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SBS TECHNOLOGY A/S

NO_x FAQ

Disclaimer

This NO_x FAQ is a guideline for customers of SBS Technology A/S. It is SBS Technology A/S's interpretation of the regulations mentioned in this text, not the legally binding text. SBS Technology is not liable for any damages that might be caused directly or indirectly through the use of these interpretations. Please contact your Flag State Administration and/or Class Society for an authoritative interpretation of the regulations.

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General Questions

What is the basis for the new regulation?

In 1997 the International Maritime Organization (IMO) adopted Annex VI of MARPOL 73/78 and the NO_x Technical Code (NO_x TC). The Marine Environment Protection Committee (MEPC) of the IMO subsequently passed several subsidiary regulations such as the

- Guidelines for On-Board NO_X Verification Procedure – Direct Measurement and Monitoring Method – MEPC.103(49)
- Guidelines for the Sampling of Fuel Oil for Determination of Compliance with Annes VI of MARPOL 73/78 – MEPC.96(47)

When do I have to comply? Which dates are important?

26 Sep. 1997	Adoption of Annex VI – Regulations for the Prevention of Air Pollution from Ships – Annex VI applies to ships of 400 GT and above The International Air Pollution Prevention Certificate (IAPP Certificate) documents that a vessel meets the requirements of Annex VI and subsequently also of the NO_X Technical Code, and the Guidelines for On-Board NO_X Verification Procedure (MEPC.103 (49)) if applicable. NO_X Technical Code applies to diesel engines with a power output >130 kW installed or converted on/after 1 January 2000
19 May 2005	Entry into force New ships require an International IAPP Certificate when being put into service. Ships constructed on/after 1 January 2000 but before 19 May 2005 must comply by their first scheduled dry docking
19 May 2008	Latest date for ships constructed on/after 1 January 2000 to be issued with an IAPP Certificate even if there has not been a scheduled dry docking before that date.

(cf. VI/5 & 6)

When you consider ordering an SBS_{4500} NO_X Monitor, please be aware of the delivery time (three months after technical clarification).

Which certificates do I need?

There are two certificates that are easily confused:

- an **engine** certificate, called Engine International Air Pollution Prevention (EIAPP) Certificate, and
- a **ship** certificate, called International Air Pollution Prevention (IAPP) Certificate.

The EIAPP (engine) Certificate is regulated in the NO_x Technical Code (cf. Ch 2). The EIAPP certificate is a pre-certificate and does not need to be renewed and is valid

throughout the engines life time (or until major conversion). The EIAPP certificate is based on a test-bed test and usually obtained by the engine manufacturer.

Via the surveys prescribed by VI/5, the EIAPP (engine) certificate becomes part of the IAPP (ship) certificate (cf. VI/5(3)(b)). The IAPP certificate is issued and endorsed in connection with the initial and renewal surveys (cf. VI/6).
Not all engines and not all ships need a certificate.

Which ships & engines have to comply?

Diesel engines with a power output of more than 130 kWh have to meet the requirements of NO_x emission. This applies to ships constructed on/after 1 January 2000 and engines that undergo major conversion on/after 1 January 2000. This does not apply to any equipment to be used solely in case of emergency.
(cf. VI/13(1))

All ships of 400 GT and above are to be issued with an International Air Pollution Prevention (IAPP) Certificate. Ships keel-laid

- **on or after** 19 May 2005 undergo an initial survey for the IAPP Certificate
- **before** 19 May 2005 are issued with the IAPP upon their first dry docking or on 19 May 2008 at the latest.

(cf. VI/6 – see also Reg. 5)

The combination of both rules implies that ships keel laid on/after 1 January 2000 have to comply with the NO_x requirements. Their engines' EIAPP (engine) certificates and on-board NO_x verification are the basis for issuing the IAPP (ship) certificate.

Which surveys at which intervals?

The EIAPP (engine) certificate is (usually) obtained by the manufacturer and does not need to be renewed. Engines produced between 1999 and 2005 are most likely issued with Statement of Compliance on the basis of the Interim Guidelines for the Application of the NO_x Technical Code (MEPC/Circ.344). Otherwise an on-board test equivalent to the testbed test will be conducted for obtaining the EIAPP certificate.

VI/5(3) regulates the following surveys that result in the issue or endorsement of an IAPP (ship) certificate:

- an initial survey,
- periodical surveys every five years,
- intermediate surveys (i.e. every two to three years),
- annual surveys, and
- additional surveys following accidents, repairs, and the like.

At each of these surveys, compliance to the NO_x requirements as laid down in the NO_x Technical Code is to varying degrees checked.

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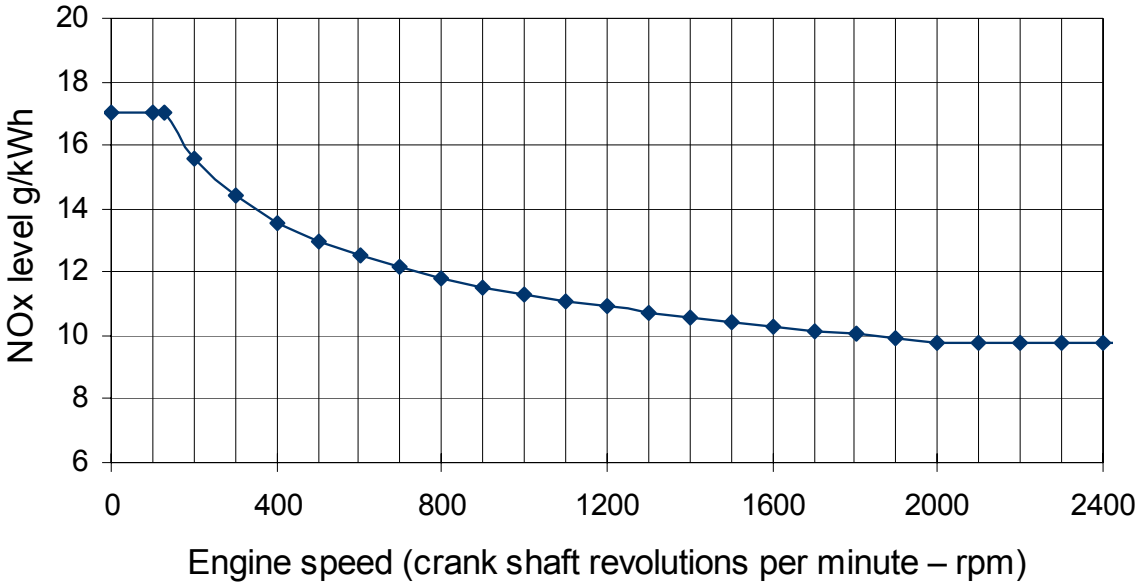
What is the limit on NO_x emissions?

NO_x emissions are measured in g/kWh. The limits depend on the rated engine speed (n measured in crankshaft revolutions per minute) as follows (cf. VI/13(3)(a)):

- 17.0 g/kWh when $n < 130$ rpm
- $45.0 * n^{(-0,2)}$ g/kWh when 130 rpm $\leq n <$ 2,000 rpm
- 9.8 g/kWh when $n \geq$ 2,000 rpm



Diesel engines emitting larger amounts of NO_x may be operated if the actual emissions is brought under the limits by exhaust gas cleaning systems such as Selective Catalytic Reduction.

Please be aware that US and EU authorities are discussing stricter NO_x limits which may or may not come into effect.

How can a ship owner comply with NO_x Technical Code?

There are three options for ship owners to document compliance with the NO_x Requirements of a ship after the initial survey: (cf. NOxTC 2.1.2)

1. engine parameter check
2. on-board simplified measurement
3. on-board direct measurement and monitoring

The engine parameter check is primarily based on the EIAPP certificate. The ship owner is supposed to keep within the narrow bounds of the allowable adjustments and alternatives for components set out in the technical file (cf. NOxTC 2.3.6 & 2.4.1.2). This implies that ship owners may only use OEM spare parts. At periodical and intermediate surveys, replaced components and modifications are checked for compliance with the technical file. This check is time consuming and might require disassembly of engines (cf. NOxTC 6.2.2). NOxTC 6.2.1.7 opens for direct NOx measurement at surveys if the

surveyor and/or administration suspects that compliance to the emission limits is unlikely.

The simplified measurement makes use of portable measurement equipment to verify NO_x emission levels on-board (cf. NOxTC 6.2). With on-board measurement there is more leeway to use non-OEM spare parts. The measurement is simplified in comparison to the test bed measurement required by NOxTC ch. 5. It requires surveyors to observe the measurement of exhaust gas from each engine and its specific test run at sea at periodical and intermediate surveys. These test runs are time consuming if not combined with the ships normal operation. The surveyors are expensive if the test run is conducted under normal travel.

For direct measurement a NO_x emission monitor is installed on-board allowing direct measurement and monitoring at all times (cf. NOxTC 2.3.4). The NOx monitor is regarded as a supplement to the engine and its EIAPP certificate (cf. MEPC.103(49) 5.3) and mentioned in the Technical File according to NOxTC 2.4.1.4. An on-board monitoring manual will be approved by the Administration (cf. MEPC.103(49) 5.3). At regular intervals (max. 30 days), test reports are produced by the NO_x emission monitor. When the ship and engine is certified including the NO_x Monitor for on-board direct measurement and monitoring the crew can conduct the test runs themselves under normal ship operation. The data is logged by the NO_x emission monitor and relevant reports are produced. As the NO_x emission monitor is installed on-board, measurements do not require external personnel or equipment to be brought on board. At periodical and intermediate surveys the functionality of the NO_x emission monitor and the reports are checked, which is much less time consuming than the engine parameter check or the simplified measurement.

What about SO_x?

MARPOL Annex VI does not require you to measure the emissions of SOx. Ships are instead required to retain a fuel sample and a bunker delivery note stating the – amongst other things – sulfur content and density of the fuel (cf. VI/18, Appendix V, MEPC.96(47)). If the relevant data is supplied to our system the SO_x emissions will be calculated.

Ship owners might wish for various reasons – for image reasons, for documentation of switch-over from high- to low-sulfur fuel, or for documenting the efficiency of an exhaust gas cleaning system – to install an on-board direct measurement SO_x Monitor. If you install an SBS_{4500} NO_X Monitor with FastFlow Sampling System it is easily possible to extend this with an SO_x Monitor

What about NOx emissions from boilers or incinerators?

MARPOL Annex VI does not require you to measure the emissions of NOx from boilers or incinerators. However it is possible to add boilers and incinerators via additional sampling points to the SBS_{4500} NO_X Monitor.

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NOx reporting with the SBS_{4500} NO_X Monitor

The SBS_{4500} NO_X Monitor has two modes of operation: ❶ the reporting mode for producing the NOx reports as required by the NOxTC and ❷ the monitoring mode which simply measures the NO_x emissions.

Do I need a survey/certificate/approval for using a NO_x Monitor?

Yes.

The using the SBS_{4500} NO_X Monitor for direct on-board measurement as NOx verification method needs to be stated in the NOx Technical File (cf. NOxTC 2.4.1.4). Furthermore, an on-board monitoring manual should be approved by the Administration (cf. MEPC.103(49) 5.3). This approval is considered to be a supplement to the EIAPP Certificate.

How often do I have to make a report?

Report data must be current, i.e. not older than 30 days. Monitoring records shall be kept on board for at least 3 months. (NOxTC 2.3.4)

These time frames apply while the ship is in operation (MEPC.103(49) § 5.2).

Report data may either include an engines complete test cycle or be split up into separate reports for each load point (MEPC.103(49) 5.2). Thus, reporting with direct on-board measurement for especially main engines may be carried out in such a way that it fits together with the voyage of the vessel.

The crew needs to turn on the report mode of the SBS_{4500} NO_X Monitor and designate the engine that is to be monitored.

How often do I have to calibrate?

Before each measurement for reporting the analyzer should be calibrated for zero & span values (MEPC.103(49) 3.3.2). That means that calibration is carried out with a maximum of 30 days in between. The SBS_{4500} NO_X Monitor will automatically carry out the calibration provided the supply of test gas.

After each measurement the analyzer's zero and span values should be verified and may show a deviation of max. 2% (MEPC.103(49) 3.3.3 & NOxTC 5.9.9). The SBS_{4500} NO_X Monitor will automatically carry out the verification of the analyzer and its results.

Is there a special test cycle required?

NOxTC 3.2 specifies four test cycles with – in most cases – four to five load points that need to be measured. If approved by the administration, it is possible to deviate from these test cycles (MEPC.103(49) 3.1.2 ff). Appendix 2 of MEPC.103(49) provides a list of typically approvable changes to the test cycles.

The measurement for one load point report should be carried out over an interval of at least ten minutes (MEPC.103(49) 3.1.9). During this measurement the engine should kept stable at this load point which is defined by two criteria. First, the average engine load should be within in the range of ±5% around the load point or from 90% – 100% for the 100% load point (MEPC.103(49) 3.1.8). Second, the actual engine load as measured by the engine data (measured at 1 Hz) should be kept within a 5% coefficient of variance (cf. MEPC.103(49) 3.1.9 and Appendix 3 of MEPC.103(49)). All these requirements are automatically controlled by the SBS_{4500} NO_X Monitor.

Which System Setup Should I Choose — FastFlow Sampling System vs. True Continuous Measurement

What are the possible configurations of the SBS_{4500} NO_X Monitor?

The standard system is equipped with the FastFlow Sampling System. A sample is drawn continuously from all stacks and the NOx emissions are measured by sequentially shifting from stack to stack. This is done automatically and steered by a controller. In monitoring mode, the system gives a measurement from each a single stack at an interval of usually less than one hour (depending of the set up and number of stacks). E.g. on a ship with six engines and a ten minutes of measurement per engine, every engine is monitored at 60 minutes intervals.
When the crew shifts into report mode for producing the reports in accordance with the NOxTC, the measurement is only done on the engine for which the report is being produced. This takes usually less than 20 minutes per load point and a whole test cycle can be completed within an hour. When the crew shifts back to monitoring mode the continuous monitoring is resumed.
If you wish to install a continuous monitoring system for NOx emissions and one measurement per engine per usually less than three hours is sufficient, the FastFlow Sampling System meets your requirements.

If you require True Continuous Measurement, one EZNOx® Analyzer can be installed on each stack. This gives you the widest range of opportunities of measurement, trend evaluation, and engine adjustments. It eliminates the sampling system, but is more expensive.

Finally, both system setups can be combined. We can install one EZNOx® Analyzer for each main engine and install a sampling system for all other sampling points.

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What is the FastFlow Sampling System?

Exhaust gas is continuously sucked from each stack to a common manifold using insulated steel pipes as sampling lines. The sample gas is taken sequentially from the sampling lines before entering the common manifold. The sequence of the exhaust gas entering the sampling manifold is controlled by solenoid valves controlled by the sample control processor.

The sequential measurement is normally carried out on a continuous basis allowing monitoring of all engines emissions. While producing engine emission reports, the system will be switched to reporting mode in order to fulfill the requirements of MEPC.103(49).

The EZNOx® analyzer measures NOx and O_2 and transmits these to the Control Processor. All engine operating parameters and environmental parameters are derived by interfacing directly with the Engine Management/Monitoring System. The customer shall provide necessary information related to the interface and signals available.

The FastFlow Sampling System is superfluous when installing a system based on True Continuous Measurement.

Why does SBS use the EZNOx® II Analyzer?

The EZNOx® II On-board NOx analyzer will be installed on the sampling system or on each stack (depending on the system steup) and provide Diesel Engine NOx emission measurements and monitoring according to NOxTC and MEPC.103(49).

DNV certifies with a Letter of Compliance that the EZNOx analyzer fulfills the requirements as analyzing equipment for emission species measurement with the and meets the analyzer specifications stated in MEPC.103(49) and NOx Technical Code.

The EZNOx® analyzer employs the Heated ChemiLuminescent Detection (HCLD) method for measuring NOx, which is the only measurement method explicitly mentioned in the NOx Technical Code. The use of this measurement method is thus by definition approved by the Administration.

Furthermore, the EZNOx® has two decisive advantages: ❶ The EZNOx® is very robust, vibration and temperature resistant. Therefore it is very compact and does not require large air-conditioned cabinets that absorb vibrations. In fact the EZNOx® can be mounted directly on exhaust gas stacks. ❷ The EZNOx® is designed to be maintenance friendly.

The use of analyzers that employ other NOx measurement methods needs to be approved by the Administration (MEPC.109(49) 1.1.3). Compared to electrochemical cells, non-dispersive infrared sensors (NDIR), and other light based systems (laser or UV), HCLD delivers the most accurate results and is more shock and vibration resistant.

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Map to the Paragraphs of the NO_x Technical Code

(all paragraphs refer to NO_x Technical Code)

Paragraphs relating to Direct Measurement and Monitoring

2.1.2.5 –establishes Direct Measurement and Monitoring in accordance with 2.3.4, 2.3.5, 2.3.7, 2.3.8, 2.3.11, 2.4.4 (repetition of paragraphs), and 5.5 (determination of exhaust gas flow).

2.3.4 – data must be current (30 days),
data must be acquired using test procedures of NOxTC (see separate section),
test reports must be kept for 3 months,
data must be corrected for ambient conditions and fuel specifications,
measuring equipment must be calibrated,
measurement downstream of exhaust gas after treatment.

2.3.5 – there must be a calculation of the weighted average NO_x emissions

2.3.6 – general rule not related to Direct Measurement and Monitoring
Establishes the Technical File for every marine diesel engine and refers to 2.4.1 where content of the technical file is regulated.
According to 2.4.1.4 the on-board NO_x verification procedure for this engine is stated in the Technical File with reference to the requirements in chapter 6.
6.1.3 refers back to the paragraphs stated in 2.1.2.5

2.3.7/8 – special regulations for exhaust gas treatment and additives

2.3.11 – adjustments & modifications outside the limits laid out in the Technical File are permissible if meeting the NO_x requirements is documented with
– direct monitoring (simplest – installed on-board)
– simplified measurement (expensive – third party needs to make a full test run)
– new test-bed testing (tedious and extremely expensive)

2.4.5 – devices for on-board measurement shall be approved by the Administration.

5.5 – The exhaust gas flow shall be measured by one of the following methods
– direct measurement
– air and fuel measurement
– carbon balance method.

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Test procedures of the NO_x Technical Code

Paragraph 2.3.4 states that direct measurement of NO_x emissions must follow the test procedures of the NO_x Technical Code without a more direct specification. Test procedures are specified in the following paragraphs (ranked in order of importance):

6.3 – Regulates simplified measurement and its tests and thus serves analogously as guideline for direct measurement. 6.3 refers to the test cycles of 3.2 and the test procedures of chapter 5.

3.2 – four test cycles and weighting factors are defined for different types of engines.

5 – Chapter 5 regulates the procedures for NO_x emission measurements on a test bed. These regulations are applied analogously to the on-board measurement.

- 5.1 General
- 5.2 Test Conditions
- 5.3 Test fuels
- 5.4 Measurement equipment (see also 5.7)
- 5.5 Determination of exhaust gas flow
- 5.6 Permissible deviations
- 5.7 Analyzer for determination fo the gaseous components
  Gas analyzers need to fulfill the specifications of Appendix 3 which defines repeatability, noise, zero drift, span drift and states the analyzer types allowed. This is for Oxygen Analysis a paramagnetic detector, a zirconium dioxide cell, or an electrochemical cell. The SBS_{4500} NO_X Monitor uses a Zirconium Dioxide Cell. Analysis of NO_x may be done with a ChemiLuminescent Detector or a Heated ChemiLuminescent Detector (HCLD). The SBS_{4500} NO_X Monitor uses a HCLD.
- 5.8 Calibration of the analytical instruments (see appendix 4)
- 5.9 Test run
- 5.10 Test report
- 5.11 Data evaluation for gaseous emissions
- 5.12 Calculation of the gaseous emissions

MEPC.103(49) Guidelines for On-Board NO_X Verification Procedure – Direct Measurement and Monitoring Method
These guidelines are recommendatory. National administrations and those acting on behalf of them are invited to base their implementation on these guidelines. These guidelines specify the following (among other things):

- 1.2 Analyzer specification (with reference to NOxTC appendix 3 & 4)
- 2. Engine performance and ambient condition measurement (with reference to NOxTC 6.3
- 3.1 Test cycles (with reference to NOxTC 3.2)
- 3.3 Analyzer calibration and verification (with reference to NOxTC 5.9.9)
- 3.4 Data recording
- 5.1 Allowance values (with reference to NOxTC 6.3.11)
- 5.3 Form of approval (with reference to NOxTC appendix 1 section 3)
- 5.4 Survey of equipment and method
- Appendix 2: Selection of load points and revision of weighting factors (with reference to NOxTC 3.2)
- Appendix 3: Determination of power set point stability (formula for calculation)