooling, or exhaust system is an integral part of the ship. A fueling system is considered integral to the ship only if it is permanently affixed to the ship. This definition includes a marine diesel engine that is used to supplement or augment the installed power capacity of the ship and is intended to be an integral part of the ship.

Electronic Record Book means a device or system, approved by the Administration or a recognized organization on behalf thereof, used to electronically record the entries required under the NO_x Technical Code, 2008, in lieu of a hard copy record book (refer to IMO resolution MEPC.317(74)).

Brake power is the observed power measured at the crankshaft or its equivalent, the engine being equipped only with the standard auxiliaries necessary for its operation on a test bed.

2 SURVEY OF MARINE DIESEL ENGINES AT THE FIRM (MANUFACTURER)

2.1 REGULATIONS ON SURVEY OF MARINE DIESEL ENGINES AT THE FIRM (MANUFACTURER)

2.1.1 Survey of a marine diesel engine at the firm (manufacturer) shall be performed within the scope necessary to ensure that the diesel engine design, equipment and adjustment, comply with the NO_x emission limits specified in Appendix 1. in case the inspection confirms the compliance, the Register shall issue the EIAPP Certificate.

2.1.2 Test bed of a diesel engine to be surveyed is performed according to the requirements of Section 4. The test bed is performed either for every marine diesel engine, or engine family or engine group represented by the parent engine. The engine family or engine group concepts set out in Section 3 and may be applied for serially produced engines, depending on the selection of the manufacturer and the approval of the Register.

2.1.3 For the Register the procedure of the marine diesel engine survey and issue of the EIAPP Certificate shall involve the verification of the following:

.1 marine diesel engine tests have been carried out by the manufacturer on a test bed;

.2 the tested marine diesel engine complies with the NO_x emission limits;

.3 the selected parent marine diesel engine is a typical representative of the diesel engine family or group (refer to 3.3.9 and 3.4.7), if application of these concepts is approved by the Register.

2.1.4 In case the survey of marine diesel engines is performed with the application of the diesel engine family or engine group concept (refer to Section 3), the EIAPP Certificate shall be issued to the parent engine in accordance with the procedures established by the Register and shall accompany every member diesel engine produced within the family/group.

2.1.5 When the marine diesel engine, intended to be installed on a ship under the Russian flag, is manufactured outside the country, the Register may accept the EIAPP Certificate issued by another Administration provided that it is accompanied with the complete set of documents pursuant to the NO_x Technical Code.

2.1.6 A flowchart of procedures for survey of marine diesel engines on a test bed of the firm (manufacturer) and issuance of the EIAPP Certificate is given in Fig. 1 of Appendix 6. in case of the survey of the diesel engine that does not correspond to the flowchart (given in this Figure), the provisions of Section 2 shall be applied.

2.1.7 If the marine diesel engine cannot be surveyed on a test bed, due to its size, construction and delivery schedule, the engine manufacturer, shipowner or shipbuilder may apply to the Register with a request for on-board test and before the test results are ready a preliminary approved Technical File, pending the results of the emission test shall be provided.

If the result of the emission test does not comply with the applicable NO_x regulation, the engines shall be re-adjusted to the compliance condition originally approved, if any, or the applicant shall apply to the Flag Administration for acceptance of further testing. The applicant shall demonstrate to the Register that the on-board test fully meets all the requirements of a test-bed procedure, as specified in Section 4. Such a procedure of survey may be accepted for one engine or for an engine group represented by the parent engine only, but it shall not be accepted for an engine family survey.

2.1.8 In accordance with 2.1.1 and 2.1.6 the satisfactory survey of the marine diesel on a test bed of the firm (manufacturer) shall result in an issuance by the Register of the EIAPP Certificate accompanied with mandatory attachments (design particulars, Technical File of Marine Diesel Engine and control methods to the extent as stated in the sample contained in Appendix 2). The Certificate and attachments thereto shall be completed both in Russian and in English.

2.1.9 For those marine diesel engines, which have got the EIAPP Certificate and have not been adjusted or modified after their installation on board, the provision of the valid EIAPP Certificate shall suffice to demonstrate compliance with the applicable NO_x emission limits at subsequent surveys.

2.1.10 Every marine diesel engine shall be provided with the Technical File. The Technical File shall be prepared by the diesel engine certification applicant, approved by the Register upon authorization of the Administration, and required to be available to accompany the diesel engine throughout the life whereof on board. in this case if the applicant is not an engine manufacturer, they shall be authorized by the manufacturer and that fact shall be documentary confirmed.

2.1.11 The Technical File of Marine Diesel Engine shall contain, as a minimum, the following information:

.1 identification of those components, settings and operating values of the diesel engine, which influence its NO_x emissions;

.2 identification of the full range of allowable adjustments for the components and units of the diesel engine;

.3 full record of the relevant diesel engine's performance, including the diesel engine's rated speed and rated power;

.4 a system of on-board NO_x verification procedures to verify compliance with the NO_x emission limits during subsequent on-board surveys of the marine diesel engine;

.5 a copy of the Test Report from the firm (manufacturer) as per the form given in Appendix 3;

.6 if applicable, the designation and restrictions for the diesel engine, which is a member of an engine group or engine family;

.7 identification marking (specifications) of those spare parts/components which, when used in the engine, according to those specifications, will result in continued compliance of the engine with the applicable NO_x emission limit. The "specification" need only address those aspects of the design of the component which directly affect its function as a NO_x critical component. For some components it shall be possible to define these components by means of an outline dimensioned drawing within the conformity of production procedures or as a drawing directly included within the Technical File, or other data defining the features used by a manufacturer's during manufacture;

.8 the EIAPP Certificate, as applicable;

.9 technical documentation of special equipment to reduce NO_x emissions, if available on board, containing information in compliance with para 3.2 of IMO resolution MEPC.291(71).

2.1.12 The NO_x emission limits given in regulation 13 of Annex VI to MARPOL 73/78 and the actual average weighted NO_x emission value calculated during survey of the marine diesel engine shall be introduced in the EIAPP Certificate.

2.1.13 Application of the NO_x emission reducing devices.

2.1.13.1 Where a NO_x-reducing device is to be included within the EIAPP certification, it shall be recognized as a component of the engine and its presence shall be recorded in the engine's Technical File. The marine diesel engine fitted with selective catalyst reduction (SCR) systems to reduce the NO_x emissions shall be certified in accordance with Chapter 2 of the NO_x Technical Code (NTC), 2008.

The procedure provided by Scheme A or Scheme B in compliance with the Guidelines Addressing Additional Aspects to the NO_x Technical Code, 2008 with regard to Particular Requirements related to Marine Diesel Engines fitted with SCR Systems adopted by IMO resolution MEPC.291(71), as amended by IMO resolution MEPC.313(74), shall be applied.

At that IACS UIs MPC112 (Rev.1 Nov 2019), MPC115 (Corr.1 May 2020) and MPC116 (Rev.1 Nov 2019) shall be considered.

2.1.13.2 The initial survey procedure for the engine combined with the NO_x-reducing device in case the marine diesel engine cannot be tested along with the NO_x-reducing device not involving the testing for the combined engine/NO_x-reducing device on a test bed as given by the above Guidelines in 2.1.13.1, and may be allowed for an individual engine or group member engines represented by the parent diesel engine but not allowed for engine family.

2.1.13.3 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/on a test bed of an enterprise (manufacturer), in order to receive the EIAPP Certificate for this assembly, the engine, including the reducing device, as installed, shall be re- tested to show compliance with the applicable NO_x emission limit. However, in this case, the assembly may be retested in accordance with the simplified measurement method in accordance with 6.3. in no case shall the allowances given in 6.3.11 be granted.

2.1.13.4 Where, in accordance with 2.1.13.3, the effectiveness of the NO_x-reducing device is verified by use of the simplified measurement method, that test report shall be added as an adjunct to the pre- certification test report which demonstrated the failure of the engine alone to meet the required emission value. Both test reports shall be submitted to the Register, and test report data, as detailed and covering both tests shall be included in the Technical File of Marine Diesel Engine.

The simplified measurement method used as part of the process to demonstrate compliance in accordance with 2.1.13.3 may only be accepted in respect of the engine and NO_x-reducing device on which its effectiveness was demonstrated, and it shall not be accepted for engine family or engine group survey.

2.1.13.5 In both cases as given in 2.1.13.1 and 2.1.13.3, the NO_x-reducing device shall be included in the EIAPP Certificate together with the emission value obtained with the device in operation and all other records as required by the Register. The Technical File shall also contain the onboard NO_x verification procedures regarding the device.

2.1.13.6 In compliance with the Guidelines the calculation method specified in 2.1.13.1, and given in Section 5.12 of the NO_x Technical Code, 2008, is also applied to engine systems fitted with SCR systems. 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 or dry/wet correction factor in equation (11), para. 5.12.3.2.2 of the NO_x Technical Code, 2008. The NO_x correction factor for humidity and temperature in equations (16) or (17) of the NO_x Technical Code, 2008 shall not be applied.

The gaseous emissions calculation method applies to both Scheme A and Scheme B certification of marine diesel engines fitted with SCR systems.

2.1.13.7 Where, due to changes of component design, it is necessary to establish a new engine family or engine group but there is no available parent engine, the engine builder may apply to the Register to use the previously obtained data of test engine modified at each specific mode of the applicable test cycle so as to allow for the resulting changes in the NO_x emission values. in such cases, the engine used to determine the modification emission data shall correspond to the requirements for the previously used engine. Where more than one component shall be changed the combined effect resulting from those changes shall be demonstrated by a single set of test results.

2.1.14 In case the marine diesel engine is fitted with the NO_x-reducing device that is an EGR system with a bleed-off water discharge system, the bleed-off water discharge system shall comply with the requirements of IMO resolution MEPC.307(73) "Guidelines for the Discharge of Exhaust Gas Recirculation (EGR) Bleed-Off Water".

The Guidelines contain instructions on surveys, requirements for treatment, storage discharge and disposal of residues from an EGR water treatment system to reception facilities and apply to marine diesel engines fitted with such system, for which the EIAPP Certificate is issued on or after 1 June 2019.

2.1.15 The EGR bleed-off water discharge system shall be subject to survey on installation and at initial, annual, intermediate and EIAPP renewal survey. The following documents shall be retained on board the ship as appropriate and shall be available for survey as required:

.1 approved manual for EGR bleed-off discharge system;

.2 copy of Certificate for Type Approval of oil content meters (15 ppm bilge alarm);

.3 operating and maintenance manuals of oil content meters (15 ppm bilge alarm);

.4 approved EGR record book.

2.2 TECHNICAL DOCUMENTATION

2.2.1 To have the EIAPP Certificate being issued, the applicant for engine certification shall forward to the Register, acting on behalf of Administration, its application which shall be accompanied by the following:

.1 Test Report on results of the marine diesel engine test bed trials as per the form given in Appendix 3;

.2 Technical File of Marine Diesel Engine in accordance with 2.1.11;

.3 documentation stated in 3.2 for the approval by the Register of the marine diesel engine family concept or marine diesel engine group concept, if one of these concepts is applied by the manufacturer;

.4 Exhaust Gas Recirculation (EGR) record book and manual for EGR bleed-off discharge system approved by RS upon authorization of the Administration in compliance with IMO resolution MEPC.307 (73), if applicable.

Based on consideration of the application and provided that the NO_x emission limits are met, the Register shall issue the EIAPP Certificate with Supplement (forms 2.4.40 and 2.4.41).

3 APPLICATION OF THE MARINE DIESEL ENGINE FAMILY OR MARINE DIESEL ENGINE GROUP CONCEPTS AT THE FIRM (MANUFACTURER)

3.1 GENERAL

3.1.1 To avoid survey testing of every engine for compliance with the NO_x emission limits at the firm (manufacturer), one of two concepts may be adopted in compliance with the provisions of the NO_x Technical Code.

3.1.2 The diesel engine family concept may be applied to any series produced marine diesel engines, which, through their design are proven to have similar NO_x emission characteristics, are used as produced, and during installation on board, require no adjustments or modifications, which could adversely affect the NO_x emissions.

3.1.3 The diesel engine group concept may be applied to any engine intended for main propulsion or auxiliary duties, where adjustment and modification following installation (and through the service life of the engine) is considered routine.

3.1.4 Engines within an Engine Family may have different cylinder bore and stroke dimensions (within the defined limits – refer to 3.3.9.2.3). Engines within an engine group concept have identical bore and stroke dimensions as a result of only one of the parameters defined under 3.4.6.2 being permitted to vary within the defined engine group.

An Onboard NO_x Verification Procedure shall be included within the Technical Files of all engines irrespective of whether they are included within an engine family or engine group.

3.1.5 Where the measured performance of a member engine to an engine family or engine group is fundamental to the verification that that member engine is operating within the parameters defined by the approved engine family or group, then that performance data (emissions, engine performance, ambient conditions) and other necessary data shall have been obtained (refer to Section 4, Chapter 5 of the NO_x Technical Code, 2008).

3.1.6 Initially the engine manufacturer may, at its discretion, determine whether engines shall be covered by the engine family or engine group concept. in general, the type of application shall be based on whether the engines will be modified, and to what extent, after testing on a test bed.

3.2 TECHNICAL DOCUMENTATION

3.2.1 The application for survey of the marine diesel engines within the family or the group concept shall be presented to the Register accompanied with the documentation in the scope sufficient for confirmation of the fact that the family concept or the group concept may be applied (refer to 3.3 and 3.4).

The preliminary Technical File of Marine Diesel Engine is compiled in accordance with 2.1.11 and shall contain all the required information, except the test bed trial results, for the issuance of the EIAPP Certificate.

3.2.2 The marine diesel engine, to which the diesel engine family or engine group concept is applied, requires documentation sufficient for determination of compliance with the NO_x emission limits by the diesel engine parameter check method.

3.3 REGULATIONS ON APPLICATION OF THE MARINE DIESEL ENGINE FAMILY CONCEPT

3.3.1 The diesel engine family concept, if applied, provides the possibility of reducing the number of marine diesel engines, which shall be submitted for approval testing, while providing safeguards that all engines within the family comply with the NO_x emission limits.

Moreover, in the marine diesel engine family concept, engines with similar design and emission characteristics shall be represented by the parent marine diesel engine within the family.

3.3.2 The marine diesel engines that are series produced and not intended to be modified during installation on board may be covered by the marine diesel engine family concept.

3.3.3 The parent marine diesel engine of the family shall have such features that provide the highest NO_x emission level among all of the engines in the family.

3.3.4 On the basis of tests, the manufacturer may propose a list of the marine diesel engines – members of the family specifying from among them the diesel engine, which produces the highest NO_x emissions and the diesel engine, which shall be selected for survey as the parent marine diesel engine.

3.3.5 The Register shall review for survey approval the selection by the manufacturer of the parent marine diesel engine within the family and shall have the option of selecting a different diesel engine in order to have confidence that the complete family of marine diesel engines complies with the NO_x emission limits.

3.3.6 The marine diesel engine family concept allows adjustments both of the diesel engine and its features but within the ranges specified by the manufacturer and stated in the Technical File of Marine Diesel Engine. A feature is not considered adjustable, if it is permanently sealed by the manufacturer prior to survey testing.

3.3.7 To have the family concept approved, the manufacturer shall provide the Register with the evidence in support of the fact that all necessary tests required to verify both the application of this concept and the selection of the family parent diesel engine have been carried out. Moreover, the conformity of manufacturing process (methods) shall be documentary proved. Necessary tests shall contain, as a minimum, measurements of all main features and operating values, depending on the diesel engine load, which may affect the NO_x emissions. Special test diesel engines may be used for these tests.

IACS Unified Interpretation (UI) MPC 106 (July 2015) addresses the status of licensees relative to the conformity of production arrangements from the entity which proposed the engine family or engine group in the first instance.

An engine family/group approval, as applicable, is granted to the entity requesting to apply the engine family or engine group concept to serially produced marine diesel engines.

The conformity of production arrangements as required by this paragraph, as proposed by the entity seeking engine family/group approval and as accepted by the Administration shall cover those marine diesel engines within that particular engine family/group as manufactured by that entity.

Additionally, where that entity has in place arrangements, which extend, under their oversight and control, the accepted conformity of production arrangements to other engine manufacturers (i.e. licensees), then candidate marine diesel engines produced by those other parties may be included in the engine family/group as established. in this circumstance the marine diesel engine selected, and accepted by the Administration as the parent engine, may be manufactured either by the entity, which requested the engine family/group certification or by one of the other parties as covered by the agreed conformity of production arrangements.

In those instances where serially produced marine diesel engines are manufactured outside an accepted conformity of production arrangement then it is the responsibility of the

manufacturer of those marine diesel engines themselves to request certification in accordance with the requirements of the NO_x Technical Code, 2008 from the relevant Administration including the establishment of the relevant engine family/group, selection and testing of the parent engine and the development of the particular conformity of production arrangements, which shall cover those marine diesel engines.

3.3.8 Before granting an engine family approval, the Register shall take the necessary measures to verify that adequate arrangements have been made to ensure effective control of the conformity of production. This may include, but is not limited to:

.1 the connection between the NO_x critical components or identification numbers as proposed for the engine family and the drawing numbers (and revision status if applicable) defining those components;

.2 the means by which the Register will be able, at the time of a survey, to verify that the drawings used for the production of the NO_x critical components correspond to the drawings established as defining the engine family;

.3 drawing revision control arrangements. Where it is proposed by a manufacturer that revisions to the NO_x critical components drawings defining an engine family may be undertaken through the life of an engine, then the conformity of production scheme shall demonstrate the procedures to be adopted to cover the cases where revisions will, or will not, affect NO_x emissions.

These procedures shall cover drawing number allocation, effect on the identification markings on the NO_x critical components and the provision for providing the revised drawings to the Register responsible for the original engine family approval, where these revisions may affect the NO_x emissions the means to be adopted to assess or verify performance against the parent engine performance shall be stated together with the subsequent actions to be taken regarding advising the Register and, where necessary, the declaration of a new parent engine prior to the introduction of those modifications into service;

.4 the implemented procedures that ensure any NO_x critical components spare parts supplied to a surveyed engine shall be identified as given in the approved Technical File and hence shall be produced in accordance with the drawings as defining the engine family; or

.5 equivalent arrangements as approved by the Register.

3.3.9 Guidelines for the selection of the marine diesel engine family.

3.3.9.1 The marine diesel engine family shall incorporate common basic design characteristics, which may affect the NO_x emissions.

3.3.9.2 The engine manufacturer is responsible for the proper selection of features common to diesel engines in the family from their different models. The following basic characteristics (but not specifications) shall be common among all diesel engines within the family:

.1 combustion cycle;

.2 cooling medium (air, water, oil);

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

.4 number of cylinders and cylinder configuration. These parameters are applicable in certain cases only, e.g., in combination with exhaust gas cleaning devices;

.5 availability and method of air aspiration;

.6 fuel type (distillate, heavy, dual fuel, gas fuel);

.7 combustion chamber (open chamber, divided chamber);

.8 valve and porting, configuration and number (cylinder head, cylinder wall);

.9 fuel system type:

pump-line-injector;

in-line;

distributor;

unit injector;

gas valve;
.10 miscellaneous features:
exhaust gas re-circulation;
water/emulsion injection;
air injection;
charge cooling system;
exhaust after-treatment;
reduction catalyst;
oxidation catalyst;
thermal reactor;
particulates trap;
.11 ignition methods:
compression ignition;
ignition by pilot injection;
ignition by spark plug or other external ignition device.

3.3.9.3 If there are diesel engines, which incorporate other features, which could be considered to affect the NO_x emissions, these features shall be identified and taken into account in the selection of the diesel engines to be included in the family.

3.3.9.4 For engines fitted with a selective catalytic reduction (SCR) system to reduce NO_x emissions specified in 3.3.9.2.3 and 3.3.9.2.4, the number and arrangement of cylinders may not be common to all members of the Engine Family. 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. Thus, the applicant shall provide clear evidence that an Engine Family concept, allowing for different numbers and arrangements of cylinders, will result in same or lower NO_x emissions of the engines with different cylinder numbers compared to the NO_x emissions of the related parent engine.

3.3.10 Guidelines for selecting the parent diesel engine of the marine diesel engine family.

3.3.10.1 The method of selection of the parent diesel engine for the NO_x measurements may be proposed by the manufacturer and approved by the Register upon authorization of the Administration.

The method may be based upon selecting the diesel engine, which incorporates diesel engine features and characteristics, which, from experience, are known to produce the highest NO_x emissions, in g/kW-h.

3.3.10.2 Selecting the parent diesel engine shall be considered regarding selecting the diesel engine having the highest emission value for the applicable test cycle.

3.3.10.3 If diesel engines within the family incorporate other variable features, which may affect the NO_x emissions, these features shall be also identified and taken into account in the selection of the parent diesel engine of the family.

3.3.11 Survey of the marine diesel engine family.

3.3.11.1 Documentation for the marine diesel engine family shall include the list, to be prepared by the manufacturer and approved by the Register, of all diesel engines (and their specifications) accepted under the same diesel engine family with the limits of their operating conditions and the details and limits of diesel engine adjustments.

3.3.11.2 The EIAPP Certificate shall be issued to the parent diesel engine as a result of test bed trials, which certifies that the parent diesel engine meets the NO_x emission limits.

3.3.11.3 If the parent marine diesel engine complies with all specified criteria (refer to 3.3.10.2) and its compliance with the NO_x emission is confirmed, the determined parent engine NO_x emission value shall be recorded in the Supplement to EIAPP Certificate for parent

engine(s) and for all subsequent member engines within the engine family or engine group as established from that parent engine test.

Where member engine pre-certification requires the measurement of some performance values, the calibration of the equipment used for those measurements shall be in accordance with the requirements of Appendices 4 and 5.

3.3.11.4 If two or more classification societies agree to accept each other's EIAPP Certificates, then an entire marine diesel engine family surveyed by one of these societies, shall be accepted by the other society, which entered into the agreement between these societies.

The EIAPP Certificate issued under such an agreement shall be acceptable as prima facie evidence that all diesel engines included in the EIAPP Certificate of the diesel engine family comply with the specific NO_x emission requirements.

There is no need for further evidence of compliance with the emission limits, if it is verified that the installed diesel engine has not been modified and diesel engine adjustments are within the range permitted in the Technical File of Marine Diesel Engine of the parent marine diesel engine.

3.3.11.5 If the parent diesel engine of the family shall be surveyed by the manufacturer in accordance with an alternative standard or a different test cycle than those allowed in Appendix 1, the manufacturer shall prove to the Register that the weighted average NO_x emissions for the appropriate test cycles fall within the relevant limit values under the Guidelines. Under these circumstances the Register may issue the EIAPP Certificate.

3.4 REGULATIONS ON APPLICATION OF THE MARINE DIESEL ENGINE GROUP CONCEPT

3.4.1 The engine group concept shall be interpreted as applicable to any engine intended for main propulsion or auxiliary duties, where adjustment and modification following installation (and through the service life of the engine) is considered routine.

However, these modifications and adjustments shall not result in the NO_x emissions exceeding the limits.

3.4.2 The diesel engine group concept provides the possibility for a reduction in survey testing to have the EIAPP Certificate issued.

3.4.3 In general, the diesel engine group concept may be applied to any diesel engine type having the same design features, as specified in 3.4.5. However, adjustments or modifications after technical supervision during test bed measurements are allowed within the scope specified by the manufacturer. The range of diesel engines in a group and choice of parent diesel engine shall be approved by the Register.

3.4.4 The application for the diesel engine group concept to be surveyed, if requested by the manufacturer, shall be considered for approval by the Register. If the shipowner, with or without technical support from the diesel engine manufacturer, decides to perform modifications on a number of similar diesel engines in service, the shipowner may apply for the diesel engine group to be surveyed.

If a party other than the engine manufacturer applies for engine survey, the applicant or the engine survey takes on the responsibilities of the engine manufacturer as in 3.3.7.

3.4.5 Before granting an initial engine group approval for serially produced engines, the Register shall take the necessary measures to verify that adequate arrangements have been made to ensure effective control of the conformity of production. The requirements of 3.3.8 apply mutatis mutandis to this Chapter.

This requirement may not be necessary for engine groups established for the purpose of engine modification on board after an EIAPP Certificate has been issued as specified in 3.3.8.

3.4.6 Guidelines for the selection of the marine diesel engine group.

3.4.6.1 The marine diesel engine group may be defined by common design characteristics in addition to the parameters defined in 3.3.9.2 for the diesel engine family.

For engines fitted with SCR system to reduce NO_x emissions some of the parameters given in 3.3.9.2 may not be common to all engines within a group, in particular, as specified in 3.3.9.2.3 and 3.3.9.2.4.

For these 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.

3.4.6.2 The following additional design characteristics sufficiently affecting the NO_x emission limits shall be common to diesel engines within the diesel engine group:

.1 bore and stroke dimensions;

.2 method and design features of pressure charging and exhaust gas system (constant pressure, pulsating system);

.3 availability and method of charge air cooling system;

.4 design features of the combustion chamber that effect the NO_x emissions;

.5 design features of the fuel injection system, plunger and fuel pump injection cam profile or gas valve, injection nozzle;

.6 maximum (rated) power per cylinder at maximum (rated) speed.

The permitted range of derating within the diesel engine group shall be declared by the manufacturer and approved by the Register.

Whilst the parameters specified in 3.4.6.2.1 shall remain common to all engines within the group, the remaining parameters listed in 3.4.6.2 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.

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

3.4.6.3 Generally, if the criteria required by 3.4.6.2 are not common to all engines within a prospective engine group, then those engines may not be considered as an engine group. However, an engine group may be accepted if only one of those criteria is not common for all of the engines within a prospective engine group.

When considering the criteria the IACS UI MPC59 (Rev. 1 Nov 2019) shall be followed. Rated power at rated speed is considered as one parameter. Derating and uprating, in terms of power per cylinder and rated speed, outside the approved power or speed ranges shall be interpreted as deviations from the specified parameter.

3.4.7 Guidelines for allowable adjustment or modification of diesel engines surveyed within diesel engine group.

3.4.7.1 Minor adjustments and modifications are allowed after test bed measurements of the parent diesel engine to be surveyed for every diesel engine within the group upon agreement of the parties concerned and approval of the Register, if:

.1 an inspection of NO_x emission-relevant diesel engine parameters and provisions of the on-board NO_x verification procedures of the diesel engine and data provided by the manufacturer confirm that the adjusted and modified diesel engine complies with the applicable NO_x emission limits. The diesel engine test bed results of NO_x emissions shall be accepted as an option for verifying on-board adjustments or modifications to the diesel engine within the diesel engine group;

.2 on-board measurements confirm that the adjusted or modified diesel engine complies with the applicable NO_x emission limits.

3.4.7.2 Examples of adjustments and modifications for diesel engines surveyed within the diesel engine group that may be permitted but are not limited to those described below:

.1 for on-board conditions, adjustment of the following:

injection or ignition timing for compensation of fuel property differences;

injection or ignition timing for optimization of maximum cylinder pressure;

fuel delivery differences between cylinders;

.2 for performance optimization, modification of the following:

turbocharger, on condition of preserving or increasing its air charge pressure and efficiency;

pressure charge air cooler, on condition of preserving or increasing the degree of air cooling.

3.4.8 Guidelines for the selection of the parent marine diesel engine of the group.

The selection of the parent marine diesel engine from small volume production diesel engines is not always possible in the same way as the mass produced diesel engines (diesel engine family).

The first diesel engine ordered may be registered as the parent diesel engine.

Furthermore at the pre- certification test where a parent engine is not adjusted to the engine builder defined reference or maximum tolerance operating conditions (which may include, but not limited to, maximum combustion pressure, compression pressure, exhaust back pressure, charge air temperature) for the engine group, the measured NO_x emission values shall be corrected to the defined reference and maximum tolerance conditions on the basis of emission sensitivity tests on other representative engines.

The resulting corrected average weighted NO_x emission value under reference conditions shall be stated in 1.9.6 of the Supplement to the IAPP Certificate. in no case shall the effect of the reference condition tolerances result in an emission value which would exceed the applicable NO_x emission limit as required by regulation 13 of Annex VI to MARPOL 73/78.

The method used to select the parent diesel engine to represent the diesel engine group shall be approved by the Register.

3.4.9 To have the group concept approved, the manufacturer shall prepare for the Register the proofs in support of the fact that test bed trials necessary to verify both the application of this concept and the method of selection of the diesel engine within the group have been carried out. Moreover, the conformity of engine production methods (process) shall be documentary confirmed. Necessary tests shall, as a minimum, contain the measurements of all main features, adjustments and operating values, depending on the diesel engine load, which may affect the NO_x emissions.

For these tests special test diesel engines may be used.

3.4.10 The requirements of 3.3.11 apply to this Chapter, as far as reasonable and practicable.

4 TECHNICAL SUPERVISION DURING TESTS OF MARINE DIESEL ENGINES AT THE FIRM (MANUFACTURER) FOR COMPLIANCE WITH THE NO_x EMISSION LIMITS

4.1 GENERAL

4.1.1 Technical supervision during tests of marine diesel engines for their compliance with the NO_x emission limits shall be performed to have the EIAPP Certificate being issued.

As a rule, the tests are carried out at the manufacturer's. Survey of the marine diesel engine may be allowed after its installation, if no EIAPP Certificate has been issued at the manufacturer's.

4.1.2 The Chapter specifies the regulations, measurement and calculation methods for gaseous exhaust NO_x emissions from marine diesel engines under steadystate conditions, necessary for determining the average weighted value in accordance with the test cycles defined in Appendix 1.

4.1.3 The Surveyor to the Register performing technical supervision during tests shall verify compliance with the procedures herein specified, which are of primary importance. Non-compliance with these procedures may result in distortion of both the measurement results obtained and the measurement results processed.

4.1.4 The Chapter also contains the procedures of drawing up the test report, which shall be submitted to the Register, accompanied with an application for the EIAPP Certificate to be issued.

4.1.5 The surveyed marine diesel engine shall be equipped with its auxiliaries in the same manner as it would be used on board.

4.1.6 The auxiliaries, which may be fitted to the diesel engine in service may not be known at the time of manufacture and survey. It is for this reason that the average weighted NO_x emissions are calculated on the basis of brake power defined in 1.3 and calculated according to Formula (4.12.1.1-2).

4.1.7 When it is not appropriate to test the diesel engine under the conditions defined in 4.2.3 (e.g., if the diesel engine and transmission form a single integral unit) the diesel engine may only be tested with other auxiliaries fitted. The auxiliary losses shall not exceed 5 % of the maximum observed power. in case of auxiliary losses exceeding 5 %, the test conditions shall be submitted to the Register for the approval.

4.1.8 All volumes and volumetric flow rates shall be related to a temperature of 273 K and pressure of 101,3 kPa.

4.1.9 All results of measurements, test data or calculations shall be recorded in the Test Report of the diesel engine in accordance with 4.10 and as per the form given in Appendix 3.

4.1.10 Requirements for gas analysers and regulations for their calibration are given in Appendix 4.

4.1.11 Permissible deviations of measurements of controlled parameters shall comply with the values given in Appendix 5.

4.1.12 References in the Guidelines to the term "charge air" apply equally to scavenge air.

4.2 TEST CONDITIONS

4.2.1 Test air condition parameter.

The absolute temperature T_a of the engine intake air in *K*, which is determined at the engine/turborcharger intake suction filter, shall be measured, and the dry atmospheric pressure p_s, in kPa, shall be measured or calculated as follows:

$$p_s = p_b - 0{,}01 R_a p_a, \quad (4.2.1)$$

where p_a = saturation vapour pressure of the intake air, in kPa (refer to Formula (10) in 5.12.3.2 of the NO_x Technical Code).

Air parameter f_a shall be determined according to the following formulae:

.1 naturally aspirated and mechanically supercharged diesel engines operating on liquid or dual fuel

$$f_a = (99/p_s)(T_a/298)^{0,7}; \quad (4.2.1.1)$$

.2 turbo-charged diesel engines operating on liquid or dual fuel with or without cooling of the intake air

$$f_a = (99/p_s)^{0,7}(T_a/298)1{,}5; \quad (4.2.1.2)$$

.3 for engines to be tested with gas fuel only with or without cooling of the intake air the parameter f_a shall be determined according to the following:

$$f_a = (99/p_s)^{1,2}(T_a/298)^{0,6}; \quad (4.2.1.3)$$

.4 for test results to be recognized as complied with the NO_x emission limits, the parameter f_a shall be between 0,93 and 1,07.

4.2.2 Engines with charge air cooling.

4.2.2.1 The temperature of the cooling medium and the charge air temperature shall be recorded.

4.2.2.2 All engines when equipped as intended for installation on board ships shall be capable of operating within the applicable NO_x emission limit of regulation 13 of Annex VI to MARPOL 73/78 at an ambient seawater temperature of 25 °C. This reference temperature shall be considered in accordance with the charge air cooling arrangement applicable to the individual installation as follows:

.1 direct seawater cooling to engine charge air coolers. Compliance with the applicable NO_x limit shall be demonstrated with a charge air cooler coolant inlet temperature of 25 °C;

.2 intermediate freshwater cooling to engine charge air coolers. Compliance with the applicable NO_x limit shall be demonstrated with the charge air cooling system operating with the designed in service coolant inlet temperature regime corresponding to an ambient seawater temperature of 25 °C.

N o t e . Demonstration of compliance at a parent engine test for a direct seawater cooled system, as given by 4.2.2.2.1, does not demonstrate compliance in accordance with the higher charge air temperature regime inherent with an intermediate freshwater cooling arrangement as required by this Chapter;

.3 for those installations incorporating no seawater cooling, either direct or indirect, to the charge air coolers, e.g., radiator cooled freshwater systems, air/air charge air coolers, compliance with the applicable NO_x limit shall be demonstrated with the engine and charge air cooling systems operating as specified by the manufacturer with 25 °C air temperature.

4.2.2.3 Compliance with the applicable NO_x emission limit as defined by regulation 13 of Annex VI to MARPOL 73/78 shall be demonstrated either by testing or by calculation using the charge air reference temperatures (T_{SCRef}) specified and justified by the manufacturer, if applicable.

4.2.3 Power.

4.2.3.1 The basis for the measurement of average weighted NO_x emissions is brake power (uncorrected according to ISO 3046) determined by Formula (4.12.1.1-2).

4.2.3.2 Auxiliaries not necessary for the operation of the diesel engine and which may be mounted on the diesel engine may be removed for the test (refer also to 4.1.5 and 4.1.6).

4.2.3.3 Where auxiliaries have not been removed, the power absorbed by them at the test speeds shall be determined in order to calculate the dynamometer settings, except for engines where such auxiliaries form an integral part of the engine (e.g., cooling fans for air cooled engines).

4.2.4 Diesel engine air inlet system.

4.2.4.1 An engine air intake system or a test shop system shall be used presenting an air intake restriction within ±300 Pa of the maximum value specified by the manufacturer for a clean air cleaner at the speed of rated power and full-load.

4.2.4.2 If the engine is equipped with an integral air inlet system it shall be used for testing.

4.2.5 Diesel engine exhaust system.

4.2.5.1 An engine exhaust system or a test shop system shall be used which presents an exhaust backpressure within ±650 Pa of the maximum value specified by the manufacturer at the speed of rated power and full load. The exhaust system shall conform to the requirements for exhaust gas sampling, as set out in 4.9.3.

4.2.5.2 If the engine is equipped with an integral exhaust system, it shall be used for testing.

4.2.5.3 If the engine is equipped with an exhaust after-treatment device, the exhaust pipe shall have the same diameter as found in-use for at least 4 pipe diameters upstream to the inlet of the beginning of the expansion section containing the after-treatment device. The distance from the exhaust manifold flange or turbocharger outlet to the exhaust after-treatment device shall be the same as in the onboard configuration or within the distance specifications of the manufacturer. The exhaust backpressure or restriction shall follow the same criteria as above, and may be set with a valve.

4.2.5.4 Where test bed installation prevents adjustment to the exhaust gas back-pressure as required, the effect on the NO_x emissions shall be demonstrated by the engine builder and, with the approval of the Register, the emission value duly corrected as necessary.

4.2.6 Cooling system.

The test diesel engine cooling system with sufficient capacity to maintain the diesel engine at normal operating temperatures shall be used, as specified by the manufacturer.

4.2.7 Lubricating oil.

The lubricating oil used for the test shall be specified by the manufacturer.

4.3 TEST FUEL OILS

4.3.1 Fuel oil characteristics may influence the engine exhaust gas emission; in particular, some fuel bound nitrogen can be converted to NO_x during combustion. Therefore, the characteristics of the fuel oil used for the test shall be determined and recorded. Where a reference fuel oil is used, the reference code or specifications and the analysis of the fuel oil shall be provided.

4.3.2 The selection of the fuel oil for the test depends on the purpose of the test. If a suitable reference fuel oil is not available, it is recommended to use a DM-grade marine fuel specified in ISO 8217:2017 or domestic analogue, with properties suitable for the engine type. in case a DM-grade fuel oil is not available, a RM-grade fuel oil according to ISO 8217:2017 shall be used. The fuel oil shall be analysed for its composition of components and properties necessary for a clear identification and determination of fuel properties shall justify ISO 8217:2017 (DMA, DMB or RM-grade), including determination of the fuel Cetane index (ISO 4264:2018), carbon residue (ISO 10370:2014).

4.3.3 The fuel oil temperature shall be in accordance with the manufacturer's recommendations. The fuel oil temperature shall be measured at the engine inlet, or as specified by the manufacturer, and the temperature and location of measurement recorded.

4.3.4 The selection of gas fuel for testing depends on the aim of tests. in case where an appropriate standard gas fuel is not available, other gas fuels shall be used with the approval of the Administration. A gas fuel sample shall be collected during the test of the parent engine. The gas fuel shall be analysed to give fuel composition and fuel specification.

4.3.5 Gas fuel temperature shall be measured and recorded with the measurement point position together with other measurements.

4.3.6 Dual-fuel engines using liquid fuel as pilot fuel shall be tested using maximum liquid to gas fuel ratio. The liquid fraction of the fuel shall comply with 4.3.1 to 4.3.3.

4.4 PARAMETERS TO BE CHECKED

4.4.1 During tests of diesel engines for compliance with the NO_x emission limits, verification of main parameters characterising diesel engine operating modes, parameters characterising ambient temperature and state of diesel engines, and composition parameters of exhaust gaseous emissions, shall be conducted.

4.4.2 The essential parameters include the following:

torque (power);

diesel engine speed;

fuel consumption;

air consumption (exhaust gas consumption).

4.4.3 The parameters characterising diesel engine operating modes, include the following:

air temperature, pressure and humidity;

cooling medium temperature;

temperature downstream the pressure charge air cooler (if there is a pressure charging system);

inlet air depression;

exhaust back pressure.

4.4.4 The composition parameters of exhaust gaseous emissions include the following:

concentration of rated components, namely nitrogen oxide NO_x calculated as NO_2;

concentration of components, necessary for calculation of fuel specific factors F_{FD}, F_{FW}, and exhaust flow calculation by the carbon balance method (CO, HC, CO_2, O_2, particulates).

Where the air flow and fuel flow are measurable, and the fuel specific factors F_{FH}, F_{FW} are known, only the NO_x concentration may be checked unless the Register requires otherwise.

4.4.5 The data set given under Appendix 3 "Test report" (refer to Annex 5 of the NO_x Technical Code (NTC), 2008), shall not be considered definitive and any other test data (i.e. engine performance or setting data, description of control devices) shall be specified as well, relevant to the approval of a specific engine design and/or on-board NO_x verification procedures, shall also be given.

For the engine fitted with selective catalytic reduction system (SCR) and tested under Scheme A, the parameters listed in 5.2.2 of IMO resolution MEPC.291(71) shall be measured and recorded in the engine test reports:

.1 reduction catalyst/reducing agent injection speed at each load point (kg/h);

.2 exhaust gas temperature at the intended inlet and outlet of the SCR chamber (°C);

.3 pressure differential (kPa);

.4 other parameters specified by Administration.

For the engine fitted with selective catalytic reduction system (SCR), under Scheme B, the exhaust gas temperature at the intended inlet of the SCR chamber shall 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 shall be recorded during the testing.

4.5 DETERMINATION OF EXHAUST GAS FLOW

4.5.1 Direct measurement method.

This method involves the direct measurement of the exhaust flow by flow nozzle or equivalent metering system and shall be in accordance with a recognised international standard.

N o t e . Direct gaseous flow measurement is a difficult task. Precautions shall be taken to avoid measurement errors, which will impact emission value errors.

4.5.2 Air and fuel measurement method.

4.5.2.1 The method for determining exhaust emission flow using the air and fuel measurement method shall be conducted in accordance with the requirements of ISO 8178 using the following formulae:

.1 exhaust gas mass flow rate on wet basis, G_{EXHW} (for wet exhaust mass)

$$G_{EXHW} = G_{AIRW} + G_{FUEL}; \quad (4.5.2.1.1)$$

.2 exhaust gasflow rate on dry basis, V_{EXHD}, (for dry exhaust volume):

$$V_{EXHD} = V_{AIRD} + F_{FD}\, G_{FUEL}; \quad (4.5.2.1.2)$$

.3 exhaust gas mass flow rate on wet basis,, V_{EXHW}, (for wet exhaust volume):

$$V_{EXHD} = V_{AIRW} + F_{FW}\, G_{FUEL} \quad (4.5.2.1.3)$$

where

G_{FUEL}	=	fuel mass flow rate , in kg/h;
G_{AIR}	=	intake air mass flow rate, in kg/h;;
V_{AIR}	=	intake air flow rate, m^3/h;
W and D	=	symbolas indicating wet basis and dry basis of exhaust gas;
F_{FD} and F_{FW}	=	fluel specific factors.

Values of factors F_{FW}, F_{FD} shall be calculated by the method contained in Appendix 6 to the NO_x Technical Code.

4.5.3 Carbon balance method.

This method involves exhaust gas mass flow calculation from fuel consumption and exhaust gas concentrations using the carbon and oxygen balance. The method for calculating the exhaust gas mass flow using the carbon balance method is specified in Appendix 6 of the NO_x Technical Code. The method is applied where the air consumption cannot be measured on a test bed or in diesel engine surveys on board. The method is recommended for the diesel engines which work on liquid fuel without oxygen.

4.6 PERMISSIBLE DEVIATIONS OF INSTRUMENTS FOR MEASURED PARAMETERS

4.6.1 Permissible deviations of measuring instruments for all diesel engine parameters measured during survey tests shall comply with the requirements of Appendix 5.

4.7 ANALYSERS FOR DETERMINATION OF THE GASEOUS COMPONENTS

4.7.1 The concentrations of the diesel engine gaseous components shall be measured only with the analysers stated in Appendix 4.

4.7.2 Alternative systems or analysers may, subject to the approval of the Administration or the Register, on behalf of Administration, be accepted for measurements if they yield equivalent results to that of the equipment referenced in 4.7.1. Such proposed alternative systems or analysers can be applied, as qualified by using recognized national or international standards, when used to measure diesel engine exhaust emission concentrations, yield in terms of the requirements referenced in 4.7.1. The determination of equivalency shall be based upon the calculation of repeatability and reproducibility, as described in ISO 5725-1 and ISO 5725-2, or any other comparable recognized standard.

4.7.3 The Guidelines prescribe no values of consumption, pressure and temperature for sampling probes of gases in measurement equipment. The values of these parameters shall be those to comply with the requirements for measurement accuracy stipulated in Appendix 5.

4.8 PERIODICITY OF CALIBRATION OF THE MEASUREMENT INSTRUMENTS

4.8.1 All instruments used for tests, including the analysers used for the measurement of gaseous components and stated in Appendix 4, shall be calibrated in terms defined in Appendix 5.

4.9 TEST RUN

4.9.1 General.

4.9.1.1 During survey tests the modes of the test cycles, as set out in Appendix 1, shall be necessarily in accordance with the intended operation of the diesel engine. Moreover, it is recommended to maintain the test mode sequence as specified in Tables 2.2 — 2.6 of Appendix 1.

4.9.1.2 During each mode of the test cycle all parameters stated in 4.4 shall be recorded, as well as all necessary data of the diesel engine contained in the Test Report in accordance with Appendix 3.

4.9.1.3 The recommended sample selecting systems and types of analysers are enumerated in 4.9.2 — 4.9.4. Special attention shall be paid to the range of appropriate temperatures ensured in the sampling lines and to the component materials of pre-sampling system.

4.9.2 Methods for measurement of CO, CO_2, HC, NO_x, O_2 and particulates.

4.9.2.1 An analytical system for the determination of the gaseous emissions in the raw exhaust gas shall be used based on the use of analysers given in Appendix 4.

4.9.2.2 When carbon balance method is used for the calculation of the exhaust gas mass flow, in addition to gaseous components, the emission of particulates shall be calculated by the methods specified in ISO 8178-1. Unless the Register requires otherwise, indirect measurement methods to measure emission particulates may be used, namely an ISO filtration method for smoke measurement or an ISO 8178-9 opacity measurement method. in this case, the manufacturer shall submit to the Register correlation data between the smoke value and the particulates concentration in exhaust gas, which shall be measured by tests for the given diesel engine using the methods accepted by an independent test laboratory recognized by the Register.

4.9.2.3 During tests of the marine main diesel engines with the cylinder power of more than 200 kW the soot particles concentration may be taken as zero for all the test trial modes.

4.9.3 Sampling system and sampling probe.

4.9.3.1 For the raw exhaust gas, the sample for all components may be taken with one sampling probe or with two sampling probes located in the exhaust pipe and internally split to all the analysers by means of the sampling system. It is necessary to take into consideration that no condensation of the exhaust components (including water and sulphuric acid) shall occur at any point of the analytic system. The exhaust gas temperature shall be at least 190 °C at the HC sample probe, and at least 70 °C at the sample probes for other measured gas species where they are separate from the HC sample probe.

4.9.3.2 The sampling probe shall be made of stainless steel and be fitted at least 10 pipe diameters after the outlet of the engine, turbocharger, or last after-treatment device, whichever is furthest downstream, but also at least 0,5 m or 3 pipe diameters upstream of the exit of the exhaust gas system, whichever is greater. The size of the sampling probe is defined by the structure of the sampling system, for which at least 3 l/min of exhaust gas emission shall be provided.

4.9.3.3 In case of a multi-cylinder diesel engine with a branched exhaust manifold, the inlet of the probe shall be located sufficiently far downstream so as to ensure that the sample is representative of the average exhaust emission from all cylinders. in multi-cylinder diesel engines having distinct groups of manifolds, such as in a "V" engine configuration, it is permissible to acquire a sample from each group individually and calculate an average exhaust emission. in this case for exhaust gas emission calculation, the total exhaust mass flow shall be used.

4.9.3.4 If the diesel engine is provided with any exhaust after-treatment system, the exhaust sample shall be taken downstream of this device.

4.9.3.5 The material of the sampling system pipes shall not affect the composition of the analysed exhaust gas. Stainless steel and teflon comply with this requirement. Cu-base, Zn-base and Sn-base (copper-base, zinc-base and tin-base) alloys, as well as carbon steel shall not be used in sampling lines.

4.9.3.6 The exhaust gas sampling system shall be leakage tested for in accordance with Section 10 of Appendix 4.

4.9.3.7 The inlet of the probe shall be located as to avoid ingestion of water which is injected into the exhaust system for the purpose of cooling, tuning or noise reduction.

4.9.4 Checking of the analysers.

Prior to the measurements of exhaust gas composition the emission analysers shall be set at zero and spanned in accordance with the requirements specified in Appendix 4.

4.9.5 The output of the analysers shall be recorded, both during the test and during all zero and span response checks, using a data acquisition system or a strip chart recorder. The recording period shall not be less than 10 min when analysing exhaust gas or not less than 3 min for each zero and span response check.For data acquisition systems, a minimum sampling frequency of 3 per minute shall be used.

Measured concentrations of CO, HC and NO_x shall be recorded in terms of, or equivalent to, ppm to at least the nearest whole number.

Measured concentrations of CO_2 and O_2 shall be recorded in terms of, or equivalent to, percents to not less than two decimal places.

To ensure this process, the requirements for checking the analysers calibration shall be followed in accordance with 4.9.7.

4.9.6 Accuracy of modes of diesel engine.

4.9.6.1 During each mode of the test cycle, the specified speed shall be held within ±1 % of rated speed or ±3 rpm (whichever is greater), except for low idle, which shall be within the tolerances declared by the manufacturer.

4.9.6.2 The specific torque shall be held so that the average over the period during which the measurements are to be taken, is within ±2 % of the maximum torque at the test speed.

4.9.6.3 After the diesel engine mode has stabilized the values specified in 4.4.2 — 4.4.4 shall be measured and recorded.

4.9.7 Re-checking the analysers.

After the emission test, the calibration of the analysers shall be re-checked using a zero gas and the same span gas as used prior to the measurements. The tests shall be considered acceptable if the difference between the two calibration results is less than ±2 %.

4.10 TEST REPORT

4.10.1 For every diesel engine tested on a test bed, the diesel engine manufacturer shall prepare a Test Report as per the form given in Appendix 3. The original of the Test Report shall be maintained by the engine manufacturer and a certified copy shall be maintained by the Register.

4.10.2 The Test Report shall be attached as a permanent part of the Technical File of Marine Diesel Engine in accordance with 2.1.

4.11 DATA EVALUATION FOR GASEOUS EMISSIONS

4.11.1 For the evaluation of the gaseous emissions, the data recorded for at least the last 60 s of each mode shall be averaged, and the average concentrations of CO, CO_2, HC, NO_x and O_2 during each mode shall be determined from the averaged recorded data. The averaged results shall be given in terms of % to not less than two decimal places for CO_2 and O_2 species and in terms of ppm to at least the nearest whole number for CO, HC and NO_x species.

4.12 CALCULATION OF THE GASEOUS EMISSIONS

The final results for the Test Report shall be determined by following the steps in 5.12.2 — 5.12.6 of the NO_x Technical Code. Thus, the amendments to paras 5.12.3.2 — 5.12.3.3, 5.12.4 and 5.12.5.1 of the NO_x Technical Code shall be considered in accordance with IMO resolutions MEPC.251(66) and MEPC.272(69). These amendments relate to the calculations of emissions of nitrogen oxides from marine diesel engines operating on gas fuel.

4.12.1 Calculation of the average weighted NO_x emissions.

4.12.1.1 Average weighted NO_x emissions shall be calculated for all individual components by the following formula:

$$GAS_X = \frac{\sum_{i=i}^{i=n} M_{GASx,i} \cdot W_{Fi}}{\sum_{i=i}^{i=n} P_i \cdot W_{Fi}} \qquad (4.12.1.1\text{-}1)$$

where $P_i = S_i + P_{AUX} = L_i / 100 (P_m + P_{AUX})$ (4.12.1.1-2)
(with the use of Formula (4.12.6.1-1) from ISO 8178-1 applied for calculation of dynamometer setting);

i	=	subscript denoting an individual mode;
P_i	=	uncorrected effective power, in kW;
S_i	=	dynamometer setting (brake power), in kW;
L_i	=	per cent torque related to the maximum torque for the test diesel engine speed (refer to Appendix 1), in %;
P_m	=	maximum measured power at the test diesel engine speed under test conditions, in kW;
P_{AUX}	=	declared total power absorbed by auxiliaries fitted for the test only, but not required on board, in kW.

4.12.1.2 The weighing factors W_{Fi} and the number of modes n used for Formula (4.12.1.1-1) are given in Appendix 1.

4.12.1.3 The resulting average weighted NO_x emission value as determined by Formula (4.12.1.1-1) shall then be compared to regulation 13 of Annex VI to MARPOL 73/78.

The obtained average weighted NO_x emission values and limits shall be stated in the EIAPP Certificate.

5 SURVEYS OF MARINE DIESEL ENGINES ON BOARD

5.1 KINDS AND METHODS OF SURVEYS

5.1.1 Each marine diesel engine installed on board shall be subject to the following surveys:

.1 initial survey, which shall be performed after the marine diesel engine is installed but before it is used in service. This survey shall be such as to ensure that the marine diesel engine, as installed on board, including the marine diesel engine subjected to any modifications or adjustments since survey at the firm (manufacturer), complies with the NO_x emission limits specified in regulation 13 of Annex VI to MARPOL 73/78. The initial survey of the marine diesel engine, as part of the ship initial survey, precedes the issuance of the IAPP Certificate;

.2 periodical and intermediate surveys of a marine diesel engine, which has not undergone any substantial modifications since the initial survey, shall be conducted to ensure that it continues to fully comply with all the requirements of the Guidelines. These surveys shall be carried out either to confirm that the existing EIAPP and IAPP Certificates are valid, or to record any amendments therein as a result of the inspections conducted;

.3 occasional surveys shall be performed every time substantial modifications are made to a marine diesel engine to ensure that thereafter the modified marine diesel engine continues to comply with the NO_x emission limits.

5.1.2 For surveys of on-board marine diesel engines pre-certified at the manufacturer's and documented by issuance of the EIAPP Certificate there are three alternative methods, from among which one may be used by the manufacturer or shipbuilder, at their option, and they are as follows:

.1 marine diesel engine parameter check method in compliance with 6.2;

.2 simplified measurement method in compliance with 6.3;

.3 monitoring method (direct measurements) in operation in compliance with 3.4 of (used at periodical and intermediate surveys only).

5.1.3 Prior to installation on board, every marine diesel engine shall:

.1 be adjusted to meet the applicable NO_x emission limits;

.2 be surveyed at the firm (manufacturer), as documented by issuance of the EIAPP Certificate by the Register.

5.2 RULES OF ON-BOARD MARINE DIESEL ENGINES SURVEYS

5.2.1 The marine diesel engines having the EIAPP Certificates shall be surveyed after their installation on board a ship, but before putting a ship in service, this survey being a part of the ship's initial survey for compliance with the requirements of Annex VI to MARPOL 73/78. Such surveys are carried out by marine diesel engine parameter check method in accordance with the instruction contained in the Technical File of Marine Diesel Engine. The marine diesel engine parameter check method on board ship may also be applied during the periodical and intermediate ship's surveys for compliance with the requirements of Annex VI to MARPOL 73/78.

5.2.2 Those marine diesel engines, which, after installation on board, have been subjected to adjustments and/or modifications, which could affect the NO_x emission limit, shall be surveyed to demonstrate the compliance with the NO_x emission limits using the on- board NO_x verification procedure of one of the check methods in accordance with the instruction contained in the Technical File of Marine Diesel Engine.

5.2.3 During the periodical and intermediate surveys of the ship the engines having the EIAPP Certificates may also be surveyed with the use of simplified measurement method in accordance with the requirements of 6.3.

5.2.4 For periodical surveys of the marine diesel engine the shipowner has a right to choose the monitoring method (direct measurements) of the NO_x emissions during marine diesel engine operation with the use of an approved registering device. Such data may take the form of spot checks logged with other marine diesel engine operating data or may result from data storage. Data shall be current, taken within the last 30 days. Data shall also be corrected for ambient conditions and fuel specification, and measuring equipment shall be calibrated in accordance with the requirements specified in Appendix 4. If the marine diesel engine is fitted with a NO_x emission reducing device, the measuring points shall be located downstream of such device.

5.2.5 To demonstrate compliance with the NO_x emission limits by the monitoring method, sufficient data shall be collected to calculate the average weighted NO_x emissions according to the relevant test cycles, as set out in Appendix 1, taking into account the allowable deviations stated in 6.3.9.2.

5.2.6 If a marine diesel engine is fitted with a NO_x emission reducing device, there shall be options providing ready means of monitoring proper operation of such a device. Thus, where for the purpose of achieving the NO_x emission limits compliance, an additional substance is introduced, such as ammonia, urea, steam, water, fuel additives, etc., means of monitoring the consumption of such substance shall be provided. The Technical File of Marine Diesel Engine shall contain sufficient information to allow ready means of demonstrating that the consumption of such additional substances is consistent with achieving compliance with the applicable NO_x emission limits.

5.2.7 If after the survey at the firm (manufacturer) the marine diesel engine was subjected to adjustments or substantial modifications, all of them shall be described in the Record Book of Engine Parameters.

5.2.8 If all the marine diesel engines installed on board are surveyed to remain within the parameters, components and adjustable features recorded in the Technical File of Marine Diesel Engine, the marine diesel engines shall be accepted as performing within the NO_x limits.

5.2.9 If any adjustment or modification is made which is outside the approved limits documented in the Technical File, the IAPP Certificate may be issued only if the overall NO_x emission performance is verified to be within the required limits by onboard Simplified Measurement Method; or, reference to the test bed testing for the relevant engine group approval showing that the adjustments or modifications do not exceed the applicable NO_x

emission limit. At surveys after the initial engine survey, the Direct Measurement and Monitoring method, as approved by the Administration, may alternatively be used.

In these instances it shall be understood that the parent engine emission value, as given in the EIAPP Certificate, thereafter only relates to the condition of that engine at the Precertification Survey stage.

5.2.10 The Register may, upon authorization of the Administration, abbreviate or reduce all parts of the survey on board to an engine that has been issued an EIAPP Certificate. However, the entire survey on board shall be completed, for at least one cylinder and/or one engine in an engine family or engine group, if applicable, and the abbreviation may be made only if all the other cylinders and/or engines are expected to perform in the same manner as the surveyed engine and/or cylinder. As an alternative to the examination of fitted components, the survey on spare parts may be carried on board provided they are representative of the components fitted.

5.2.11 Guidance in respect of the survey and certification of marine diesel engines, installed on board, at initial, renewal, annual and intermediate surveys is given in the flowcharts in Figs. 2 and 3 of Appendix 6.

5.3 ON-BOARD NO_X VERIFICATION PROCEDURES

5.3.1 In order to confirm that the actual value of the marine diesel engine NO_x emission is within the limit range every marine diesel engine after the installation on the ship shall be surveyed for compliance with the NO_x emission limits by using the verification procedures and means of monitoring as specified by the marine diesel engine manufacturer, approved by the Register and stated in the Technical File of Marine Diesel Engine.

5.3.2 The verification procedure and means of monitoring shall make it possible for the surveyor to determine easily whether the actual value of the marine diesel engine NO_x emission is within the limit range. The verification shall not cause undue delay of the ship, require indepth knowledge of a particular marine diesel engine characteristics or assistance of a measurement devices' specialist.

5.3.3 On-board verification procedures and means of monitoring shall be determined by using one of the following methods of surveying a marine diesel engine, namely:

.1 marine diesel engine parameter check method in accordance with 6.2;

.2 simplified measurement method in accordance with 6.3;

.3 direct measurement and monitoring method in accordance with 6.4.

A selected method, relevant verification procedures and means of monitoring shall be recorded in the Technical File.

5.3.4 Where a monitoring method is specified as an on board NO_x verification procedure, the Register shall approve the following:

.1 duration of NO_x emission monitoring taking into consideration both the steady-state marine diesel engine operation conditions and the transitional ones;

.2 data recording, processing and retention;

.3 availability of instruction for checking the precision of the equipment used for these tests;

.4 availability of instruction for using the registering device.

6 SURVEY OF DIESEL ENGINES ON BOARD FOR COMPLIANCE WITH THE NO_X EMISSION LIMITS

6.1 ITEMS AND METHODS OF SURVEY

6.1.1 After installation on board a ship, every marine diesel engine surveyed at the firm (manufacturer) shall be subject to surveys as prescribed in 5.1.1 to confirm that the marine diesel engine NO_x emissions are still within the statutory limit range.

6.2 MARINE DIESEL ENGINE PARAMETERS CHECK METHOD

6.2.1 General.

6.2.1.1 The following marine diesel engines shall be eligible for the marine diesel engine parameter check method at verification surveys for compliance with the NO_x emission limits:

.1 marine diesel engines that have received the EIAPP Certificate on a test bed procedure;

.2 marine diesel engines that have undergone modifications or adjustments within the allowable range specified in the Technical File of Marine Diesel Engine after the last survey.

6.2.1.2 The marine diesel engine parameter check method shall be conducted, whenever there is a check in components and/or adjustable features of the marine diesel engine that affect the NO_x emission levels.

In compliance with IACS UI MPC77 (Rev.1 Nov 2019) a survey shall additionally be required where the component or adjustable feature change is outside that already approved for the engine group or engine family and as given in the engine's Technical File. in such cases the change shall need to be documented in accordance with 6.2.3.2.

6.2.1.3 Marine diesel engines shall be designed in advance for any easy check of components, adjustable features and marine diesel engine parameters that affect the NO_x emission levels.

6.2.1.4 The marine diesel engine parameter check method shall be intended to provide accessible means of indirect assessment of the NO_x emission performance.

6.2.1.5 If an electronic engine management system is employed, this shall be evaluated against the original settings to ensure that appropriate parameters are within "as-built" limits.

6.1.2.6 For marine diesel engines fitted with exhaust after-treatment equipment the checking of this equipment working ability, which is the major constituent of the parameter check method, is required.

6.2.2 Procedures for the marine diesel engine parameter check method.

6.2.2.1 The method of marine diesel engine parameter check method shall be based on the following procedures:

.1 documentation check of the marine diesel engine parameters, including the check of record book of engine parameters or Electronic Record Book, and verification that marine diesel engine parameters are within the allowable range specified in the Technical File of Marine Diesel Engine;

.2 actual check of the marine diesel engine components and adjustable features to verify that they fully comply with the results of the documentation survey.

6.2.2.2 The surveyor is entitled, at his discretion, to verify the data on one or all the marine diesel engine components and settings or operating values to ensure that the marine diesel engine with no, or minor, adjustments or modifications complies with the applicable emission limits and that only the components corresponding to specifications are used in the marine diesel engine.

6.2.2.3 The full check list for the marine diesel engine parameter check method is specified in Appendix 6.

6.2.3 Technical documentation.

6.2.3.1 Every marine diesel engine shall have the Technical File of Marine Diesel Engine, which identifies the marine diesel engine components, settings or operating values, which influence the NO_x and exhaust gas emissions. These settings and operating values shall be checked to ensure that the actual reading of the marine diesel engine NO_x emission is within the limit range.

6.2.3.2 When marine diesel engines are surveyed with the use of the parameter check method, the following documentation referring to the verification procedures and means

of monitoring, apart of the Technical File of Marine Diesel Engine, shall be kept on board:

.1 Record Book of Engine Parameters or Electronic Record Book for recording of all the changes made relative to a marine diesel engine components and settings;

.2 a list of the marine diesel engine designated components affecting NO_x emission amount and/or documentation of the marine diesel engine load dependent operating values (submitted by the applicant for engine certification and approved by the Register upon authorization of the Administration);

.3 technical documentation of the marine diesel engine modification components when such modification is made to any of the marine diesel engine designated components.

6.2.3.3 Record Book of Engine Parameters or Electronic Record Book of Engine Parameters shall contain the description of any changes affecting the designated marine diesel engine parameters, including adjustments, parts replacements and modifications to marine diesel engine parts. The records shall be entered chronologically in the Record Book of Engine Parameters and shall be supplemented with any applicable data for the assessment of the marine diesel engine NO_x emission level.

6.2.3.4 List of the marine diesel engine designated components affecting NO_x emission amount may be either an integral part of the Technical File of Marine Diesel Engine or its attachment and shall contain as follows:

.1 injection or ignition timing;
.2 injection nozzle;
.3 injection pump;
.4 fuel cam profile;
.5 fuel injection pressure;
.6 combustion chamber;
.7 compression ratio;
.8 turbocharger type and build;
.9 charge air cooler (pre-heater);
.10 valve timing;
.11 NO_x abatement equipment as follows:
"water injection";
"emulsified fuel";
"exhaust gas recirculation";
"selective catalytic reduction";
.12 other parameters specified by the Register in every individual case;
.13 gas valve.

6.2.3.5 Technical documentation on the marine engine component modifications shall contain data on their influence on the NO_x emissions, and it shall be supplied at the time when modifications are carried out. Test bed data obtained from the later marine diesel engine, which is within the applicable range of the marine diesel engine group concept, may be accepted.

6.3 SIMPLIFIED MEASUREMENT METHOD

6.3.1 General.

6.3.1.1 The simplified measurement method, the procedure of which is specified in this chapter, shall be applied only for periodical and occasional surveys.

6.3.1.2 To conduct periodical and intermediate surveys on board by the simplified measurement method, as a minimum, the gaseous emission concentrations of NO_x and CO_2 shall be measured in accordance with the appropriate test cycle. The weighting factors W_F and the number of modes *n* used in the calculation shall be in accordance with Appendix 1.

6.3.1.3 The marine diesel engine torque and speed shall be measured under test conditions, however if it is difficult to measure the torque directly, the brake power may be estimated by any other means approved by the Register.

6.3.1.4 In practical cases, it is often impossible to estimate the marine diesel engine fuel consumption on board. To simplify this procedure, the results of fuel consumption measurements can be derived from the test bed results report. in such cases, especially concerning residual fuel oil operation (RM-grade fuel in compliance with ISO 8217:2005) and gas fuel operation, the fuel flow rate on similar marine diesel engine modes shall be corrected for any difference in net calorific values between the fuel on board and the fuel on test bed.

6.3.1.5 All results of measurements, test data and calculations, including those used for the simplified measurement method shall be recorded in the marine diesel engine Test Report as per the form specified in Appendix 3.

6.3.1.6 When the carbon balance method used for the calculation of the exhaust gas flow, in addition to gaseous components, the emission of solid particulates shall be calculated by the methods specified in GOST ISO 8178. On the Register approval, indirect measurement methods to measure emission particulates may be accepted, namely GOST ISO 8178 filtration method for smoke measurement. In this case the manufacturer shall provide the Register with the data on correlation between the exhaust smoke value the particulates concentration, which shall be measured in tests for a given marine diesel engine type by the method agreed with an independent test laboratory recognized by the Register.

6.3.2 Marine diesel engine parameters to be measured and recorded.

Table 6.3.2 lists marine diesel engine parameters to be measured and recorded during on-board NO_x monitoring by using the simplified measurement method.

Table 6.3.2

Marine diesel engine parameters to be measured and registered

Symbol	Parameter	Dimension
H_a	Absolute humidity (mass of engine intake air water content related to mass of dry air)	g/kg
$n_{d,i}$	Marine diesel engine speed[1]	rpm
$n_{turb,i}$	Turbocharger speed[1] (if applicable)	rpm
p_b	Total barometric pressure	kPa
$p_{C,i}$	Charge air pressure after the charge air cooler[1]	kPa
P_i	Brake power[1]	kW
$q_{mf,i}$	Fuel (in case of dual-fuel engine – liquid fuel and gas)	kg/h
s_i	Fuel rack position[1] (for each cylinder, if applicable)	K
T_a	Intake air temperature at air inlet (site ambient thermodynamic air temperature)	K
$T_{SC,i}$	Air temperature after the charge cooler[1] (if applicable)	°C
T_{caclin}	Coolant temperature inlet	°C
$T_{caclout}$	Coolant temperature outlet	°C
$T_{Exh,i}$	Exhaust gas temperature at the sampling point[1]	°C

Symbol	Parameter	Dimension
T_{Sea}	Sea water temperature	°C
T_{Fuel_L}	Fuel oil temperature before the engine	°C
$T_{Fuel\ G}$	Gas fuel temperature before the engine[2]	

[1] At the *i*-th mode during the cycle.
[2] Only for engines to be tested with gas fuel.

6.3.3 Brake power.

6.3.3.1 During on-board marine diesel engine testing, brake power may be estimated by direct measurement with the help of tensometer, or by indirect method approved by the Register.

6.3.3.2 For generators, brake power is determined by using voltage and amperage measurements together with the manufacturer's declared generator efficiency. Fore propeller law governed equipment, a declared speed power curve may be applied together with the ensured capability to measure engine speed either form the free end or by ratio of camshaft speed.

6.3.4 Test fuel oils.

6.3.4.1 As a rule, all emission measurements with liquid fuel shall be carried out with the engine running on marine fuel oil of an ISO 8217:2005, DM-grade or its Russian equivalent, GOST 305-82. All emission measurements with gas fuel shall be generally carried out with the engine running on gas fuel equivalent to that specified in ISO 8178-5:2008.

6.3.4.2 On-board measurements may be allowed with the marine diesel engine running on heavy fuel oil of an ISO 8217, RM-grade or its Russian equivalent, GOST 1667. in such a case, however, the fuel bound nitrogen will be a burden to the shipowner.

6.3.4.3 In case of dual-fuel or gas-fuelled engines, the gas fuel used shall be the gas fuel available on board.

6.3.5 Sampling for gaseous emissions.

6.3.5.1 The general requirements for the sampling system specified in Appendix 4 are compulsory for taking measurements on board.

6.3.5.2 The installation on board of all engines shall be such that these tests may be performed safely and with minimal interference to the engine. Adequate arrangements for the sampling of the exhaust gas and the ability to obtain the required data shall be provided on board a ship. The uptakes of all engines shall be fitted with an accessible standard sampling point. An example of a sample point connecting flange is given in Section 5 of Appendix 8 of the NO_x Technical Code.

6.3.6 Measurement equipment.

The accuracy of the measurement equipment to be used for on-board measurements shall have an accuracy in compliance with the requirements given in Appendix 2.

6.3.7 Permissible deviations for measurements.

Tables 1 — 3 of Appendix 5 list the permissible deviations for measurements during on-board verification procedures.

6.3.8 Determination of the gaseous components concentrations.

The analytical measuring equipment and methods described in Appendix 4 shall be applied for determination of the gaseous components concentrations.

6.3.9 Test cycles.

6.3.9.1 Test cycles used for on-board testing of marine diesel engines shall conform to the applicable test cycles as specified in Appendix 1.

6.3.9.2 Marine diesel engine operation on board under standard test cycles may not always be possible based on the recommendation of the marine diesel engine manufacturer

and approved by the Register, shall be as close as possible to these cycles. Therefore, values measured in this case may not be directly comparable with test bed results because measured values are very much dependent on the test cycles.

6.3.9.3 If the number of measuring points on board differs from the number of measuring points on the test bed, the measuring points and weighing factors shall correspond to the manufacturer's recommendations and be approved by the Register.

6.3.10 Data evaluation for gaseous emissions.

6.3.10.1 For evaluation of average weighted NO_x emissions during the on-board tests by the simplified measurement method, the following values shall be determined during each mode close to the test cycle mode specified in Appendix 1:

.1 gaseous emission in accordance with requirements of 6.3.1.2 and 6.3.8;

.2 marine diesel engine torque and marine diesel engine speed or brake power in accordance with requirements of 6.3.1.3 and 6.3.3;

.3 marine diesel engine fuel consumption in accordance with requirements of 6.3.1.4 and 6.3.4.

6.3.10.2 By applying the measurement results specified in 6.10.1, the exhaust gas flow rate (G_{EXHW} and V_{EXHW}) for each marine diesel engine operation mode shall be determined in accordance with the carbon balance method. The detailed description of the method is given in Appendix 6 of the NO_x Technical Code.

6.3.11 Allowances of resulting values.

6.3.11.1 Due to the possible deviations when applying the simplified NO_x emission measurement procedures on board a ship, an allowance of ±10 % of the applicable limit value may be accepted for periodical and intermediate surveys.

6.3.11.2 The marine diesel engine NO_x emissions may vary depending on the ignition quality of fuel and the fuel bound nitrogen. If there is insufficient information available on the influence of the fuel cetane number on the NO_x formation during the combustion process and the fuel bound nitrogen conversion rate, an allowance of ±10 % may be granted for an on-board test run carried out on a RM-grade fuel specified in ISO 8217, or its equivalent, GOST 1667, except of cases when the marine diesel engine is certified on board. The fuel oil and gas fuel used shall be analysed for its composition of carbon, hydrogen, nitrogen, sulphur and, to the extent given in ISO 8217:2005 and ISO 8178-5:2008, any additional components necessary for a specification of the fuel oil and gas fuel.

6.3.11.3 In no case shall the total granted allowance for both the simplification of the on-board measurements and for the use of a heavy fuel specified in ISO 8217, RM-grade fuel, exceed 15 % of the applicable NO_x limit value.

6.4 DIRECT MEASUREMENT AND MONITORING METHOD

6.4.1 Direct measurement and monitoring method conducted continuously on board a ship in operation shall comply with the requirements of 6.4 of the NO_x Technical Code, Appendix 8 of the NO_x Technical Code, and are intended for carrying out renewal, annual and intermediate surveys. in the measurement procedures and calculations of the NO_x specific emissions, this method is identical to the simplified measurement method described in detail in 6.3.

6.4.2 For this method to be applied at least the following is required:

emission species measurements;
engine performance measurements;
ambient condition measurements;
provision of load according to test cycles;
data for emission calculation;
fuel oil composition;
data for demonstrating compliance (that is within 30 days).

6.4.3 The direct measurement and monitoring method shall be documented in an Onboard Monitoring Manual. The Onboard Monitoring Manual shall be submitted to the Register for approval. The approval reference of that Onboard Monitoring Manual shall be entered under Section 3 of the Supplement to the EIAPP Certificate. The Register may issue a new EIAPP Certificate, with the details in Section 3 of the Supplement duly amended, if the method is approved after the issue of the first EIAPP Certificate, i.e. following the pre-certification survey.

6.4.4 The survey of the direct measurement and monitoring method shall take into account, but is not limited to:

.1 the data obtained and developed from the required measurements;

.2 the means by which that data has been obtained, taking into account the information given in the Onboard Monitoring Manual.

7 SURVEY OF THE EXISTING ENGINE

7.1 Where an existing engine shall comply with regulation 13.7 of Annex VI to MARPOL 73/78, then the entity responsible for obtaining emissions survey shall apply to the Register for survey.

7.2 Where an application for the approved method approval includes gaseous emission measurements and calculations, those shall be in accordance with Chapter 5 of the NO_x Technical Code.

7.3 Emission and performance data obtained from one engine may be shown to apply to a range of engines.

7.4 The approved method for achieving compliance with regulation 13.7 of Annex VI to MARPOL 73/78 shall include a copy of the Approved Method File which is required to accompany the engine throughout its life on board ship.

7.5 A description of the engine's onboard verification procedure shall be included in the Approved Method File.

7.6 After installation of the approved method, a survey shall be conducted in accordance with the Approved Method File.

If this survey confirms compliance, the Register shall amend the ship's IAPP Certificate accordingly.

APPENDIX 1

NO_X EMISSION STANDARDS AND TEST CYCLES

1 NO_x EMISSION STANDARDS FOR MARINE DIESEL ENGINES

1.1 The maximum allowable NO_x emission limit values are given in paras 3, 4, 5.1.1 and 7.4 of regulation 13 of Annex VI to MARPOL 73/78 as applicable. The total weighted NO_x emissions, as measured and calculated, rounded to one decimal place, in accordance with the procedures in the Guidelines, shall be equal to or less than the applicable calculated value corresponding to the rated speed of the engine.

1.2 When the engine operates on test fuel oils in accordance with 5.3, the total emission of nitrogen oxides (calculated as the total weighted emission of NO_2) shall be determined using the relevant test cycles and measurement methods as specified in the Guidelines.

1.3 An engine's exhaust emissions limit value, given from the formulae included in paragraph 3, 4 or 5.1.1 of regulation 13 of Annex VI to MARPOL 73/78 as applicable, and the actual calculated exhaust emissions value, rounded to one decimal place for the engine, shall be stated in the engine's EIAPP Certificate. If an engine is a member engine of an engine family or engine group, it is the relevant parent engine emission value that is compared to the applicable limit value for that engine family or engine group. The limit value given here shall be the limit value for the engine family or engine group based on the highest engine speed to be included in that engine family or engine group, in accordance with paragraphs 3, 4 or 5.1.1 of regulation 13 of Annex VI to MARPOL 73/78, irrespective of the rated speed of the parent engine or the rated speed of the particular engine as given on the engine's EIAPP Certificate.

1.4 In the case of an engine to be surveyed in accordance with paragraph 5.1.1 of regulation 13 of Annex VI to MARPOL 73/78 the specific emission at each individual mode point shall not 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 specified in 2.5;
.2 the 10 % mode point in the C1 test cycle specified in 2.6;
.3 the idle mode point in the C1 test cycle specified in 2.6.

2 TEST CYCLES AND WEIGHTING FACTORS

2.1 For every individual engine or parent engine of an engine family or engine group, one or more of the relevant test cycles specified in 2.2 – 2.6 shall be applied for verification of compliance with the applicable NO_x emission limits contained in regulation 13 of Annex VI to MARPOL 73/78.

2.2 For constant speed marine diesel engines for ship main propulsion, including diesel electric drive, test cycle E2 accordance with Table 2.2 shall be applied.

For those cases when the installed engine with a constant speed can be used either exclusively as the main engine or for auxiliary purposes, then such an engine shall be certified for both test cycles E2 and D2. Where the generator is permanently installed or coupled to the main engine, which is a part of the propulsion shafting system, then certification of such a main engine only in E2 or E3 cycles, as applicable, shall be required.

Table 2.2

Test cycle for constant speed main propulsion application (including diesel electric drive or variable pitch propeller installations)

Test cycle type E2	Speed, %	100	100	100	100
	Power, %	100	75	50	25
	Weighting factor	0,2	0,5	0,15	0,15

2.3 For variable pitch propeller sets, test cycle E2 shall be also applied.

2.4 For propeller low operated main and propeller low operated auxiliary engines, test cycle E3 shall be applied in accordance with Table 2.4.

Table 2.4

Test cycle for propeller low operated main and propeller low operated auxiliary engine application

Test cycle type E3	Speed, %	100	91	80	63
	Power, %	100	75	50	25
	Weighting factor	0,2	0,5	0,15	0,15

2.5 For constant speed auxiliary engines, test cycle D2 shall be applied in accordance with Table 2.5.

Table 2.5

Test cycle for constant speed auxiliary engine application

Test cycle type D2	Speed, %	100	100	100	100	100
	Power, %	100	75	50	25	10
	Weighting factor	0,05	0,25	0,3	0,3	0,1

2.6 For variable speed, variable load auxiliary engines, not included above, test cycle C1 shall be applied in accordance with Table 2.6.

Table 2.6

Test cycle for variable speed, variable load auxiliary engine application (pressure chargers, cranes, drilling pumps)

Test cycle type C1	Speed, %	Rated				Intermediate			Idle
	Power, %	100	75	50	10	100	75	50	0
	Weighting factor	0,15	0,15	0,15	0,1	0,1	0,1	0,1	0,15

2.7 The torque figures given in test cycle C1 in percentage values represent for a given test mode the ratio of the required torque to the maximum possible torque at this given speed.

2.8 The intermediate speed for test cycle C1 shall be declared by the manufacturer, taking into account the following requirements:

.1 for marine diesel engines, which are designed to operate over a speed range on a full load torque curve, the intermediate speed shall be declared maximum torque speed, if it occurs between 60 and 75 % of rated speed;

.2 if the declared maximum torque speed is less than 60 % of rated speed, then the intermediate speed shall be 60 % of the rated speed;

.3 if the declared maximum torque speed is greater than 75 % of rated speed, then the intermediate speed shall be 75 % of the rated speed;

.4 for marine diesel engines, which are not designed to operate over a speed range on the full load torque curve at steady state conditions, the intermediate speed will typically be between 60 and 70 % of the maximum rated speed.

2.9 If the marine diesel engine manufacturer applies for a new test cycle application on the marine diesel engine already surveyed under a different test cycle specified in 2.2 — 2.6, then it may be sufficient to demonstrate compliance by recalculation, by applying the measurement results from the specific modes of the first survey test to the calculation of the total weighted emissions for the new test cycles application, using the corresponding weighting factors from the new test cycle.

APPENDIX 2

TECHNICAL FILE (UNIFIED FORM DEVELOPED BY THE REGISTER)

TECHNICAL FILE (UNIFIED FORM DEVELOPED BY THE REGISTER)
(sample form)

Manufacturer's trademark

Manufacturer's full name

Approved by
(signature, position and full name of the official appointed by the manufacturer)
stamp

TECHNICAL FILE

of emissions from marine diesel engine

_____(
marine diesel engine identification as assigned by the manufacturer)

surveyed as a parent engine of the marine diesel engine family/group or as a member engine of the marine diesel engine family/group (hereinafter referred to as "the Technical File").

The Technical File is worked out in compliance with provisions of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, (hereinafter referred to as "the Convention") as modified by the Protocol of 1978 relating thereto.

Engine manufacturer	Model (type) number	Serial number	Test cycle(s) by ISO 8178 (Part 4)	Rated power (kW) and speed (rpm)	Engine approval number

This is to certify that the Technical File:

.1 is drawn up on the basis of the test bed engine trials (or onboard trials) for the issuance of Certificate of Compliance with the requirements of regulation 13 of Annex VI to the Convention and NO_x Technical Code;

.2 contains the necessary data about procedures of holding initial and periodical surveys on parent and member engines of marine diesel engine family/group on board ship;

.3 the above-mentioned procedures fully comply with the requirements of regulation 13 of Annex VI to the Convention and NO_x Technical Code.

Prepared by: _____
(full name of the organization recognized by the Register)

Approved by: _____
(name of Classification Society)

_____ seal or stamp as _____
(date of approval) (full signature of the authorized official)

_____ _____
(date of agreement) (full signature of the authorized official)

_____ _____
(date of working out) (full signature of the authorized official)

1. PARTICULARS OF THE ENGINE

1. Name and address of manufacturer

2. Place of engine build

3. Date of engine build

4. Place of pre-survey test

5. Date of pre-survey test

6. Engine type

Number of cylinders Cylinder diameter, mm Bore and stroke dimensions, in mm

7. Engine serial number

8. Engine is: Individual engine Parent engine

Family member engine Group member engine

9. Test cycle(s) (according to ISO 8178, Part 4)

10. Rated maximum continuous power, in kW, and engine speed, in rpm

11. Calculated average effective cylinder pressure/maximum cylinder pressure, in MPa

12. Engine approval certificate number

13. Test fuel grade (and/or number of fuel sample analysis certificate)

14. Maximum permissible values of NO_x emission, in g/kW·h

15. Measured values of noxious substances emission:

NO_x, in g/kW·h CO, in g/kW·h

HC, in g/kW·h Concentration of smoke particulates, in %

1 INFORMATION ON MARINE DIESEL ENGINE FAMILY/GROUP

1.1 FORMATION OF A MARINE DIESEL ENGINE FAMILY/GROUP

1.1.1 Design features of marine diesel engine family/group.

The marine diesel engine family/group (the identification of an engine as belonging to a family or a group) is formed on the basis of totality of engines general design features, the identity of which ensures the likeness of values of noxious substances contained in exhaust gas emissions.

Example: the Gr6S50MC-C group comprises two-cycle crosshead slow speed water-cooled main engines with uniflow valve-control scavenging, open combustion chamber, direct fuel injection (motor and heavy fuels), separate high pressure fuel pumps, turbo-supercharge and scavenging air cooling; these engines are fixed-pitch propeller engines and are tested according to the E2 cycle specified by ISO 8178 (Part 4).

1.1.2 Technical features of family/group marine diesel engines.

List of engine family design features according to ISO 8178 (Part 7)/group design features according to ISO 8178 (Part 8)	Units of measurement
1	2
Family or group identification Operation cycle Cylinder diameter Bore and stroke dimensions Ignition method/system Coolant medium Cylinders configuration Air supply/scavenging method/system Pressure charging/air aspiration method/system Type and design features of pressure charging equipment Method of scavenging air cooling Number of inlet valves/scavenging ports per cylinder Total cross-section area of inlet valves/scavenging ports Number of outlet valves/scavenging ports per cylinder Total cross-section area of outlet valves/scavenging ports Fuel type Combustion chamber type and design features Fuel system type and design features Unit injector type and design features Injection spray tip/nozzle type and design features Number of injection spray tip/nozzle openings Injection spray tip/nozzle openings diameter and disposition Injection timing angle at rated power Method of cycle fuel speed (power) adjustment Cylinder output range within the family/group Rated engine speed range within the family/group Cylinder number range Total compression ratio Other design features influencing the exhaust gas noxious substances emission	

1.1.3 Recommendations for filling in Chapter 1.1.

The main design features as a whole, on the basis of which a family/group is formed, are determined by their manufacturer who is fully responsible to the classification society and customer for the correctness of the choice made.

The chapter specifies the list of main design features recommended by ISO 8178 (Part 7) for forming a marine diesel engine family and ISO 8178 (Part 8) for forming a marine diesel engine group. The manufacturer is entitled to alter or supplement the recommended list of design features substantially influencing the values of exhaust gas noxious substances emission.

1.2 CRITERIA FOR SELECTION OF A PARENT ENGINE OF THE FAMILY/GROUP FOR TEST BED TRIALS

Main criterion	
Maximum average weighted NO_x emission value (according to test cycle modes recommended by ISO 8178 (Part 4), in g/kW·h)	
With minimum specific effective fuel consumption (according to test cycle modes recommended by ISO 8178 (Part 4), in g/kW·h)	
Additional criteria	
Maximum average effective pressure, in MPa Maximum maximum combustion pressure, in MPa Maximum rated cylinder power, in kW Maximum rated engine speed, in min^{-1} Maximum temperature of charge air at rated power, in °C Largest angle of injection timing at rated power, in °CA BTDC Lowest pressure of air aspiration/charged air, in kPa Other design features	

N o t e . The criteria for selection of the family/group parent engine shall ensure that it has the highest average weighted NO_x emission value and these criteria are adopted in accordance with ISO 8178 recommendations (Parts 7 and 8). The manufacturer is entitled to alter or supplement the recommended list of criteria substantially influencing the values of exhaust gas noxious substances emission.

1.3 MARINE ENGINE DESIGN FEATURES CAUSING NOXIOUS EMISSION REDUCTION

Design features	Type and characteristic
Electronic injection or ignition control Variable injection timing angle or ignition Adjustable turbocharger Charge air cooling system Exhaust gas re-circulation Water/emulsion injection Exhaust gas after treatment equipment Double fuel	

N o t e . Design features of the equipment for reduction of harmful substances emission are listed only if such features are available.

1.4 RECOMMENDED CONTROL OF CORRECTNESS OF THE PARENT ENGINE SELECTION

The application of the engine family/group concept provides for test bed trials to estimate the full scope of the average weighted NO_x emission value only for the family/group parent engine. in order to ensure the selection correctness it is recommended to apply the following method.

The method is based on the use of general inverse relationship between the average weighted NO_x emission value and specific average weighted heat consumption $NO_x \rightarrow f(1/b)$.

All possible effects on operating values and marine diesel engine characteristics within the family/ group, which cause the increase of the specific average weighted heat consumption, decrease the average weighted NO_x emission value, and vice versa.

So, the parent engine shall have the highest level of the NO_x emission and the lowest specific average weighted effective heat consumption, which is determined according to the formula

$$b = (\sum_{i=1}^{n} Bi \cdot Fw_i)/(\sum_{i=1}^{n} Pe_i \cdot Fw_i),$$

where Bi = fuel consumption per hour reduced to thermal/calorific power of 42,0 MJ/kg; kg/h;
Pe_i = effective brake power under conditions specified in ISO 3046 (Part 1), in kW;
Fw = mode weighing factor.

The correctness of the family/group parent engine selection shall be confirmed by the following inequality:

(*b*) *parent engine* ≤(*b*) *family/group member*, which guarantees complying with the condition (*eNO$_x$*) *parent engine* ≥(*eNO$_x$*) *family/group member.*

If according to the results of the tests, it is established that average effective heat consumption per cycle by the family/group member engine is lower than average effective heat consumption per cycle by the parent engine, then the former engine shall be recognized as a new parent engine for the family/group. The test bed technical supervision procedure of the new parent engine shall be carried out on full scale with the estimation of the exhaust gas composition.

2 DATA ON COMPONENTS, SETTINGS AND OPERATING VALUES INFLUENCING MARINE DIESEL ENGINE EMISSION OF HARMFUL SUBSTANCES

2.1 COMPONENTS

In this Chapter of the Technical File form the manufacturer specifies all components substantially affecting the noxious substances emission and offers the method of their identification for the tests. The recommended list of the components and spare parts is given in Table 2.1.

Table 2.1

Item of survey	Component	Source of identification	Information for number reference
Combustion chamber	Cylinder liner	Fig. 1.1-1, Appendix A	
	Cylinder cover	Fig. 1.1-2, Appendix A	
	Piston crown	Fig. 1.1-3, Appendix A	
Fuel equipment	Fuel pump barrel	Fig. 1.2-1, Appendix A	
	Fuel pump plunger	Fig. 1.2-2, Appendix A	
	Fuel valve nozzle	Fig. 1.2-3, Appendix A	
	Roller guide for fuel pump	Fig. 1.2-4, Appendix A	
Air supply system	Turbocharger	Figs 1.3-1 and 3.1, Appendix A	
	Compressor	Fig. 1.3-1*a*, Appendix A	
	Turbine	Fig. 1.3-1*b*, Appendix A	
	Diffuser	Fig. 1.3-1*c*, Appendix A	
	Nozzle ring	Fig. 1.3-1*d*, Appendix A	
	Charge air cooler		
	Auxiliary blast/draught blower		
Outlet system	Roller guide for outlet valve drive (or camshaft)	Fig. 1.3.2, Appendix A	
	Outlet valve		
	Other components		

2.1.1 Comments on Chapter 2.1.

The Chapter specifies the list of components substantially influencing exhaust gas noxious substances emissions that is recommended by ISO 8178 (Parts 7 and 8). The manufacturer has a right to change or supplement the recommended list.

Either the firm (manufacturer) design drawing number, or catalogue number, used for booking original spare parts produced by the manufacturer or buying them through the firm (manufacturer) official dealer, can be used as a component identification number.

The place for applying the component marking is usually indicated by the manufacturer in Appendix A.

If the components and spare parts listed in Table 2.1 are replaced by other ones, the latter shall have the manufacturer's marking. The spare part replacements shall be registered in the Design Modifications

Record Book which shall be kept on board.

The components and spares without marking cannot be identified and the marine diesel engine with such components and spares cannot be recognized as compliant with the emission standards.

If a part is substituted by another part having a different identification number, another family/group identification shall be assigned to the engine.

The turbochargers produced by different manufacturers can be employed on condition that they provide either the same or better operating values in the test run carried out according to the standard manufacturer's program.

The air supply system can be fitted with a different type of scavenging air cooler if the latter provides the same or lower scavenging air temperature at the same sea-water cooling temperature.

The two-stroke marine diesel engine may be fitted with an auxiliary blast/draught blower if the identical characteristics of scavenging air output and pressure are provided.

If different kinds of marine diesel engines having different lists of equipment are combined into one family (in compliance with all requirements and restrictions imposed by this concept) a table (similar to Table 2.1) shall be compiled for every kind (list of equipment) of the marine diesel engine belonging to the family.

2.2 SETTINGS

In this Chapter of the Technical File the manufacturer shall show all settings substantially influencing the exhaust gas noxious emissions together with the permissible range of their alterations and the method of their checking during the onboard surveys. The recommended settings and permissible range of their changes are given in Table 2.2.

Table 2.2

	Parameter	Source of identification	Information for reference	Range
Main characteristics of marine diesel engine	Maximum continuous rating, in kW	Test Protocol		
	Engine speed at maximum continuous power, in rpm	Test Protocol		
	Average effective pressure at maximum continuous rating, in MPa (bar)	Calculation		
	Other characteristics			
Settings	Maximum combustion pressure, Pmax, maximum continuous power (if measured), in MPa (bar)			
	Injection timing angle			
	Compression ratio			
	Angle of installation of roller guide for outlet valve drive			
	Adjustable clearances in valve timing gear. Injector nozzle needle opening/ closing pressure, in MPa (bar)			
	Other settings			

2.2.1 Comments on Chapter 2.2.

The Chapter specifies the list of settings substantially influencing the exhaust gas harmful substances emissions. The list is recommended by ISO 8178 (Parts 7 and 8).

The manufacturer has a right to change or supplement the recommended list of settings substantially influencing the exhaust gas harmful substance emissions.

Table 2.2 normally specifies the average setting values estimated in the course of the test bed trials. More detailed information on settings for each engine cylinder and methods of their control can be found in Appendix A.

If the marine diesel engine family concept is applied, the alteration of settings after test bed trials is permitted only within the limit range allowed by the manufacturer's technical specifications.

If the marine diesel engine group concept is applied, it is permitted to adjust the engine to provide, at the place of its installation, for the following:

continuous cycle fuel feed to cylinders;

optimization of maximum combustion pressure in cylinders;

compensation for differences in fuel characteristics (diesel fuel and heavy fuel).

The methods of checking the settings shall be listed as a separate chapter of Appendix A or an individual appendix/supplement.

2.3 OPERATING VALUES

In this Chapter of the Technical File the manufacturer specifies all the operating values substantially influencing the exhaust gas noxious emissions together with their permissible tolerance range in accordance with the NO_x Technical Code. The recommended parameters of the operating values and permissible range of their deviation from the standard are specified in Table 2.3.

Table 2.3

	Parameter, units of measurement	Parameter values of parent engine at standard ambient conditions according to ISO 3046 (Part 1)				Permissible tolerance limits			
Engine parameters	Maximum continuous rating/power, in kW								
	Supercharge (excessive) pressure, in kPA								
	Scavenging air temperature, in °C								
	Exhaust gas temperature upstream of the turbine, in °C								
	Maximum pressure in the cylinder (if checked), in MPa								
	Compressive stress (if checked), in MPa								
	Exhaust back pressure, in kPa								
	Depression at the inlet, in kPa								
	Specific effective fuel consumption (if checked), in g/kW·h								
	Other operating values								
Standard ambient conditions according to ISO 3046 (Part 1)	Atmospheric pressure, in kPA	100,0							
	Atmospheric air temperature, in °C	25							
	Absolute atmospheric air humidity, in g water/kg dry air	10,71							
	Seawater temperature, in °C	25							

2.3.1 Comments on Chapter 2.3.

The Chapter contains the list of operating values substantially influencing the exhaust gas noxious emissions. These values are recommended, on the basis of practical experience

in testing marine diesel engines, by the author of this document for issuing a corresponding certificate. The manufacturer has a right to change or supplement the recommended list of operating values substantially influencing the exhaust gas noxious emissions.

As reference values for operating parameters, the compromise values between the expected values (according to manufacturer's specifications and design values) and actual ones (obtained during the test bed trials) may be adopted. The actual measured operating values shall be within the limit range of their permitted alterations.

The operating values shown in Table 2.3 can vary depending on the atmospheric conditions, engine settings and fuel type.

To correct the operating values monitoring, when the engine is surveyed on board, methods of reducing the operating values to standard atmospheric conditions shall be described either in the section of the Technical File dedicated to survey procedures or in a separate appendix. If the method of reducing operating values to standard atmospheric conditions is worked out by the manufacturer and differs from the standard one it shall be approved by the Register.

In order to exclude the effect of settings on the measured values of working parameters, the monitoring of the latter shall be performed only after the check of the setting.

It is not recommended to check the engine operating values with the use of different fuel types.

During the onboard periodical surveys of engine group members the following can serve as a source of information about the operating values checking and their permissible divergence limits:

this Technical File;

Protocol of Test Bed Marine Diesel Engine Trials;

Record Book of Engine Parameters or Electronic Record Book of Engine Parameters which shall be included into the marine diesel engine maintenance documentation.

3 DATA ON MARINE DIESEL ENGINE TEST BED TRIALS

In this Section of the Technical File the manufacturer specifies general information about the tests including the program of tests, brief description of the methods applied for measuring both main and auxiliary values, and test results. The program and methods of tests may be presented as a separate supplement.

3.1 TEST BED

In this Chapter of the Technical File the manufacturer gives a short description of the motor test bed and of its starting, loading, air inlet and outlet, fuel and cooling systems.

If the engine was tested on board ship the information about similar systems available on board is given.

3.2 PARAMETERS TO BE MEASURED AND MEASURING EQUIPMENT

In this Chapter of the Technical File the manufacturer specifies the measurement parameters required for estimation and calculation of the engine emission standards. The list of the parameters to be measured shall include the following values:

effective brake power P, in kW; crankshaft speed n, in rpm;

mass fuel consumption per hour, in kg/h;

exhaust gas flow rate V_{exh}, in m^3/h, reduced to normal atmospheric conditions (P_o = 101,3 kPa, T_o = 273 K);

inlet air temperature T_a, in K;

total barometric pressure p_a, in kPa;

air relative humidity j, % or air absolute humidity H, in g/kg;

temperature of cooling liquids (water and oil), in K;

other operating values provided for by the preliminary Technical File;

carbon oxide concentration in exhaust gases CO, in vol % (ppm);

nitrogen oxide concentration in exhaust gases (as reduced to NO_2), NO_x, in vol % (ppm);

concentration of all hydrocarbons in exhaust gases (as reduced to HC 1,85) HC, in vol % (ppm);

carbon dioxide concentration in exhaust gases CO_2, in vol % (if the exhaust gas flow rate is estimated by carbon balance method);

oxygen concentration in exhaust gases O_2, in vol % (if the exhaust gas flow rate is estimated by oxygen balance method or for the calculation of the exhaust gas dilution degree when simplified measurements are carried out);

concentration of smoke particulates in exhaust gases (it is measured by optical or filtration method).

A complete list of measurement equipment shall be given in the Test Protocol.

In a separate supplement the data about calibration of the measurement equipment are shown (copies of certificates).

The information about calibration means and results of the last measurement equipment calibration carried out in accordance with the requirements of the NO_x Technical Code is also included into the supplement. An example of how to introduce the calibration results into the supplement is shown in Appendix C.

Reducing the NO_x measured values to standard atmospheric conditions according to ISO 3046 (Part 1) is effected in compliance with the procedure of the NO_x Technical Code.

3.3 TEST PROTOCOL

The Test Protocol is either a compulsory chapter or a separate supplement to the Technical File. Its form and content are regulated by the requirements of the NO_x Technical Code, as amended.

The selection of the on-board marine diesel engine survey procedure for compliance with the emission standards is effected by the manufacturer and is approved by the Register.

3.4 SELECTION OF SURVEY PROCEDURE

The surveys of engines installed on the ship for compliance with the noxious substances emission standards and smoke concentration standards are recommended to be carried out by one of the following methods:

method of parameter check;

method of simplified measurements;

method of monitoring (direct measurements) in the process of maintenance.

The method of parameter check is recommended as the main method of engine surveys on board, on condition that the marine diesel engine was surveyed by the manufacturer.

The method of simplified measurements is recommended for usage during the initial and periodical surveys of engines which were not subjected to substantial modifications after their installation on board ship, if the tests for issuing certificates were carried out by the manufacturer, but the test results were not recorded in accordance with the requirements of the NO_x Technical Code.

The method of monitoring (method of direct measurement) in the process of ship's maintenance is recommended for application during periodical engine surveys on ships where the engine room is fitted with special measuring equipment.

3.5 PROCEDURE OF PARAMETERS VERIFICATION METHOD

3.5.1 Checking components.

Checking components influencing harmful substances emissions is effected by verifying their marking and identification numbers against the data of Table 2.1. The place where each part is marked shall be indicated on drawings (refer to Appendix A). If it is impracticable to see the marking and identification numbers on the part, it is permitted to verify them against the records in the Record Book of Marine Diesel Engine Modifications which shall be included into complete set of documents on marine diesel engine maintenance.

3.5.2 Settings check.

The check of settings compliance with the initial values used for test bed trials (taking into account the range of their alterations) is held in accordance with the list specified in Table 2.2. The check procedure is carried out with the use of methods and techniques recommended in the engine manufacturer's technical documents. An example of recording the results of checking adjustable settings is given in Appendix A.

The shipowner may offer alternative checking methods if there are appropriate facilities for their implementing on board. The settings are checked during both the initial and periodical surveys.

3.5.3 Operating values check.

The check of operating values compliance with the initial values used for survey trials is held in accordance with the list specified in Table 2.3.

The verifying of the operating values compliance, at the shipowner's option, may be performed during mooring tests or by method of monitoring. The monitoring, for the purpose of this test, is understood as the process of operating values registering when the engine is

running, and in the course of its operation it is developing an output corresponding to the output of the standard test cycle.

The procedure of verifying the operating values compliance against their initial values is the procedure of comparing the measured values with the values given in Table 2.3 at the appropriate engine operation modes considering the permissible tolerance limits. The engine output generated during the check mode shall correspond to the test bed output with +5 % tolerance.

The results of the operating values measurement are entered in the Record Book of Engine Parameters or Electronic Record Book of Engine Parameters the latters shall be included into the set of documents on marine diesel engine maintenance. The check of operating values parameters compliance with their initial values during the group member marine diesel engine survey can be held with the use of record from the Record Book of Engine Parameters or Electronic Record Book of Engine Parameters.

An example of registering the recommended methods of operating values check is given in Appendix B.

The recommended checklist for the parameters verification method includes the following engine parts and parameters:

unit injector: its type, components and settings identification;

fuel pump: identification of its type, settings and components which influence the amount, injection timing angle and type of fuel feed;

injection cam profile;

fuel injection pressure;

combustion chamber;

compression ratio;

turbocharger type, design and operating parameters;

pressure charged air heater (cooler) type, design and operating parameters;

valve timing phases;

driving shaft cam profile of inlet/outlet valves with the indication of the number and sizes of the latter;

NO_x reducing device, its type and design features;

other design features and settings.

4 TEST BED TRIALS PROTOCOL

(sample form)

Full name of the testing company _____

Test laboratory _____

"Laboratory for Internal Combustion Engine Emission Control"

Recognized by the Russian Maritime Register of Shipping
Certificate of Recognition
Reg. № 00. 002. 002 (21001200)
of 31 March 2000

Approved by
Head of Laboratory
_____
_____
"_____"_____20____
Official stamp

Protocol №_____

of parent marine diesel engine tests_____of the family/group

_____for compliance with the requirements of the Technical Code on Control of Emissions of NO_x from Marine Diesel Engines.

St. Petersburg
20__

1 GENERAL INFORMATION

Sheet 1

Engine manufacturer	
Manufacturer's address	
Manufacturer's trademark	
Marine diesel engine family/group identification	
Serial number	
Date of build	
Technical characteristics	
Rated engine speed n, in rpm	
Rated engine power P_e, in kW	
Number of cylinders	
Cylinder diameter D, in mm	
Bore and stroke dimensions S, in mm	
Cylinders configuration	
Operating volume	
Geometric injection or ignition timing angle	
Compression ratio (geometrical)	
Mean effective pressure at rated power	
Pressure charge method	
Design features	
Electronic injection or ignition control	
Variable injection timing angle or ignition control	
Adjustable turbocharger	
Scavenging air cooling system	
Exhaust gas re-circulation	
Water/emulsion injection	
Exhaust gas after treatment equipment	
Double fuel	
Restrictions	
Maximum combustion pressure	
Maximum cooling water temperature	
Maximum depression at the inlet	
Maximum exhaust back pressure	
Maximum temperature of oil for bearings lubrication	
Minimum pressure of oil for bearings lubrication	
Application/intended for	
Customer	
Final application, ship	
Final application, engine	
Test run data	
Test type	
Test date	
Test place	
RS surveyor	
Date of Protocol issue	
Test laboratory	

2 INFORMATION ON MARINE DIESEL ENGINES GROUP

Sheet 2

Design features characteristic to a group of marine diesel engines

Group identification number	
Manufacturer's specification	
Operating cycle	
Cylinder diameter, in mm	
Bore and stroke dimensions, in mm	
Ignition method	
Cooling medium	
Cylinders configuration	
Scavenging (air supply) method	
Pressure charge method	
Fuel type	
Combustion chamber	
Type of fuel system	
Init injector (two per cylinder)	
Injector spray tip (nozzle)	
Diameter of nozzle openings	
Cylinder power	
Rated engine speed *n*, in rpm	
Cylinders number range	
Ignition method	

Criteria for selecting the parent engine for test bed trials

Main criteria	
Highest average weighted NO_x emission value reduced to standard ambient conditions (in accordance with the test mode recommended by ISO 8178 (Part 4))	
Lowest specific effective fuel consumption (in accordance with the test mode recommended by ISO 8178 (Part 4))	
Additional criteria	
Highest average effective pressure	
Highest maximum combustion pressure	
Highest temperature of scavenging air	
Largest fuel injection timing angle	
Other criteria	

3 DATA ON MEASURING EQUIPMENT

Sheet 3

Gas analyzers

Measured parameter, units of measurement	Manufacturer (country)	Model and type of detector	Range of span	Calibration gas concentration	Deviation, in %[1]
NO_x concentration, in ppm CO concentration, in ppm CO_2 concentration, in % O_2 concentration, in % HC concentration, in ppm					

[1] Deviation, in %, refers to the deviation of the analyzer calibration and not the deviation of the span gas concentration.

Sample preparation block

Manufacturer (country)	Model, its number	Temperature in the measuring channels, in °C				
		in the sample taking main	HC	CO, CO_2	O_2	NO_x

Other means of measuring

Measured parameter, units of measurement					
Main value readings					
Engine speed, in rpm Torque, in kg·m Fuel portion, in kg Time of portion consumption, in s					
Means of measuring auxiliary values Temperature					
Coolant agent, in °C Lubricating oil, in °C Exhaust gases, in °C Intake air, in °C Scavenging air, in °C Fuel, in °C					
Pressure					
Atmospheric, mm of mercury Pressure charge air, in bar In cylinder, in bar In outlet collector, in bar					
Humidity					
Intake air, in %					

4 DATA ON FUEL AND LUBRICATING OIL

Sheet 4

Fuel

Grade (ISO 817:2017) Density according to ISO 3675 Viscosity according to ISO 3104 Lowest combustion heat Elemental fuel composition (according to analysis): C H S N O F_{FD} F_{FW} Gas fuel characteristics (in compliance with IMO resolution MEPC.272(69), as amended) Cetane index (ISO 4264:2018) Carbon residue (ISO 10370:2014)	 (calculation according to carbon balance method) (calculation according to carbon balance method)

Lubricating oil

Lubricating oil specification	

Outlet tube

Diameter Length Distance from the flange to sampler Heat insulation	

5 INFORMATION ON AMBIENT CONDITIONS, MARINE DIESEL ENGINE PARAMETERS AND HARMFUL SUBSTANCES EMISSIONS

Sheet 5

Test cycle – _____

Operation mode				
Output, in %				
Engine speed, in %				
Weighing factor				
Starting time of the operation mode				
Data on ambient conditions				
Atmospheric pressure, in kPa				
Air temperature, in °C				
Air humidity, in %				
Air humidity, in g/kg				
Atmospheric factor *fa*				
Marine diesel engine parameters				
Engine speed, in rpm				
Output, in kW				
Fuel consumption, in kg/h				
Specific effective fuel consumption, in g/kW·h				
Air consumption (according to calculation), in kg/h				
Charge pressure, in kPa				
Scavenging air temperature, in °C				
Average effective pressure, in MPa				
Maximum combustion pressure, in MPa				
Maximum compressive stress, in MPa				
Inlet depression, in kPa				
Exhaust back pressure, in kPa				
Exhaust gas temperature downstream of the turbine, in °C				
Water temperature at the engine outlet, in °C				
Lubricating oil temperature, in °C				
Lubricating oil pressure, in MPa				
Gaseous emissions				
NOx concentration, in ppm dry/wet				
CO concentration, in ppm dry/wet				
CO2 concentration, in % dry/wet				
O_2 concentration, in % dry/wet				
HC concentration, in ppm wet (reduced to C_3H_8 content)				
Exhaust gas flow rate, in H·m/h				
NOx emission mass flow rate, in kg/h				
NOx emission mass flow rate (corrected), in kg/h				
CO emission mass flow rate, in kg/h				
HC emission mass flow rate, in kg/h				
NO_X average weighted emission (measured), in g/kW·h				
NO_X average weighted emission (ISO corrected), in g/kW·h				
CO average weighted emission, in g/kW·h				
HC average weighted emission, in g/kW·h				
Correcting coefficients				
K corr NOX (reduced to ambient conditions, ISO 3046-1)				
FFH (calculation)				
K_{wr} (calculation)				

6 RESULTS OF CALCULATIONS OF AVERAGE WEIGHTED EMISSION VALUES OF NOXIOUS SUBSTANCES

Sheet 6

Notation, units of measurement	NO_x, in g/kW·h
Maximum permissible parameter value	Survey result

Conclusion

Marine diesel engine _____№ _____complies with/does not comply with the requirements of the Technical Code of Emission of Nitrogen Oxides from Marine Diesel Engines.

The test has been carried out by _____

The head of the test _____

Appendix A

COMPONENTS AND ENGINE REGULATION (sample form)

1 COMPONENTS

1.1 DETAILS OF COMBUSTION POT

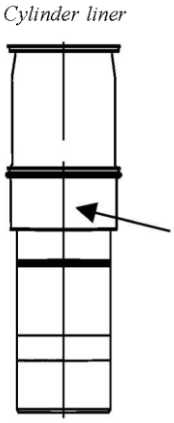


Fig. 1.1-1
To be stamped: drawing No.

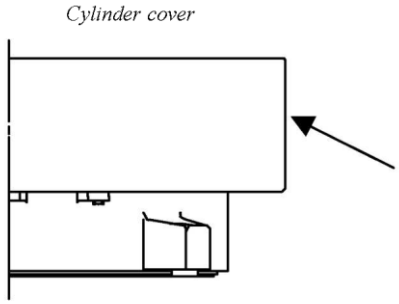


Fig. 1.1-2
To be stamped: drawing No.

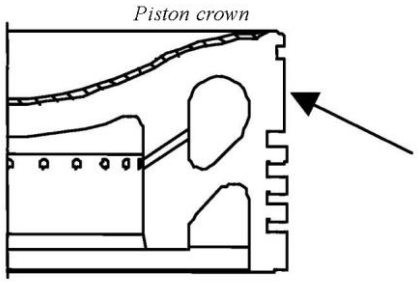


Fig. 1.1-3

To be stamped: drawing No.

1.2 FUEL INJECTION SYSTEM

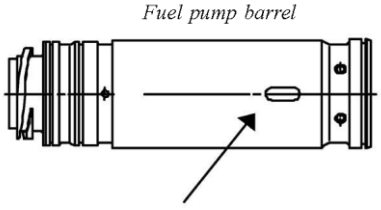


Fig. 1.2-1
To be stamped: drawing No.

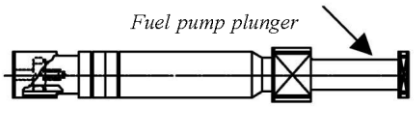


Fig. 1.2-2
To be stamped: drawing No.

Fuel valve nozzle

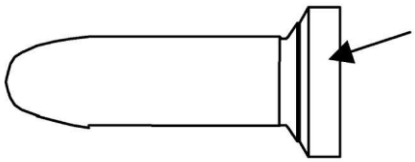


Fig. 1.2-3
To be stamped: drawing No.

Roller guide for fuel pump

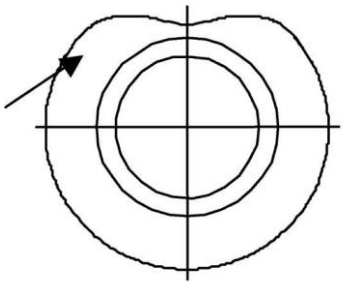


Fig. 1.2-4
To be stamped: drawing No.

1.3 COMPONENTS AND PARTS OF AIR SUPPLY SYSTEM

Given below is the list of components and parts of air supply system. Each item of the list shall be accompanied by a figure with indication of the place of marking and number of marking.

1.3.1 Turbo-compressor**.**

Turbo-compressor marking

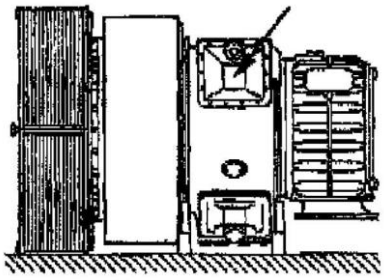


Fig. 1.3.1

Compressor whell

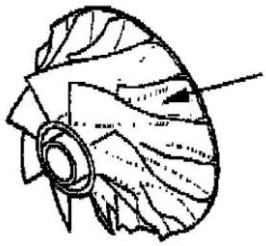


Fig. 1.3.1*a*

Turbine shaft

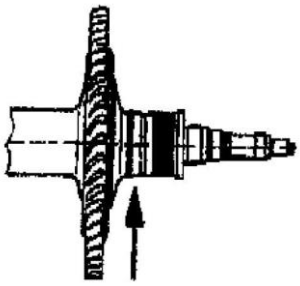


Fig. 1.3.1*b*

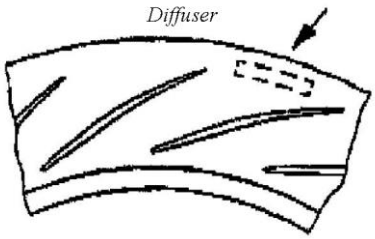


Fig. 1.3.1*c*

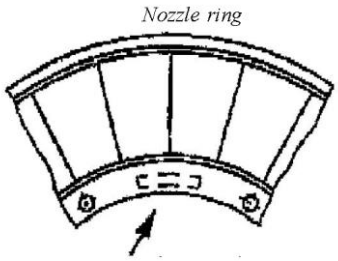


Fig. 1.3.1*d*

1.3.2 Other components.

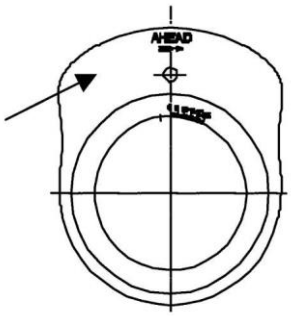


Fig. 1.3.2

To be stamped: drawing No.

2 ADJUSTMENT

2.1 INJECTION TIMING

The injection timing is checked using the firm's (manufacturer's) procedure containing brief description of the check method with explanatory figures.

Cylinder number	1	2	3	4	5	6
Injection timing, deg. CA BTDC	5,5	5,0	5,5	5,0	6,0	5,5
Note. Data have been obtained from acceptance test.						

2.2 COMPRESSION RATIO

The compression ratio is checked using the firm's (manufacturer's) procedure containing brief description of the check method with explanatory figures.

Example. Turn the crankthrow in the direction to exhaust side in order to provide access for measuring the thickness of the shim inserted between the piston rod and crosshead pin (refer to Fig. 2.2). The thickness of the shim *t* shall be equal to 16 mm.

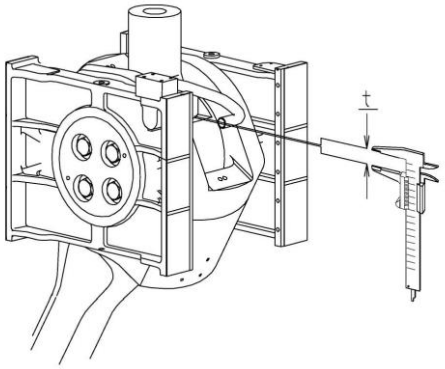


Fig. 2.2

2.3 FITTING OF ROLLER GUIDES FOR EXHAUST VALVE/CAMSHAFT DRIVE

Fitting of roller guides for exhaust valve/camshaft drive is checked using the firm's (manufacturer's) procedure containing brief description of the check method and explanatory figures.

3 DESIGNATION STRIPS

3.1 Given below are sketches of designation strips for turbo-compressor, auxiliary blower, scavenging/ charge air cooler, fuel injection pump and other equipment affecting significantly emissions of harmful substances with exhaust gases.

Example.

Designation strip of turbo-compressor

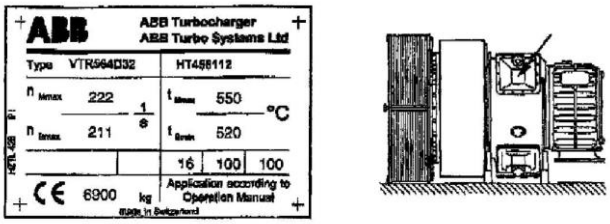


Fig. 3.1

Appendix B

CHECK OF WORKING PARAMETERS DURING ON-BOARD SURVEYS OF ENGINE

Given below are methods of working parameter measurement during on-board survey of marine diesel engine using the manufacturer's procedure with explanatory figures.

Example.

1.1 Measurement of engine power by means of indicator diagram

The compression pressure and maximum pressure in cylinder are measured by the use diagrams by means of scale rule the marking of which corresponds to the stiffness of the spring fitted in the indicator.

The area of the indicator diagram is measured by planimeter.

If the planimeter is adjustable, then prior to use it shall be verified either by the use of primary standard or by means of measuring a thoroughly drawn rectangle or circle.

When measuring area of indicator diagram the planimeter and diagram shall be placed on a flat plate (not too smooth), as shown on Fig. 1.1. The diagram shall be outlined several times until two obtained readings coincide within one division of Vernier scale of the planimeter. Only such values may be accepted as satisfactory.

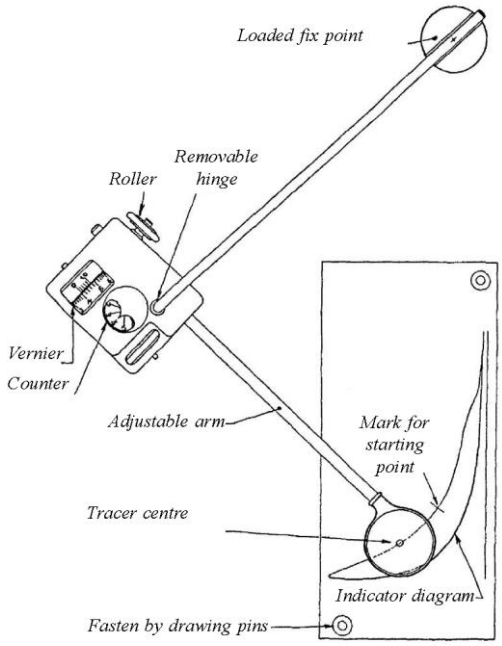


Fig. 1.1

The indicated and effective power of the engine are calculated in the order given below. The mean indicated power is calculated by the formula

$$P_i = LC_s/A, \quad (1.1\text{-}1)$$

where A = area of indicator diagram determined by planimetering, in mm^2;
L = length of indicator diagram during one full revolution of the crankshaft, in mm;

C_s = spring constant (vertical travel of indicator pen, mm, per 1 bar of pressure in cylinder), in mm/bar.

The indicated power per cylinder of the engine, in kW, is determined by the formula

$$N_i = k_1 n P_i. \quad (1.1\text{-}2)$$

The value k_1 (cylinder constant) is defined by engine size (the engine power is measured in kW) and calculated by the formula

$$k_1 = 1{,}309 D_2 S, \quad (1.1\text{-}3)$$

where D = cylinder bore, m;
S = piston stroke, m.

It has been established that the average friction losses do not essentially depend on the engine type and load. They are represented by a constant k_2 the value of which may be taken approximately as equal to 1 bar.

Then the mean effective pressure in cylinder, bar, will be equal to

$$P_e = (P_i - k_2) = (P_i - 1), \quad (1.1\text{-}4)$$

while the effective power per cylinder of the engine N_e will be equal to

$$N_e = k_1 n P_e = k_1 n (P_i - 1). \quad (1.1\text{-}5)$$

Appendix C

CALIBRATION OF MEASURING EQUIPMENT

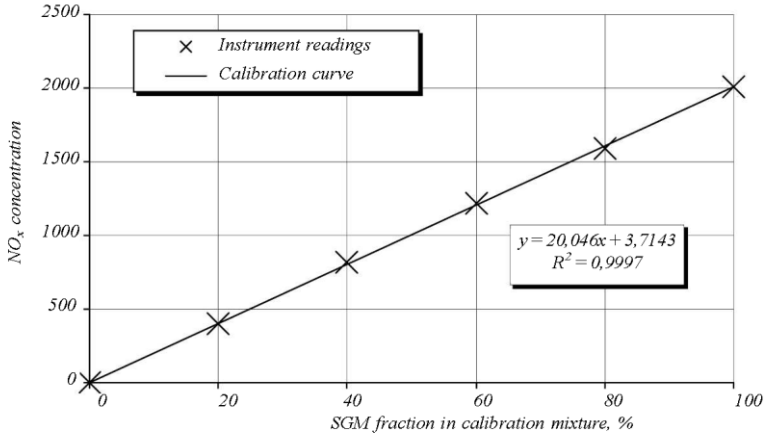
The results of the last calibration of the measuring equipment made in accordance with the requirements of the NO_x Technical Code are given.

Example. Calibration of gas analyser "RS 325L" No. D45363.

Calibration Certificate of GOSSTANDART of RF No. 2420/9304-03 (valid till 29 December 2004). Ranges of measurement: 0 – 5000 ppm.

Comparison standard (span gas mixture – SGM): NO/N2 = 2010 ppm (valid till 2 March 2005). Date: 22.03.2004.

SGM fraction in mixture, in %	NO fraction in mixture, in ppm	Analyser readings, in ppm	Calibration curve-based calculation, in ppm Deviation, in %	Deviation, in %
0	0	0	4	0,2
20	402	396	405	– 0,7
40	804	820	806	– 0,2
60	1206	1220	1206	0,0
80	1608	1590	1607	0,0
100	2010	2010	2008	0,1
N o t e . Deviation – in relation to the scale end.				



APPENDIX 3

TEST REPORT
(sample form)

Emission Test Report No _____Marine diesel engine information[1]

Marine diesel engine	
Manufacturer	
Engine type	
Family or group identification	
Serial number	
Rated speed	rpm
Rated power	kW
Intermediate speed	rpm
Maximum torque at intermediate speed	N-m
Geometric injection or ignition timing angle	° CA BTDC
Electronic injection or ignition control	no/yes
Variable injection or ignition control	no/yes
Variable turbocharger geometry	no/yes
Bore	mm
Stroke	mm
Nominal compression ratio	
Mean effective pressure, at rated power	kPa
Maximum cylinder pressure, at rated power	kPa
Cylinder number and configuration	Number V: in-line
Auxiliaries	
Specified ambient conditions	
Maximum seawater temperature	°C
Maximum charge air temperature (if applicable)	°C
Cooling system spec. intermediate cooler	
Cooling system spec. charge air stages	no/yes
Low/high temperature cooling system set points	°C
Maximum inlet depression	kPa
Maximum exhaust back pressure	kPa
Fuel oil (specification)	
Fuel oil temperature	°C
Lubricating oil specification	
Application/Intended for:	
Customer	
Final application/installation, ship	
Final application/installation, engine	Main/auxiliary

[1] If applicable.

Emission test results						
Cycle NO_x						g/kW·h
Test identification						
Date, time						
Test site/bench						
Test number						
Surveyor						
Date and place of the Report						
Signature						
Engine family information/group information (common specification)						
Combustion cycle	2 stroke cycle/4 stroke cycle					
Cooling medium	Air/water					
Cylinder configuration	Required to be written, only if the exhaust cleaning devices are applied					
Method of aspiration	Naturally aspired/pressure charged					
Fuel type to be used on board	Distillate/heavy/dual fuel					
Combustion chamber	Open chamber/divided chamber					
Valve port configuration	Cylinder head/cylinder wall					
Valve port size and number						
Fuel system type						
Ignition method						
Miscellaneous features						
Exhaust gas re-circulation	no/yes					
Water injection/emulsion	no/yes					
Air injection	no/yes					
Charge cooling system	no/yes					
Exhaust after-treatment	no/yes					
Exhaust after-treatment type						
Dual fuel	no/yes					
Engine family/group information (selection of parent engine for test bed trial)						
Family/group identification						
Method of pressure charging						
Charge air cooling system						
Criteria of the selection (specify)	Maximum fuel delivery rate/another method (specify)					
Number of cylinders						
Maximum rated power per cylinder						
Rated speed						
Injection timing (range)						
Max. fuel parent engine						
Selected parent engine						
Application						

Exhaust pipe					
Diameter			mm		
Length			m		
Insulation			no/yes		
Probe location					
Remark					
Measurement equipment					
	Manu-facturer	Model	Measurement ranges	Calibration	
				Span gas concentration	Deviation
Analyser					
NOx analyser			ppm		%
CO analyser			ppm		%
CO2 analyser			%		%
O2 analyser			%		%
HC analyser			ppm		%
Speed			rpm		%
Torque			N·m		%
Power			kW		%
Fuel flow					%
Air flow					%
Exhaust flow					%
Temperatures					
Coolant			°C		°C
Lubricant			°C		°C
Exhaust gas			°C		°C
Inlet air			°C		°C
Intercooled air			°C		°C
Fuel			°C		°C
Pressures					
Exhaust gas			kPa		%
Inlet manifold			kPa		%
Atmospheric			kPa		%
Vapour pressure					
Intake air			kPa		%
Humidity					
Intake air			kPa		%

Gas fuel characteristics

Fuel type				
Fuel properties:			Fuel elemental analysis	
Density	ISO 3675	kg/dm^3	C	% mass
Viscosity	ISO 3104	mm^2/s	H	% mass
			N	% mass
			O	% mass
			S	% mass
			LHV/Hu (low heat value)	MJ/kg

N o t e . Gas fuel characteristics shall comply with amendments to the NO_x Technical Code specified in item 38 of IMO resolution MEPC.272(69).

Ambient and gaseous emission data[1]

Mode	1	2	3	4	5	6	7	8	9	10
Power/torque, in % Speed, in %										
Time at beginning of mode										
Ambient data:										
Atmospheric pressure, in kPa										
Intake air temperature, in °C										
Intake air humidity, in g/kg										
Atmospheric factor f_a										
Gaseous emission data:										
NO_x concentration, dry/wet, in ppm										
CO concentration, dry/wet, in ppm										
CO_2 concentration, dry/wet, in %										
O_2 concentration, dry/wet, in %										
HC concentration, dry/wet, in ppm										
NO_x humidity correction factor										
Fuel specification factor F_{FH}										
Dry/wet correction factor										
NO_x mass flow, in kg/h										
CO mass flow, in kg/h										
CO_2 mass flow, in kg/h										
O_2 mass flow, in kg/h										
HC mass flow, in kg/h										
NO_x specific, in g/kW·h										

[1] If applicable.

Engine test data[1]

Mode	1	2	3	4	5	6	7	8	9	10
Power/torque, in % Speed, in % Time at beginning of mode Engine data: Speed, in rpm Auxiliary power, in kW Dynamometer setting, in kW Power, in kW Mean effective pressure, in bar Fuel rack, in mm Uncorrected specific fuel consumption, in g/kW·h Fuel flow, in kg/h Air flow, in kg/h Exhaust flow (G_{EXHW}), in kg/h Exhaust temperature, in °C Exhaust back pressure, in mbar Cylinder coolant temperature out, in °C Cylinder coolant temperature in, in °C Cylinder coolant pressure, in bar Intercooled air temperature, in °C Lubricant temperature, in °C Lubricant pressure, in bar Inlet depression, in mbar										

[1] If applicable.

APPENDIX 4

TECHNICAL**SPECIFICATIONS, OPERATING PROCEDURES FOR ANALYSERS AND CALIBRATION OF ANALYSERS**

1 GENERAL

1.1 The components included in an exhaust gas analysis system for the determination of the concentrations of CO, CO_2, NO_x, HC and O_2 are shown in Fig. 1.1. All components in the sampling gas path shall be maintained at the temperatures specified for the respective systems.

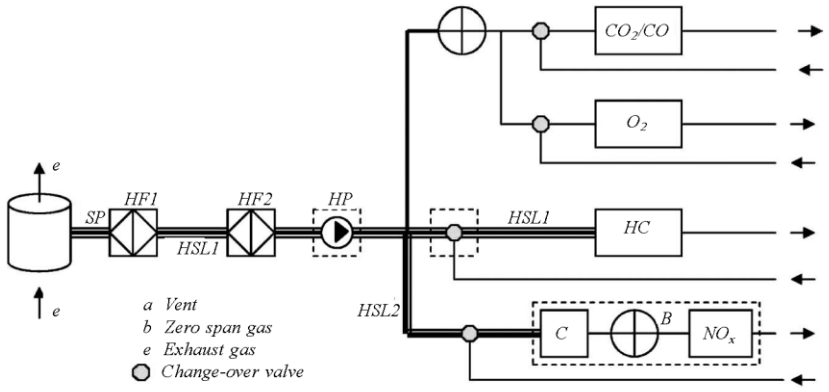


Fig. 1.1

Arrangement of exhaust gas analysis system

1.2 An exhaust gas analysis system shall include the following components (in accordance with Chapter 5 of the NO_x Technical Code equivalent arrangements and components may, subject to approval by the Register, be accepted):

.1 *SP* – raw exhaust gas sampling probe.

A stainless steel, straight, closed-end, multi-hole probe. The inside diameter shall not be greater than the inside diameter of the sampling line. The wall thickness of the probe should not be greater than 1 mm. There shall be a minimum of three holes in three different radial planes sized to sample approximately the same flow.

For the raw exhaust gas, the sample for all components may be taken with one sampling probe or with two sampling probes located in close proximity and internally split to the different analysers.

N o t e . If exhaust pulsations or engine vibrations are likely to affect the sampling probe, the wall thickness of the probe may be enlarged subject to the approval of the Register;

.2 *HSL1* – heated sampling line.

The sampling line provides a gas sample from a single probe to the split point(s) and the *HC* analyser. The sampling line shall be made of stainless steel or PTFE and have a 4 mm minimum and a 13,5 mm maximum inside diameter.

The exhaust gas temperature at the sampling probe shall not be less than 190 °C. The temperature of the exhaust gas from the sampling point to the analyser shall be maintained by using a heated filter and a heated transfer line with a wall temperature of 190±10 °C.

If the temperature of the exhaust gas at the sampling probe is above 190 °C, a wall temperature greater than 180 °C shall be maintained.

Immediately before the heated filter and the *HC* analyser a gas temperature of 190±10 °C shall be maintained;

.3 *HSL2* – heated NO_x sample line.

The sampling line shall be made of stainless steel or PTFE and maintain a wall temperature of 55 to 200 °C, up to the converter *C* when using a cooling unit *B*, and up to the analyser when a cooling unit *B* is not used;

.4 *HF1* – heated pre-filter (optional).

The required temperature shall be the same as for *HSL1*;

.5 *HF2* – heated filter.

The filter shall extract any solid particles from the gas sample before the analyser. The temperature shall be the same as for *HSL1.* The filter shall be changed as necessary;

.6 *HP* – heated sampling pump (optional).

The pump shall be heated to the temperature of *HSL1*;

.7 *SL* – sampling line for CO, CO_2 and O_2.

The line shall be made of PTFE or stainless steel. It may be heated or unheated;

.8 *CO_2/CO* – carbon dioxide and carbon monoxide analysers.

Non-dispersive infrared (NDIR) absorption. Either separate analysers or two functions incorporated into a single analyser unit;

.9 *HC* – hydrocarbon analyser.

Heated flame ionization detector (HFID). The temperature shall be kept at 180 to 200 °C;

.10 *NO_x* – nitrogen oxides analyser.

Chemiluminescent detector (CLD) or heated chemiluminescent detector (HCLD). If a HCLD is used, it shall be kept at a temperature of 55 to 200 °C.

N o t e . in the arrangement shown NO_x is measured on a dry basis. NO_x may also be measured on a wet basis in which case the analyser shall be of the HCLD type;

.11 *C* – converter.

A converter shall be used for the catalytic reduction of NO_2 to NO prior to analysis in the CLD or HCLD;

.12 *O_2* – oxygen analyser.

Paramagnetic detector (PMD), zirconium dioxide (ZRDO) or electrochemical sensor (ECS). ZRDO shall not be used for dual fuel or gas-fuelled engines.

N o t e . in the arrangement shown O_2 is measured on a dry basis. O_2 may also be measured on a wet basis in which case the analyser shall be of the ZRDO type;

.13 *B* – cooling unit.

To cool and condense water from the exhaust sample. The cooler shall be maintained at a temperature of 0° to 4 °C by ice or refrigerator. If water is removed by condensation, the sample gas temperature or dew point shall be monitored either within the water trap or downstream. The sample gas temperature or dew point shall not exceed 7 °C.

1.3 The analysers shall have a measuring range appropriate for the accuracy required to measure the concentrations of the exhaust gas components (refer to Appendix 5). All analysers shall be capable of continuous measurement from the gas stream and provide a continuous output response capable of being recorded. It is recommended that the analysers be operated such that the measured concentrations falls between 15 and 100 % of full scale.

1.4 If read-out systems (computers, data loggers, etc) that provide sufficient accuracy and resolution below 15 % of full scale are used, concentrations below 15 % of full

scale may also be acceptable. in this case, additional calibrations shall be made to ensure the accuracy of the calibration curves.

1.5 The electromagnetic compatibility of the equipment shall be on a level to minimise additional errors.

2 DEFINITIONS

Repeatability of an analyser is defined as the standard deviation of 10 repetitive responses to a given calibration or span gas.

Zero response of an analyser is defined as the mean response, including noise, to a zero gas during 30 s time interval.

Span is defined as the difference between the span response and the zero response.

Span response is defined as the mean response, including noise, to a span gas during 30 sec time interval.

3 MEASUREMENT ERROR

3.1 TOTAL MEASUREMENT ERROR

The total measurement error of an analyser (ignoring the span gas error), including the cross sensitivity to other gases (refer to Section 12), shall not exceed ±5 % of the reading or ±3,5 % of full scale, whichever is smaller. For concentrations of less than 100 ppm, the measurement error shall not exceed ±4 ppm.

3.2 ADDITIONAL MEASUREMENT ERRORS

3.2.1 Repeatability.

The repeatability of an analyser shall not be greater than ±1 % of full scale concentration for each range used above 155 ppm or ±2 % of each range used below 155 ppm.

3.2.2 Noise.

The analyser peak-to-peak response to zero and calibration or span gases over any 10 s period shall not exceed ±2 % of full scale on all ranges used.

3.2.3 Zero drift.

The zero drift during one hour period shall be less than ±2 % of full scale on the lowest range used.

3.2.4 Span drift.

The span drift during one hour period shall be less than ±2 % of full scale on the lowest range used.

3.2.5 Influence of pre-sampling system**.**

Deviation of the pre-sampling system shall not exceed 0,1 of total measurement error. For NO_x analyser the deviation due to $NO_2 \rightarrow NO$ converter shall be taken into account additionally (refer to Section 11).

3.2.6 Deviation due to calibration gases.

The deviation due to calibration gases shall be within ±2 % (refer to Section 6).

4 PRE-SAMPLING SYSTEM

4.1 When selecting a pre-sampling system, it is necessary to be guided by the requirements prescribed in ISO 8178-1. The delivered pre-sampling system type, as requested by the customer, including the gas drying device, shall have a minimal effect on the concentration of the measured gases. Chemical dryers are not acceptable method of removing water from the water.

5 ANALYSERS

5.1 The gases to be measured shall be analysed with the following instruments. (For non-linear analysers the use of linearising circuits is permitted).

.1 carbon monoxide (CO) analyser.

The carbon monoxide analyser shall be of the non-dispersive infrared (NDIR) absorption type;

.2 carbon dioxide (CO_2) analyser.

The carbon dioxide analyser shall be of non-dispersive infrared (NDIR) absorption type;

.3 oxygen (O_2) analyser. Paramagnetic detector (PMD), zirconium dioxide (ZRDO) or electrochemical sensor (ECS). ZRDO shall not be used for dual fuel or gas-fuelled engines.

N o t e . Electrochemical sensors shall be compensated for CO_2 and NO_2 interference;

.4 hydrocarbon (HC) analyser.

The hydrocarbon analyser shall be of the heated flame ionization detector (HFID) type with detector, valves, pipe-work and associated components heated so as to maintain a gas temperature of 190±10 °C. Optionally, for gas-fuelled engines (without liquid pilot injection), the hydrocarbon analyser may be of the non-heated flame ionization detector (FID) type;

.5 nitrogen oxides (NO_x) analyser.

The nitrogen oxides analyser shall be of the chemiluminescent detector (CLD) or heated chemiluminescent detector (HCLD) type with a NO_2/NO converter, if measured on a dry basis. If measured on a wet basis, a HCLD with converter maintained above 55 °C shall be used, provided the water quench check (refer to 12.2.2) is satisfied. For both CLD and HCLD, the sampling path shall be maintained at a wall temperature of 55 to 200 °C up to the converter for dry measurement, and up to the analyser for wet measurement.

6 CALIBRATION GASES

6.1 The shelf life of all calibration gases, as recommended by the manufacturer, shall not be exceeded. The expiration date of the calibration gases stated by the manufacturer shall be recorded.

6.1.1 Pure gases.

The following gases shall be available for operation during the test bed measurement:

purified nitrogen (contamination: ≤1 ppm C, ≤1 ppm CO, ≤400 ppm CO_2, ≤0,1 ppm NO);

purified oxygen (purity > 99,5 % volume O_2);

hydrogenhelium mixture (≤0 +2 % hydrogen, balance helium), (contamination: ≤1 ppm C, ≤400 ppm CO);

purified synthetic air (contamination ≤1 ppm C, ≤1 ppm CO, ≤400 ppm CO_2, ≤0,1 ppm NO), (oxygen content between 18 and 21 % volume).

6.1.2 Calibration and span gases.

6.1.2.1 Mixtures of gases having the following chemical compositions shall be available: CO and purified nitrogen;

NO and purified nitrogen (the amount of NO_2 in this calibrating gas shall not exceed 5 % of the NO content);

O_2 and purified nitrogen; CO_2 and purified nitrogen.

N o t e . Other gas combinations are allowed provided the gases do not react with one another.

6.1.2.2 The true concentration of a calibration or span gas shall be within ±2 % of the nominal value. All concentrations of calibration gas shall be given on a volume basis (volume percent or ppm).

6.1.2.3 The gases used for calibration and span may also be obtained by means of gas divider, diluting with purified nitrogen or with purified synthetic air. The accuracy of the mixing device shall be such that the concentration of the diluted calibration gases may be determined to within ±2 %.

7 OPERATING PROCEDURES FOR ANALYSERS AND SAMPLING SYSTEM

7.1 The operating procedure for analysers shall follow the start-up and operating instructions specified by the instrument manufacturer. The minimum requirements given in Sections 8 to 13 shall be included.

8 LEAKAGE TEST

8.1 A system leakage test shall be performed. The probe shall be disconnected from the exhaust system and the end plugged. The analyser pump shall be switched on. After an initial stabilisation period, all flow meters shall read zero; if not, the sampling lines shall be checked and the fault corrected.

8.2 The maximum allowable leakage rate on the vacuum side shall be 0,5 % of the inuse flow rate for the portion of the system being checked. The analyser flows and bypass flows may be used to estimate the inuse flow rates.

8.3 Another method that may be used is the introduction of a concentration step change at the beginning of the sampling line by switching from zero to span gas. After an adequate period of time, the reading shall show a lower concentration compared to the introduced concentration; this points to calibration or leakage problems.

9 CALIBRATION PROCEDURE

9.1 CALIBRATION GAS FLOW RATE

The same gas flow rates shall be used as when sampling exhaust during engine test.

9.2 WARMING-UP TIME

The warming-up time shall be according to the recommendations of the analysers' manufacturer. If not specified, a minimum of two hours is recommended for warming-up the analysers.

9.3 TUNING OF ANALYSERS

The analysers shall be tuned in accordance with the manufacturer’s recommendations.

9.4 CALIBRATION

9.4.1 Each normally used operating range shall be calibrated.

9.4.2 Using purified synthetic air (or nitrogen), the CO, CO_2, NO_x and O_2 analysers shall be set at zero.

9.4.3 The appropriate calibration gases shall be introduced to the analysers, the values recorded, and the calibration curve established according to 9.5 below.

9.4.4 The zero setting shall be rechecked and the calibration procedure repeated, if necessary.

9.5 ESTABLISHMENT OF THE CALIBRATION CURVE

9.5.1 General guidelines.

9.5.1.1 The analyser calibration curve shall be established by at least six calibration points (excluding zero) spaced as uniformly as possible. The highest nominal concentration shall be greater than or equal to 90 % of full scale.

9.5.1.2 The calibration curve is calculated by the method of least squares. If the resulting polynomial degree is greater than 3, the number of calibration points (zero included) shall be at least equal to this polynomial degree plus 2.

9.5.1.3 The calibration curve shall not differ by more than ±2 % from the nominal value of each calibration point or by more than ±0,3 % of full scale at zero.

9.5.1.4 From the calibration curve and calibration points, it is possible to verify that the calibration has been carried out correctly. The different characteristic parameters of the analyser shall be indicated, particularly:

.1 the measuring range;

.2 the sensitivity;

.3 the date of carrying out the calibration.

9.5.2 Calibration below 15 % of full scale.

9.5.2.1 The analyser calibration curve shall be established by at least 10 calibration points (excluding zero) spaced so that 50 % of the calibration points are below 10 % of full scale.

9.5.2.2 The calibration curve shall be calculated by the method of least squares.

9.5.2.3 The calibration curve shall not differ by more than ±4 % from nominal value of each calibration point and by more than ±1 % of full scale at zero.

9.5.3 Alternative methods.

If it can be shown that alternative technology (e.g. computers, electronically controlled range switch, etc.) provides equivalent accuracy, then these alternatives may be used.

10 VERIFICATION OF THE CALIBRATION

10.1 Each normally used operating range shall be checked prior to each analysis with the following procedure:

.1 the calibration shall be checked by using a zero gas and a span gas whose nominal value shall be more than 80 % of full scale of the measuring range;

.2 if, for the two points considered, the value found does not differ by more than ±4 % of full scale from the declared reference value, the adjustment parameters may be modified. If this is not the case, a new calibration curve shall be established in accordance with 9.5.

11 EFFICIENCY TEST OF THE NO_X CONVERTER

The efficiency of the converter used for conversion $NO_2 \rightarrow NO$ shall be tested as specified in 11.1 — 11.8.

11.1 TEST SET-UP

Using the test set-up as shown in Fig. 11.1 and the procedure below, the efficiency of converters shall be tested by means of an ozonator.

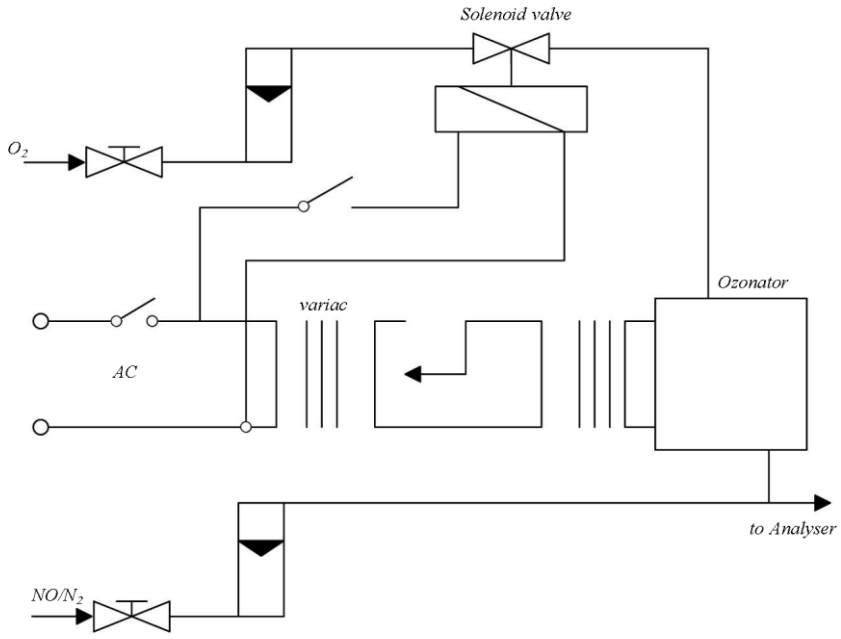


Fig. 11.1
Schematic of NO_2 converter efficiency device

11.2 CALIBRATION OF CONVERTER EFFICIENCY DEVICE

The converter efficiency device shall be calibrated in the most common operating range following the manufacturer's specifications using zero and span gas (the NO content of which should amount to about 80 % of the operating range and the NO_2 concentration of the gas mixture to less than 5 % of the NO concentration). The NO_x analyser shall be in the NO mode so that the span gas does not pass through the converter. The indicated concentration shall be recorded.

11.3 CALCULATION

The efficiency of the NO_x converter shall be calculated as follows using the formula

$$Efficiency\,(\%) = [1 + (a - b)/(c - d)] \cdot 100, \qquad (11.3)$$

where *a* = NO_x concentration according to 11.6;
b = NO_x concentration according to 11.7;
c = NO concentration according to 11.4;

d = NO concentration according to 11.5.

11.4 ADDING OF OXYGEN

11.4.1 Via a T-fitting, oxygen or zero air shall be added continuously to the gas flow until the concentration indicated is about 20 % less than the indicated calibration concentration given in 11.2 above (the analyser shall be in NO mode).

11.4.2 The indicated concentration *c* (refer to Formula (11.3)) shall be recorded. The ozonator shall be kept deactivated throughout the process.

11.5 ACTIVATION OF THE OZONATOR

The ozonator shall now be activated to generate enough ozone to bring the NO concentration to about 20 % (minimum 10 %) of the calibration concentration given in 11.2. The indicated concentration *d* (refer to Formula (11.3)) shall be recorded (the analyser shall be in NO mode).

11.6 NO_X MODE

The NO analyser shall then be switched to the NO_x mode so that the gas mixture (consisting of NO, NO_2, O_2 and N_2) now pass through the converter. The indicated concentration *a* (refer to Formula (11.3)) shall be recorded.

11.7 DEACTIVATION OF THE OZONATOR

The ozonator shall now be deactivated. The mixture of gases described in 11.6 above passes through the converter into detector. The indicated concentration *b* (refer to Formula (11.3)) shall be recorded (the analyser shall be in the NO mode).

11.8 NO MODE

Switched to the NO mode with the ozonator deactivated, the flow of oxygen or synthetic air shall also be shut off. The NO_x reading of the analyser shall not deviate by more than +5 % from the value measured according to 11.2 (the analyser shall be in the NO_x mode).

11.9 TEST INTERVAL

The efficiency of the converter shall be tested prior to each calibration of the NO_x analyser.

11.10 EFFICIENCY REQUIREMENT

The efficiency of the converter shall not be less than 90 %, but higher efficiency of more than 95 % is strongly recommended.

Note. If, with the analyser in the most common range, the NO_x converter cannot give a re-duction from 80 % to 20 % according to 11.2 above, then the highest range, which will give the reduction, shall be used.

12 INTERFERENCE EFFECTS WITH CO, CO2, NO_X AND O2 ANALYSERS

Gases present in the exhaust other than the one being analysed may interfere with the reading in several ways. Positive interference may occur in NDIR and PMD instruments where the interfering gas gives the same effect as the gas being measured, but to a lesser degree.

Negative interference may occur in NDIR and CLD instruments by the interfering gas broadening the absorption band of the measured gas. The interference checks shall be performed prior to an analyser's initial use and after major service intervals.

12.1 CO ANALYSER INTERFERENCE CHECK

Water and CO_2 may interfere with the CO analyser performance. Therefore, a CO_2 span gas having a concentration of 80 to 100 % of full scale of the maximum operating range used during testing shall be bubbled through water at room temperature and the analyser response recorded. The analyser response shall not be more than 1 % of full scale for ranges greater than or equal to 300 ppm or 3 ppm for ranges below 300 ppm.

12.2 NO_X ANALYSER QUENCH CHECK

The two gases of concern for CLD and HCLD analysers are CO_2 and water vapour. Quench responses to these gases are proportional to their concentrations, and therefore, require test techniques to determine the quench at the highest expected concentrations expected during testing according to 12.2.1 and 12.2.2. Similar techniques of determining CO_2 and H_2O quench checks are used for CLD and HCLD analysers.

12.2.1 CO_2 quench check.

12.2.1.1 A CO_2 span gas having a concentration of 80 to 100 % of full scale of the maximum operating range shall be passed through the NDIR analyser and the CO_2 value recorded as *A*. It shall then be diluted approximately 50 % with NO span gas and passed through NDIR and (H)CLD, with the CO_2 and NO values recorded as *B* and *C*, respectively. The CO_2 shall then be shut off and only the NO span gas shall be passed through the (H)CLD and the NO value recorded as *D*.

12.2.1.2 The quench, per cent, shall be calculated as follows:

$$\%\, Quench = [1 - ((C \cdot A)/(D \cdot A - D \cdot B))] \cdot 100, \qquad (12.2.1.2)$$

where *A* = undiluted CO_2 concentration measured with NDIR, in %;
B = diluted CO_2 concentration measured with NDIR, in %;
C = diluted NO concentration measured with (H)CLD, in ppm;
D = undiluted NO concentration measured with (H)CLD, in ppm,
and shall not be greater than 3 % of full scale.

12.2.1.3 Alternative methods of diluting and quantifying of CO_2 and NO span gas values, such as dynamic mixing/blending may be used.

12.2.2 Water quench check.

12.2.2.1 The water quench check applies to NO_x wet gas concentration measurements only. The calculation of water quench shall take into consideration the dilution of the NO span gas with water vapour and scaling of water vapour concentration of the mixture to that expected during testing.

12.2.2.2 A NO span gas having a concentration of 80 to 100 % of full scale of the normal operating range shall be passed through the (H)CLD and the NO value recorded as *D*.

The NO span gas shall then be bubbled through water at room temperature and passed through the (H)CLD and the NO value recorded as *C*. The analyser's absolute operating pressure and the water temperature shall be determined and recorded as *E* and *F*, respectively.

The mixture's saturation vapour pressure that corresponds to the bubbled water temperature *F* shall be determined and recorded as *G*. The water vapour concentration, in %, of the mixture shall be calculated according to the formula

$$H = 100\,(G/E) \qquad (12.2.2.2\text{-}1)$$

and recorded as *H*.

The expected diluted NO span gas (in water vapour) shall be calculated according to the formula

$$D_e = D\,(1 - H/100) \qquad (12.2.2.2\text{-}2)$$

and recorded as D_e.

For marine diesel engine exhaust, the maximum exhaust water vapour concentration, in %, expected during testing shall be estimated under the assumption of a fuel atom hydrogen/carbon (H/C) ratio of 1,8/1, from the undiluted CO_2 span gas concentration (*A*, as measured in 12.2.1)

$$H_m = 0{,}9A \qquad (12.2.2.2\text{-}3)$$

and recorded as H_m.

12.2.2.3 The water quench, in per cent, shall be calculated according to the formula

$$\%\,Quench = 100\,[(D_e C)/D_e]\,(H_m/H) \qquad (12.2.2.3)$$

where D_e = expected diluted NO concentration, in ppm;
C = diluted NO concentration, in ppm;
H_m = maximum water vapour concentration, in %;
H = actual water vapour concentration, in %,

and shall not be greater than 3 % of full scale.

N o t e . It is important that the NO span gas contains minimal NO_2 concentration for this check, since absorption of NO_2 in water has not been accounted for the quench calculations.

12.3 O_2 ANALYSER INTERFERENCE

12.3.1 Instrument response of a PMD analyser caused by gases other than oxygen is comparatively slight. The oxygen equivalents of the common exhaust gas constituents are in Table 12.3.1.

T a b l e 12.3.1

Oxygen equivalents

100 % gas concentration	Equivalents % O_2
Carbon dioxide, CO_2	– 0,623
Carbon monoxide, CO	– 0,354
Nitric oxide, NO	+ 44,4

100 % gas concentration	Equivalents % O_2
Nitrogen dioxide, NO_2	+ 28,7
Water, H_2O	– 0,381

12.3.2 The observed oxygen concentration shall be corrected by the following formula, if high precision measurements shall be done:

$$Interference = (Equivalent\ \%\ O_2 \times Observed\ Concentration)/100. \quad (12.3.2)$$

12.3.3 For ZRDO and ECS analysers, instrument interference caused by gases other than oxygen shall be compensated for in accordance with the instrument supplier's instructions.

13 CALIBRATION INTERVALS

13.1 The analysers shall be calibrated according to Section 9 of this Appendix at least every 3 months or whenever a system repair or change is made that could influence calibration.

APPENDIX 5

PERMISSIBLE DEVIATIONS OF MEASURED PARAMETERS

1 PERMISSIBLE DEVIATIONS OF INSTRUMENTS FOR MEASUREMENT OF MARINE DIESEL ENGINE PARAMETERS ON A TEST BED

The permissible deviations for measurement of marine diesel engine parameters on a test bed and calibration intervals shall comply with the requirements stated in Tables 1 to 5.

Table 1

Permissible deviations and calibration validity periods of instruments for engine related parameters for measurements on a test bed

Measurement instrument	Permissible deviationr	Calibration validity period (months)
Engine crankshaft speed	± 2 % of reading or ± 1 % of engine's maximum value, whichever is larger	3
Torque	± 2 % of reading or ± 1 % of engine's maximum value, whichever is larger	3
Power (where measured directly)	± 2 % of reading or ± 1 % of engine's maximum value,whichever is larger	3
Fuel consumption	± 2 % of engine's maximum value	6
Air consumption	± 2 % of reading or ± 1 % of engine's maximum value, whichever is larger	6
Exhaust gas flow	± 2,5 % of reading or ± 1,5 % of engine's maximum value, whichever is larger	6

Table 2

Permissible deviations and calibration validity periods of instruments for other essential parameters for measurements on a test bed

Measurement instrument	Permissible deviation	Calibration validity period (months)
Temperatures ≤ 327 °C	±2 °C absolute	3
Temperatures > 327 °C	±1 % of reading	3
Exhaust gas pressure	±0,2 kPa absolute	3
Charge air pressure	±0,3 kPa absolute	3
Atmospheric pressure	±0,1 kPa absolute	3
Other pressures ≤ 1000 kPa	±20 kPa absolute	3
Other pressures > 1000 kPa	±2 % of reading	3
Relative humidity	±3 % absolute	1

Table 3

Permissible deviations and calibration validity periods of instruments for engine related parameters for measurements on board a ship when the engine is already pre-certified

Measurement instrument	Permissible deviation	Calibration validity period (months)
Engine speed	±2 % of engine's maximum value	12
Torque	±5 % of engine's maximum value	12

Measurement instrument	Permissible deviation	Calibration validity period (months)
Power (where measured directly)	±5 % of engine's maximum value	12
Fuel consumption	±4 % of engine's maximum value	12
Air consumption	±5 % of engine's maximum value	12
Exhaust gas flow	±5 % of engine's maximum value	12

Since in compliance with the requirements of the Russian standards the manufacturers of analytical instruments shall indicate the total measurement deviation of gas analysis without specifications, Table 5 contains the deviations for measurements of gas analysis permissible both according to the NO_x Technical Code and the Guidelines.

Table 4

Permissible deviations and calibration validity periods of instruments for other essential parameters for measurements on board a ship when the engine is already pre-certified

Measurement instrument	Permissible deviation	Calibration validity period (months)
Temperatures ≤ 327 °C	±2 °C absolute	12
Temperatures > 327 °C	±15 °C absolute	12
Exhaust gas pressure	±5 % of engine's maximum value	12
Charge air pressure	±5 % of engine's maximum value	12
Atmospheric pressure	±0,5 % of reading	12
Other pressure values	±5 % of reading	12
Relative humidity	±3% absolute	6

Table 5

Permissible deviations of gas analysis for measurement of exhaust emissions from marine diesel engines

Constituents of measurement deviation	Deviation values for various analysers				
	NO_x (H)CLD	CO NDIR	CO_2 NDIR	HC FID	O_2 PMD
Total deviation	+6	+3,5	+3,5	+3,5	+3,5
Common additional deviation	+4	+4	+4	+4	+4
Deviation due to the influence of pre-sampling system	+1	+0,5	+0,5	+0,5	+0,5
Summary deviation of gas analysis	+9,5	+5,5	+5,5	+5,5	+5,5

APPENDIX 6

FLOWCHARTS FOR SURVEY OF MARINE DIESEL ENGINES (REFER TO 2.1.6 AND 5.2.11 OF THE GUIDELINES)

Guidance for compliance with survey of marine diesel engines, as described in Sections 2 and 5 of the Guidelines, is given in Figs. 1 — 3.

N o t e . These flowcharts do not show the criteria for the survey of an existing engine as required by regulation 13.7 of Annex VI to MARPOL 73/78.

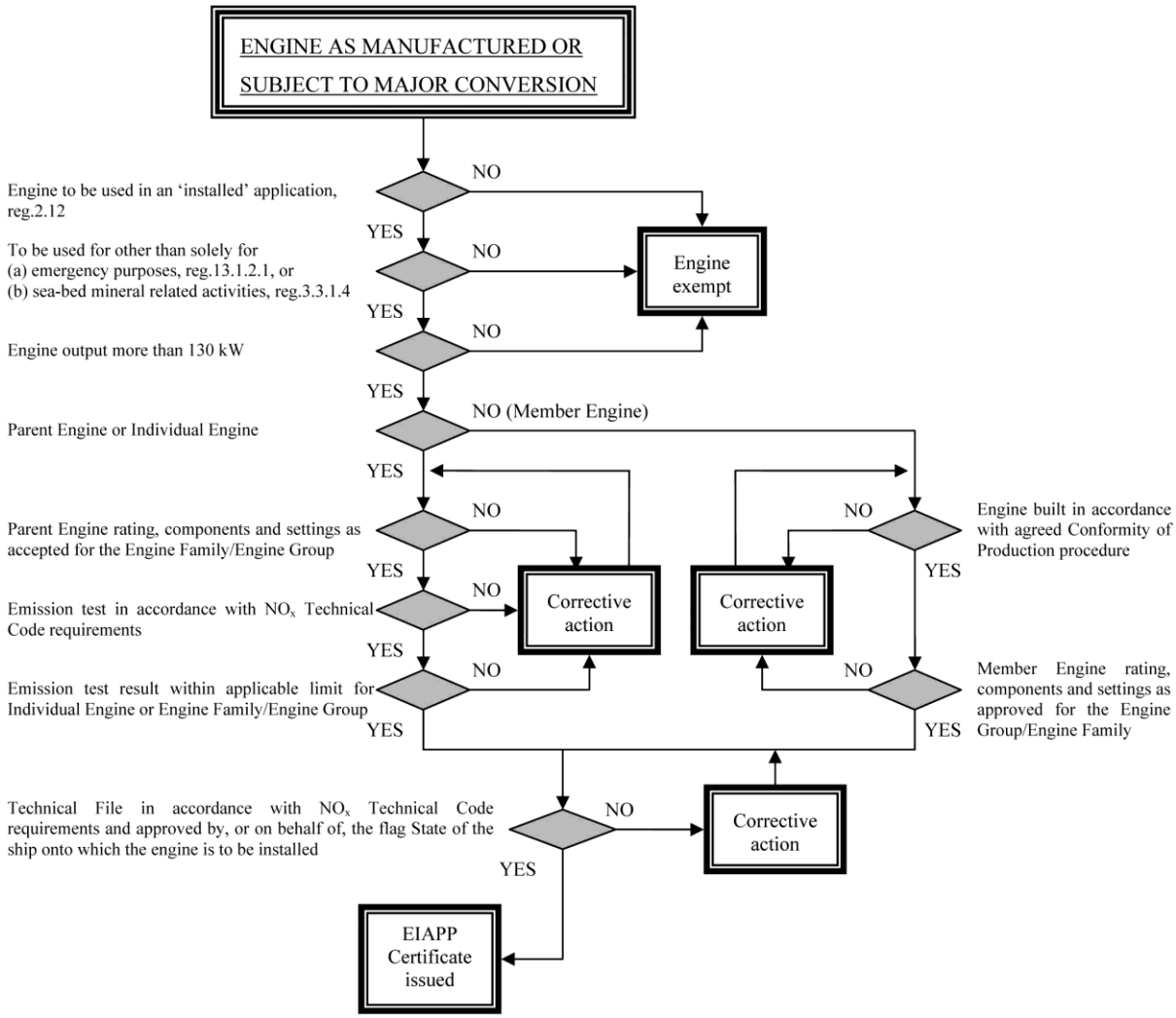


Fig. 1

Pre-certification survey at the firm (manufacturer)

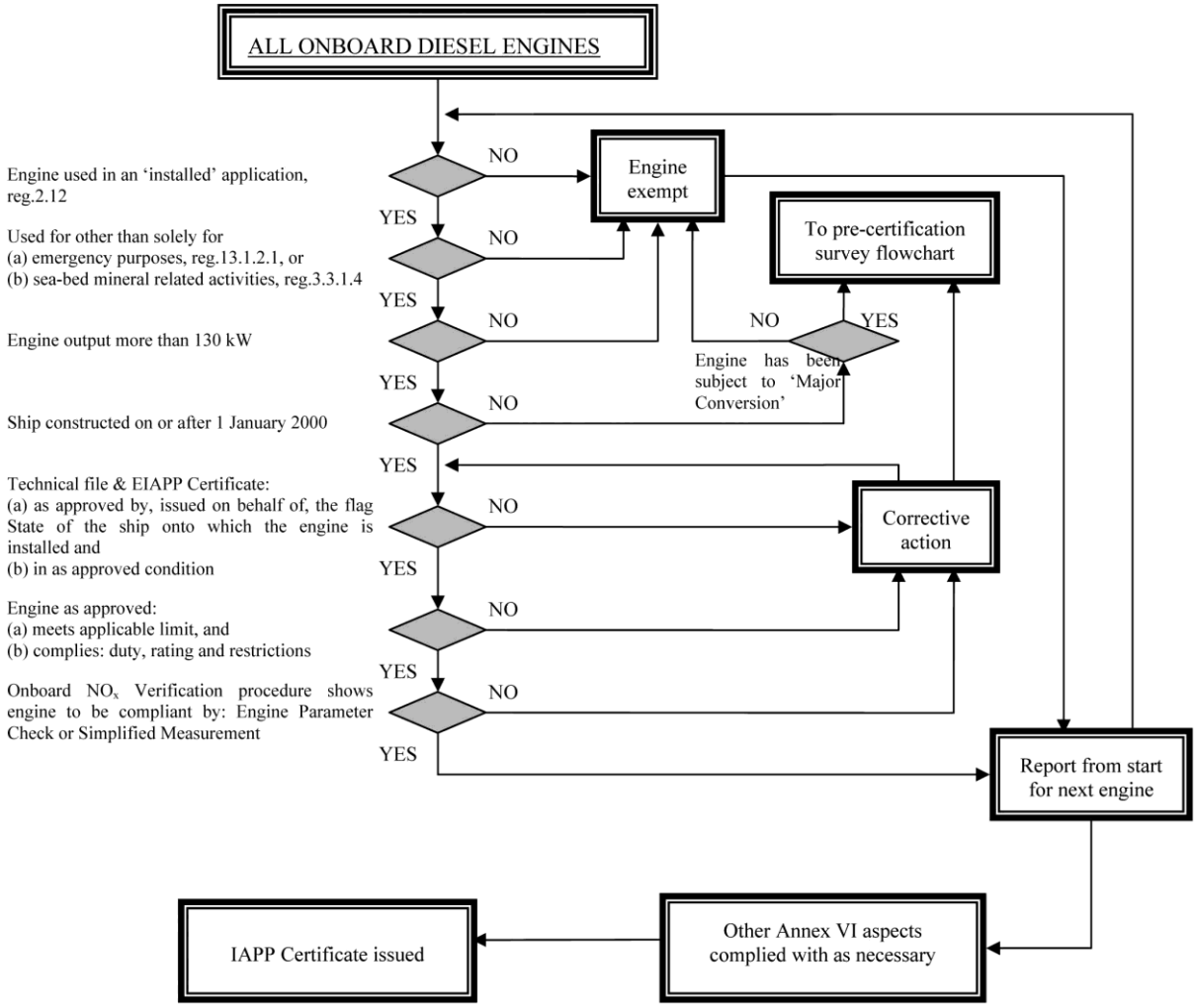


Fig. 2

Initial survey on board a ship

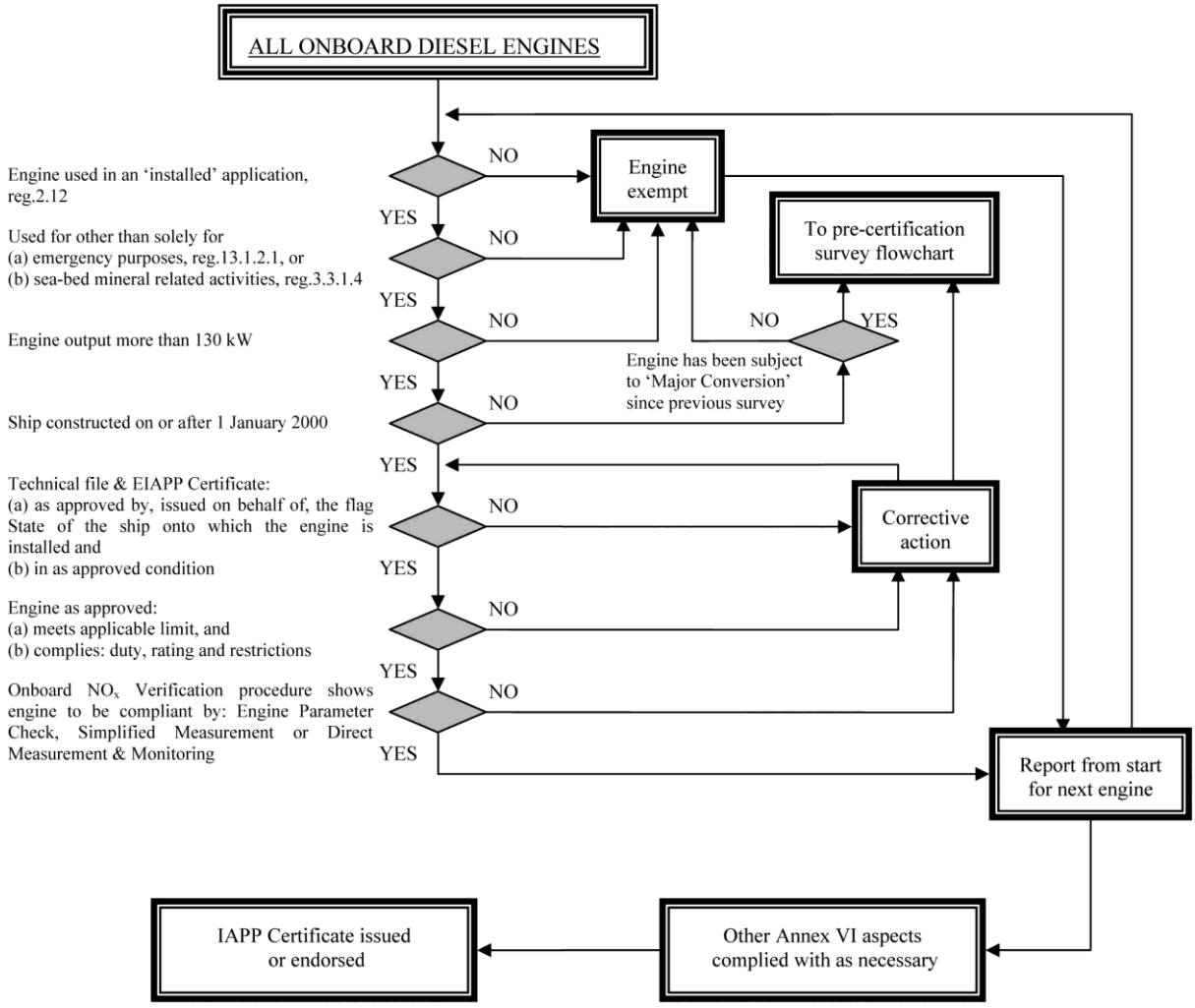


Fig. 3
Renewal annual or intermediate survey on board a ship

APPENDIX 7

CHECK LIST FOR THE MARINE DIESEL ENGINE PARAMETERS CHECK METHOD

1 GENERAL

1.1 For some parameters, different survey possibilities exist, whereby anyone of the methods may be sufficient to show compliance of the surveyed parameters those designated. Upon authorization of the Administration, the shipowner, supported by the applicant for engine certification, may choose what method is applicable.

1.2 Operating marine diesel engine parameters suffuciently influencing NO_x emissions values of which are load-dependent, for example, such as charge air pressure, combustion peak pressure, charge air temperature, exhaust gas temperature shall be verified to determine influence of their modifications on NO_x emissions. Additionally, it shall be ensured that the diesel compression ratio corresponds to the initial certification value (refer to 2.7).

2 NO_X INFLUENCING PARAMETER CHECK METHODS

2.1 The parameter "injection timing" shall be checked for:

.1 fuel cam position (individual cam or camshaft if cams are not adjustable), e.g., position of a link between the cam and the pump drive;

.2 actual start of injection (delivery) measured as follows:

recording (oscillography) of a fuel pressure for certain fuel rack positions;

recording of the start of injection valve opening for certain load points, e.g., using an induction sensor or a capacitance sensor.

N o t e . To assess the actual timing, it is necessary to know the allowable limits for meeting the emission limits and the graphs showing the influence of timing on NO_x, based on the test bed NO_x measurements results.

2.2 The parameter "injection nozzle" is checked:

.1 for specification;

.2 for component identification number.

2.3 The parameter "injection pump" is checked by the following method:

.1 specification;

.2 component identification number (specifying plunger and barrel design).

2.4 The parameter "fuel cam" shall be checked:

.1 for component identification number (specifying shape);

.2 for start and end of delivery for a certain fuel rack position (dynamic fuel pressure measurement).

2.5 The parameter "injection pressure" shall be checked only for common rail systems for the load- dependent pressure in the rail and diagram showing the correlation with NO_x.

2.6 The parameter "combustion chamber" shall be checked for component identification numbers for a cylinder head and piston head.

2.7 The parameter "compression ratio" shall be checked:

.1 for actual clearance;

.2 for shims in piston rod or connecting rod.

2.8 The parameter "turbocharger type and build" shall be checked:

.1 for model and specification (identification numbers);

.2 for load-dependent charge air pressure and graph showing the correlation with NO_x.

2.9 The parameter "charge air cooler, charge air pre-heater" is checked:

.1 for model and specification;

.2 for load-dependent charge air temperature corrected to reference conditions and diagram showing the correlation with NO_x.

2.10 The parameter "valve timing" (only for 4-stroke marine diesel engines with inlet valve closure before BDC) shall be checked:

.1 for cam position;

.2 for actual valve timing;

.3 for actual valve timing duration.

2.11 The parameter "water injection" shall be checked for load-dependent water consumption (monitoring) and the diagram showing the influence on NO_x.

2.12 The parameter "emulsified fuel" shall be checked:

.1 for load-dependent fuel rack position (monitoring);

.2 for load-dependent water consumption (monitoring) and diagram showing the influence on NO_x.

2.13 The parameter "exhaust gas recirculation" shall be checked:

.1 for load-dependent mass flow of recirculated exhaust gas (monitoring) and diagram showing the correlation with NO_x;

.2 for CO_2 concentration in the mixture of fresh air and recirculated exhaust gas, i.e. in the "scavenge air" (monitoring);

.3 for O_2 concentration in the "scavenge air" (monitoring).

2.14 The parameter "selective catalytic reduction" (SCR) shall be checked:

.1 for load-dependent mass flow of reducing agent (monitoring) and diagram showing the influence on NO_x concentration after SCR;

.2 for load-dependent NO_x concentration after SCR (periodical spot checks).

For marine diesel engines with selective catalytic reduction (SCR) without feed-back control, an optional NO_x measurement (periodical spot checks or monitoring) is useful to show that the SCR efficiency still corresponds to the state at the time of certification regardless of whether the ambient conditions or the fuel quality led to different raw emissions.

Russian Maritime Register of Shipping

Guidelines on the Application of Provisions of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines

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