108TH CONGRESS *1st Session*	SENATE	TREATY DOC. 108–7

PROTOCOL OF 1997 AMENDING MARPOL CONVENTION

MESSAGE

FROM

THE PRESIDENT OF THE UNITED STATES

TRANSMITTING

PROTOCOL OF 1997 TO AMEND THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973, AS MODIFIED BY THE PROTOCOL OF 1978 THERETO (HEREINAFTER THE "PROTOCOL OF 1997"). THE PROTOCOL OF 1997, WHICH WOULD ADD ANNEX VI, REGULATIONS FOR THE PREVENTION OF AIR POLLUTION FROM SHIPS, TO THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973, AS MODIFIED BY THE PROTOCOL OF 1978 (HEREINAFTER THE "MARPOL CONVENTION"), WAS SIGNED BY THE UNITED STATES ON DECEMBER 22, 1998

MAY 15, 2003.—The Treaty was read the first time, and together with the accompanying papers, referred to the Committee on Foreign Relations and ordered to be printed for the use of the Senate

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LETTER OF TRANSMITTAL

THE WHITE HOUSE, *May 15, 2003.*

To the Senate of the United States:

I transmit herewith, for the advice and consent of the Senate to its ratification, the Protocol of 1997 to Amend the International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 thereto (hereinafter the "Protocol of 1997"). The Protocol of 1997, which would add Annex VI, Regulations for the Prevention of Air Pollution from Ships, to the International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 (hereinafter the "MARPOL Convention"), was signed by the United States on December 22, 1998. I also enclose, for the information of the Senate, the report of the Department of State and its attached analysis of the Protocol of 1997, as well as Resolution 2 of the 1997 MARPOL Conference with its annexed Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines.

The MARPOL Convention is the global agreement to control pollution from ships. MARPOL Annex VI regulates the emission into the atmosphere of specified pollutants from ships. It complements the other annexes to the MARPOL Convention, which relate to the transport of oil (Annex I), harmful substances carried in bulk (Annex II) harmful substances in packaged form (Annex III), ship-generated sewage (Annex IV) and garbage (Annex V). The United States is a party to all of these annexes with the exception of Annex IV.

MARPOL Annex VI regulates the prevention of air pollution from ships by limiting the discharge of nitrogen oxides from larger marine diesel engines, governing the sulfur content of marine diesel fuel, prohibiting the emission of ozone-depleting substances, regulating the emission of volatile organic compounds during the transfer of cargoes between tankers and terminals, setting standards for shipboard incinerators and fuel oil quality, and establishing requirements for platforms and drilling rigs at sea.

MARPOL Annex VI is an important step toward controlling and preventing emissions of harmful air pollutants from ships. U.S. ratification of the Protocol of 1997 will demonstrate U.S. commitment to an international solution and should hasten the entry into force of the Protocol of 1997. Ratification will also enhance our ability to work within the treaty framework to obtain subsequent amendments that will require further reductions in emissions of nitrogen oxides that are now achievable through the use of modern control technologies which the United States strongly supports.

I recommend that the Senate give early and favorable consideration to the Protocol of 1997 and give its advice and consent to ratification, subject to the declarations and understanding set out in the accompanying report of the Secretary of State.

GEORGE W. BUSH.

LETTER OF SUBMITTAL

THE SECRETARY OF STATE,
Washington, DC.

The PRESIDENT,
The White House.

THE PRESIDENT: I have the honor to submit to you with a view to its transmittal to the Senate for advice and consent to ratification, the Protocol of 1997 to Amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 thereto (hereinafter the "Protocol of 1997"). The Protocol of 1997, which would adds Annex VI, Regulations for the Prevention of Air Pollution from Ships, to the International Convention for the Prevention of Pollution from ships, 1973, as Modified by the Protocol of 1978 thereto (hereinafter the "MARPOL Convention"), was signed by the United States on December 22, 1998. I also enclose, for the information of the Senate, Resolution 2 of the 1997 MARPOL Conference with the annexed Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines, and a detailed analysis of Annex VI prepared by the Department.

The MARPOL Convention is the global agreement to control accidental and operational discharges of pollution from ships. It currently includes a framework agreement setting forth general obligations, and five annexes that relate to particular sources of marine pollution from ships. Two of these annexes are mandatory for all MARPOL Convention Parties—Annexes I and II, that relate, respectively, to the transport of oil and the transport of harmful substances carried in bulk. The other three annexes are optional—Annex III, which relates to the transport of harmful substances in packaged form, and Annexes IV and V, which regulate ship-generated sewage and garbage respectively. The Convention and the Protocols of 1978 and 1997 are to be interpreted as one single instrument between Parties to the same Protocol.

On August 12, 1980, the United States ratified the Protocol of 1978 (which incorporates with modifications the 1973 Convention), along with Annexes I and II. The MARPOL Convention and Annexes I and II entered into force for the United States on October 2, 1983. On December 30, 1987, the United States ratified Annex V, which entered into force on December 31, 1988. On December 3, 1991, the United States ratified Annex III, which entered into force on July 1, 1992. While Annex IV, concerning ship-generated sewage, is expected to enter into force internationally on September 27, 2003, the Administration is not requesting Senate advice and consent to ratification of that Annex.

Substantive provisions of Annex VI

Annex VI seeks to reduce air pollution from ships at sea and in port. It does so by limiting the emission of nitrogen oxides (NO_X) from marine diesel engines above 130 kW (175 hp); governing the sulfur content of marine diesel fuel; prohibiting the deliberate emission of ozone-depleting substances; regulating the emission of volatile organic compounds during transfer of cargoes between tankers and terminals; and setting international standards for shipboard incinerators and fuel oil quality. Annex VI also establishes similar requirements for platforms and drilling rigs at sea, with some exceptions. The NO_X Technical Code attached to Resolution 2 of the 1997 MARPOL Conference contains testing and certification procedures for the engine NO_X limits. The substantive provisions of Annex VI are discussed in this and subsequent sections of this report and the attached analysis of the regulations.

Regulation 13 of Annex VI would limit NO_X emissions from large marine diesel engines to levels that the negotiating States in 1997 agreed as being achievable by the year 2000. These limits, which require the use of readily available emission control technology, apply to any such engine installed on a ship constructed on or after January 1, 2000, and to any such engine that undergoes a major conversion after that date. The limits do not otherwise apply to engines on ships.

Regulation 14 of the Annex controls emissions of sulfur oxides (SO_X) by imposing a global cap of 4.5% m/m (4.5% sulfur mass to total mass or 45,000 parts per million) on the sulfur content of fuel oil used on ships for combustion and calls on the International Maritime Organization (IMO) to monitor the worldwide average sulfur content of residual fuel oil once the Protocol of 1997 comes into force. Annex VI contains provisions for the establishment of special "SO_X Emission Control Areas". The sulfur content of fuel used by ships operating in these areas must not exceed 1.5% m/m (15,000 ppm). Alternatively, a ship can use an exhaust gas cleaning system or another technological method to limit sulfur oxide (SO_X) emissions. The Annex designates the Baltic Sea as a SO_X Emission Control Area and provides a mechanism by which the IMO may designate other SECAs. In March 2000, the North Sea was designated as such an area. The United States may seek the establishment of SO_X Emission Control Areas in certain areas pursuant to the procedures set out in Appendix III to Annex VI. However, proposals for the designation of SO_X Emission Control Areas by the IMO may be made only by States that have consented to be bound by the Protocol of 1997. The general requirements for the sulfur content of fuel will go into effect when the Protocol of 1997 enters into force. Ships entering a SECA are exempt from the SECA's more stringent requirements for the first twelve months immediately following the bringing into force of the SECA.

Regulation 12 of Annex VI prohibits deliberate emissions of ozone-depleting substances that are controlled under the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer (a treaty to which the United States is party). These substances include halon compounds and five chlorofluorocarbon compounds (CFCs). New installations containing ozone-depleting substances, such as those found in certain fire extinguishers, are prohibited on

all ships. However, new installations containing hydrochlorofluorocarbons (HCFCs) are permitted until January 1, 2020.

Regulation 16 of Annex VI establishes requirements for the incineration of materials on board ship. These include prohibitions on the incineration on board ship of certain products, such as contaminated packaging materials and polychlorinated biphenyls (PCBs).

Application of Annex VI

As with all other MARPOL Convention Regulations in force for them, States bound by Annex VI will be required to apply Annex VI Regulations to all ships, including those of non-party States, using their ports or the offshore terminals under their jurisdiction as may be necessary to ensure that no more favorable treatment is given to the ships of non-Parties to the Annex.

As compared to mandatory Annexes I and II on pollution by oil and noxious liquid substances in bulk, which have been construed to apply only to seagoing vessels, Annex VI will apply to all ships operating in the marine environment except where expressly provided elsewhere in the Regulations contained in Annex VI.

Article 3 of the MARPOL Convention of 1973 exempts warships, naval auxiliary and other ships owned or operated by a State and used in governmental non-commercial service, from the application of the provisions of the annexes. The State Parties participating in the 1997 MARPOL Conference that produced the Protocol of 1997 therefore agreed that such ships will be exempt from the application of the provisions of Annex VI under Article 3(3) of the MARPOL Convention of 1973. However, each Party will still be required to take appropriate measures not impairing the operations or operational capabilities of such ships owned or operated by it, to ensure that such ships act in a manner consistent, so far as is reasonable and practicable, with Annex VI. In the case of the U.S. Navy, most of its fossil fuel-powered ships now use gas turbines, which are not regulated by Annex VI, for main propulsion. U.S. Navy ships that do use diesel engines for main propulsion use low (<1%) sulfur distillate fuel that is much cleaner than the heavy fuel oils used by many commercial marine diesel engines. In addition, new classes of U.S. Navy surface ships are no longer constructed to use CFCs in shipboard air conditioning and refrigeration equipment, nor halons in shipboard fire-fighting equipment.

Domestic regulation of NO_X emissions

The Environmental Protection Agency has proposed to regulate NO_X emissions from Category 3 marine diesel engines pursuant to section 213 of the Clean Air Act, 42 U.S.C. § 7547. This announcement, which is contained in a Notice of Proposed Rule Making in the May 29, 2002, edition of the Federal Register at pages 37547–37608, proposed to apply the Annex VI standards to new diesel engines on U.S.-flag vessels starting in 2004 and sought comment on whether the Clean Air Act authorizes application of these standards to engines on foreign-flag ships that enter U.S. ports. EPA also sought comment on the feasibility, costs and benefits of additional control measures and on whether it should consider a sulfur content limit for marine diesel fuel in order to reduce particulate

emissions from those engines. The comment period ended July 16, 2002.

Possibility of more stringent standards

As noted in the 1977 Secretary of State's Report to the President on the International Convention for the Prevention of Pollution from Ships, 1973, recommending its transmittal to the Senate for advice and consent to ratification, the United States and other States defeated attempts at the 1973 Conference to "restrict national powers to apply domestic regulations more stringent than prevailing international standards to foreign vessels in ports." Such authority is also preserved under customary international law as reflected in the 1982 United Nations Convention on the Law of the Sea. Thus, the Protocol of 1997, does not, as a matter of international law, prohibit Parties from imposing more stringent measures as a condition of entry into their ports or internal waters, unless a particular regulation in Annex VI expressly imposes such a limitation.

In this context, it should be noted that Regulation 15, Volatile Organic Compounds, obligates Parties to provide notice to the IMO of the ports and terminals under their jurisdiction to be subject to vapor emission control requirements and to include in such notification the information specified in paragraph 2 of that Regulation, including a requirement that notification occur six months before the effective date of the controls. Regulation 15 also requires such States to take into account the safety guidance developed by the IMO, that such systems are operated in a safe manner, and to avoid undue delay to ships. In light of these obligations, Parties may not specify requirements inconsistent with these obligations (e.g., imposing vapor emission controls on vessels or cargoes that take effect before the six month notification period, stipulating unsafe procedures, or causing undue delay to ships). Regulation 15 does not, however, establish actual emission standards. Recognizing this, Parties are free to prescribe standards applicable to VOC emissions consistent with the obligations noted above.

It should also be noted that Regulation 15 applies only to VOC emission recovery associated with cargo transfer operations between tankers and port facilities.

The Department of State believes it is important to memorialize clearly the scope of these requirements, and accordingly, I propose that the following declaration be included in the U.S. instrument of ratification of the Protocol of 1997:

> The Government of the United States of America understands that Regulation 15 applies only to safety aspects associated with the operation of vapor emission control systems that may be applied during cargo transfer operations between a tanker and port-side facilities and to the requirements specified in Regulation 15 for notification to the International Maritime Organization of port State Regulation of such systems.

Apart from the legal issue of whether specific provisions in a treaty might limit port state authorities, the United States has basic and enduring national interests related to the oceans and

U.S. port regions, and has consistently taken the position that the full range of these interest is best protected through a widely accepted international framework governing uses of the sea. A workable international regime for the prevention of air pollution from ships is in the best interests of all States because it will subject international shipping to a uniform standard that is environmentally protective. While retaining the right to impose more stringent requirements on ships entering U.S. ports, the United States will work to strengthen international standards by promoting development of more stringent emission limits that reflect the capabilities of available technology.

The NO_X emission control limits contained in Regulation 13 of Annex VI are those that were agreed in 1997 as being achievable by January 1, 2000, on new marine diesel engines. Consistent with the dates contained in the Regulation 13 NO_X requirements, EPA has advised the Department of State that engine manufacturers worldwide are currently producing and selling marine diesel engines that meet these standards. EPA also advises that engine manufacturers are now applying a variety of basic emission-control technologies to meet these limits, including in-cylinder technologies such as optimized turbocharging, increased compression ratio, and optimized fuel injection, which generally includes timing retard and changes to the number and size of injector holes to increase injection pressure.

Regulation 13(d)(b) of Annex VI itself contemplates that new technology will become available to reduce onboard NO_X emissions below those limits. EPA has noted that such technology is now available on the land-based counterparts of these engines, in the form of innovations such as improved fuel systems and in-cylinder controls. Other advanced technologies have the potential to achieve much greater reductions, including engine cooling, water emulsification and injection after-treatment including selective catalyst reduction, and fuel cells. EPA further advises that engine manufacturers are developing and apply all of these technologies in demonstration projects on marine vessels.

In view of these developments, the Department of State favors revision of the emission standards set forth in Regulation 13 to achieve the greatest degree of emission reduction achievable through the application of the new technology, taking into account the availability of such technology and its cost. The Department of State views it as essential that the IMO agree on such reductions in NO_X emissions on an urgent basis and amend these technical provisions of Annex VI accordingly.

Resolution 1 of the 1997 MARPOL Conference invited the Marine Environment Protection Committee (MEPC) of the IMO, if the conditions for entry into force of the Protocol of 1997 had not been meet by December 31, 2002, to initiate at its first meeting thereafter as a matter of urgency a review to identify the impediments to entry into force of the Protocol and any necessary measures to alleviate those impediments. At the request of the IMO Assembly, the MEPC has agreed to initiate that review at its first meeting in 2003, now tentatively scheduled for July 14–18, 2003. The United States intends to press the IMO to set more stringent NO_X emission standards on an expedited basis and encourages other

States to ratify the Protocol so it may enter into force promptly; amendments to Annex VI could then be adopted and enter into force through the long-established simplified amendment procedure specified in Article 16(2) of the MARPOL Convention of 1973. At the same time, consistent with its rights and obligations under the Protocol of 1997, the United States government retains the prerogative to consider imposing more stringent standards as a condition of port entry, especially in the event it is not possible to develop credible and effective NO_X emission standards through the IMO.

The United States is also considering whether the Annex VI sulfur oxide limits should be lowered under this Convention, particularly in SO_X Emission Control Areas.

With the foregoing considerations in mind, I propose that the following declaration be included in the U.S. instrument of ratification of the Protocol of 1997:

> The Government of the United States of America notes that at the time of adoption of the Protocol of 1997, the NO_X emission control limits contained in Regulation 13 were those agreed as being achievable by January 1, 2000, on new marine diesel engines, and further notes that Regulation 13(3)(b) contemplated that new technology would become available to reduce on-board NO_X emissions below those limits. As such improved technology is now available, the United States expresses its support for an amendment to Annex VI, that would, on an urgent basis, revise the agreed NO_X emission control limits contained in Regulation 13 in keeping with new technological developments.

Similarly, I propose that the following understanding be included in the U.S. instrument of ratification of the Protocol of 1997:

> The Government of the United States of America understands that, with respect to emissions of nitrogen oxides pursuant to Regulation 13 of Annex VI, the Protocol of 1997 does not, as a matter of international law, prohibit Parties from imposing more stringent measures than those identified in the Protocol as a condition of entry into their ports or internal waters.

The simplified amendment procedure detailed in Article 16(2) of the MARPOL Convention of 1973 has been used with regard to all four MARPOL Convention Annexes after their entry into force. It was established to permit more effective and rapid adoption and entry into force of technical amendments to the MARPOL Convention. Pursuant to longstanding practice under the MARPOL Convention, U.S. acceptance of amendments to Annex VI will not require further advice and consent by the Senate.

Entry into force and implementation

Only States that are Parties to the MARPOL Convention may become Parties to the Protocol of 1997. The Protocol of 1997 will enter into force twelve months after the date on which not less than 15 States have consented to be bound, the combined merchant fleets of which constitute not less than fifty percent of the gross

tonnage of the world's merchant shipping. As of October 31, 2002, six States (Bahamas, Liberia, Marshall Islands, Norway, Singapore and Sweden) have ratified Annex VI, constituting approximately 25 percent of the world's shipping tonnage. Recently, a sufficient number of other States (Belgium, Cyprus, Denmark, Finland, Germany, Greece, Luxembourg, the Netherlands, Panama and Spain) have publicly indicated their indication to ratify the Protocol of 1997 in the near future. Were this to happen, the conditions for entry into force of the Protocol of 1997 would be met by the time MEPC meets in the early summer of 2003. U.S. ratification by that time would significantly enhance our ability to work through the IMO to achieve our environmental objectives as they relate to international maritime commerce.

The Protocol will enter into force for the States consenting to be bound after the Protocol of 1997 enters into force three months after the date of deposit of their instruments of ratification, accession or acceptance.

The Protocol may be denounced at any time after five years from the date on which it entered into force for that Party, effective twelve months after receipt of the denunciation.

Annex VI will implementing legislation that is being submitted separately.

The Protocol of 1997, through Annex VI, will make an important contribution to the protection of the environment by addressing harmful air pollutants from ships. Ratification will also strengthen our ability to work through the IMO for international agreement on more stringent standards in the future. The Environmental Protection Agency, the U.S. Coast Guard, and the Departments of Defense, Justice, Interior and Transportation, join me in recommending ratification of the Protocol of 1997 with the declarations and understanding described herein. I understand it also enjoys the support of a substantial majority of the maritime industry.

I recommend that Annex VI be transmitted to the Senate for its advice and consent to ratification at an early date.

Respectfully submitted,

COLIN L. POWELL.

Enclosures: As stated.

ANALYSIS OF ANNEX VI
REGULATIONS FOR THE PREVENTION OF AIR POLLUTION FROM SHIPS

The Regulations contained in Annex VI are, for the most part, modeled upon similar provisions in MARPOL Annex I, Regulations for the Prevention of Pollution by Oil, as amended, taking into account the differences in the pollutants regulated in Annex VI from those regulated in Annex I.

Chapter I - General Regulations

Regulation 1, Application

Regulation 1 states that the provisions of Annex VI apply to all ships, except as indicated in Regulations 3 (emissions necessary for safety or resulting from damage); 5 (ships not required to be surveyed and inspected); 6 (ships not required to be certificated); 13 (lifeboats and ships on domestic voyages); 15 (ships not subject to vapor handling requirement); 18 (ships not required to have bunker fuel delivery notes) and 19 (fixed and floating platforms and drilling rigs engaged in the exploration, exploitation and associated offshore processing of sea-bed mineral resources).

In addition, Article 3(3) of the MARPOL Convention exempts warships, naval auxiliaries and other ships owned or operated by a State and used in government non-commercial service from the application of MARPOL and its annexes. However, Article 3(3) requires each Party to ensure by the adoption of appropriate measures not impairing the operations or operational capabilities of such ships owned or operated by it, that such ships act in a manner consistent, so far as is reasonable and practicable, with the MARPOL Convention and its annexes.

Regulation 2, Definitions

Regulation 2 defines 13 terms used in the Regulations: a similar stage of construction; continuous feeding; emission; new installations; NOx Technical Code; ozone-depleting substances; sludge oil; shipboard incineration; shipboard incinerator; ships constructed; SOx Emission Control Area; tanker; and The Protocol of 1997.

Regulation 3, General Exceptions

Regulation 3 provides two general exceptions from the Regulations of Annex VI. The first is an exception for any emission necessary for the purpose of securing the safety of a ship or saving life at sea. The second exception exempts any emission resulting from damage to a ship or its equipment (provided that all reasonable precautions have been taken after the occurrence of the damage or discovery of the emission for the purpose of preventing or minimizing the emission). However, the second exception would not apply if the owner or master acted either with intent to cause damage, or recklessly and with knowledge that damage would probably result. These exceptions are based upon Regulations 11(a) and (b) of MARPOL Annex I.

Regulation 4, Equivalents

Regulation 4 permits an Administration (i.e., the Government of the State whose flag the ship is entitled to fly) to allow any fitting, material, appliance or apparatus to be fitted on a ship as an alternative to that required by Annex VI if such fitting, material, appliance or apparatus is at least as effective as that required by the Annex. Any such authorized alternative is to be communicated to the IMO for circulation to all MARPOL parties for their information and appropriate action. The United States currently grants waivers, exemptions and certificates of alternate compliance for existing requirements under the MARPOL Convention through various authorities in Title 46, U.S. Code, and Titles 33 and 46, Code of Federal Regulations (C.F.R.).

Chapter II - Survey, Certification and Means of Control

Regulations 5-9, regarding survey and certification, are modeled upon Regulations 4-8 of MARPOL Annex I as amended by the harmonized system of survey and certification for MARPOL Annexes I and II that entered into force internationally on February 3, 2000, and which are implemented by the U.S. pursuant to 46 U.S. Code, Subtitle II, Part B, Inspection and Regulation of Vessels. Regulations 10 and 11 on means of control are modeled upon Regulation 8A of MARPOL Annex I as amended and on Article 6 of the International Convention for the Prevention of Pollution from Ships, done at London November 2, 1973, respectively,

both of which are implemented by the United States pursuant to 14 U.S. Code § 89 and 46 U.S. Code, Subtitle II, Part B.

Regulation 5, Surveys and Inspections

Regulation 5 sets forth the requirements for surveys and inspections. Every ship 400 gross tonnage and above and every fixed and floating drilling rig and other platform is required to pass the following surveys: an *initial survey* before the International Air Pollution Prevention Certificate is issued pursuant to Regulation 6; an *intermediate survey* at about halfway through the period of validity of the Certificate that may not exceed five years; and at least one *periodic survey* not exceeding every five years after the Certificate is originally issued. The initial and periodic surveys are to ensure that the equipment, systems, fittings, arrangements and material fully comply with the applicable requirements of Annex VI. The intermediate survey is to ensure that the equipment and arrangements fully comply with the requirements of Annex VI and are in good working order. *Unscheduled surveys* are required to be conducted as specified by the Administration if it does not require annual periodic surveys.

Surveys of vessels less than 400 gross tonnage are left to Administrations. Administrations are responsible for the validity of the surveys, but may permit them to be performed by another entity.

The NOx Technical Code is to be used for surveys of marine diesel engines. When an engine is manufactured outside the country of the Administration of the ship on which it will be installed, section 2.2.7.1 of the Code permits the Administration of a ship to request the Administration of the country in which an engine is manufactured to survey the engine. EPA advises that, consistent with the Clean Air Act, it does not intend to avail itself of this provision; rather, EPA intends to survey foreign-manufactured engines to be installed in ships under construction in the United States.

The surveying organization is required to notify the flag State and port State of violations detected during a survey. The surveying organization is also required to ensure that the ship is brought into compliance before it continues its voyage. If the ship is not brought into compliance, the Administration should withdraw the ship's

Certificate. The port State is to assist the flag State in carrying out these duties.

Equipment is required to be properly maintained; no changes may be made without the express approval of the Administration except for direct replacement of such equipment and fittings. If there is an accident or a defect with the equipment, the ship owner must notify the Administration or the organization responsible for issuing the relevant Certificate.

Regulation 5 is modeled on Regulation 4 of Annex I to the MARPOL Convention as modified by the harmonized system of survey and certification.

Regulation 6, Issue of International Air Pollution Prevention Certificate

Regulation 6 requires the issuance of an International Air Pollution Prevention (IAPP) Certificate, after a survey conducted in accordance with Regulation 5, to any ship of 400 gross tonnage or above engaged in voyages to ports or offshore terminals under the jurisdiction of other Parties and to platforms and drilling rigs engaged in voyages to waters under the sovereignty or jurisdiction of other Parties to the Protocol of 1997, that is to their exclusive economic zone, territorial sea or internal waters. The IAPP Certificate shall be issued to ships constructed before the date of the entry into force of the Protocol of 1997 no later than the first scheduled drydocking after entry into force of the Protocol of 1997, but in no case later than three years after entry into force of Annex VI. The Certificate may be issued by the Administration or any person or organization duly authorized by it; however, in every case the Administration assumes full responsibility for the Certificate. Regulation 6 is based upon Regulation 5 of MARPOL Annex I.

Regulation 7, Issue of a Certificate by another Government

Regulation 7 governs the issuance of an IAPP Certificate by another Government Party to the Protocol of 1997. In this case, the surveying Administration must submit a copy of the Certificate and survey report to the requesting Administration. This arrangement must be noted on the IAPP Certificate. Such an IAPP Certificate has the same force and is to receive the same recognition as if it were issued by the Administration. However, no IAPP Certificate can be

issued to a ship flagged in a State that is not a Party to the Protocol of 1997. Regulation 7 is substantively identical to Regulation 6 of MARPOL Annex I.

Regulation 8, Form of Certificate

Regulation 8 requires the form of the IAPP Certificate to be substantially similar to that set out in Appendix I to Annex VI. Regulation 8 follows the text of Regulation 7 of MARPOL Annex I, while recognizing that English, Spanish and French are now the official languages of the IMO.

Regulation 9, Duration and Validity of Certificate

Regulation 9 governs the duration and validity of the IAPP Certificate. The Certificate is valid for no more than five years (as determined by the Administration), but may be extended for no more than five months to enable the ship to continue its voyage to the port where it is to be resurveyed. The Certificate ceases to be valid if the required inspections and surveys are not carried out in a timely manner; if there are significant unauthorized alterations to the ship's equipment, systems, fittings, arrangements or material; or upon transfer of the ship to a flag of another State. A new Certificate may be issued only when the gaining Government is fully satisfied that the ship meets the requirements of Regulation 5. Regulation 9 is based on Regulation 8 of MARPOL Annex I, which is administered by the U.S. pursuant to 46 U.S. Code Chapter 33.

Regulation 10, Port State Control on Operational Requirements

Regulation 10 provides for inspection by port State authorities concerning the operational requirements of Annex VI if there are clear grounds for believing that the master or crew are not familiar with essential shipboard procedures relating to the prevention of air pollution from ships. In such circumstance, the port State authority shall take such steps as will ensure that the ship shall not sail until the situation has been brought to order in accordance with the requirements in Annex VI.

This provision is substantially identical to Regulation 8A of MARPOL Annex I, which entered into force internationally on March 3, 1996, and is enforced pursuant to IMO

resolution A.787(19), Procedures for port State control, as amended, and 46 U.S. Code, Subtitle II, Part B.

Regulation 11, Detection of Violations and Enforcement

Regulation 11 sets out the rules for detection of violations and enforcement of Annex VI. Parties to Annex VI are required to cooperate in detecting violations. A ship can be inspected in any port of a Party and, if any violations are found, the port State is to send a report to the Administration. Any Party can inform an Administration of a violation. The Party should also inform the master of the ship when practicable. An Administration can request additional information about the violation from the informing Party. After receiving sufficient evidence, the Administration is required to take action under its law, and to report the action taken to the informing Party and to the IMO. A Party may also inspect a ship when it enters its ports or offshore terminals under its jurisdiction if it receives a request for an inspection from any Party together with sufficient evidence that a ship has emitted any regulated substance in violation of Annex VI. In this case, a report of the investigation is to be sent both to the Party requesting the inspection and the Administration so that appropriate action may be taken under MARPOL. These rules, contained in subparagraphs (1) through (5), are identical to those found in Article 6 of the MARPOL Convention of 1973.

Subparagraph (6) provides that the international law concerning the prevention, reduction, and control of pollution of the marine environment from ships, including the law relating to enforcement and safeguards, in force at the time of application or interpretation of Annex VI, applies, *mutatis mutandis*, to the rules and standards set forth in Annex VI. Subparagraph (6) derives from Article 9(3) of the MARPOL Convention of 1973, which provides that the term "jurisdiction" in MARPOL is to be construed in light of the international law in force at the time of application or interpretation of MARPOL. Article 9(2) of the MARPOL Convention of 1973 provides that nothing in that Convention shall prejudice the codification and development of the international law of the sea then under way under the auspices of the United Nation General Assembly. Subparagraph (6) was drafted to take account of the adoption and entry into force of the Law of the Sea Convention subsequent to the adoption of MARPOL and refers to the provisions of Part XII of the 1982 United Nations Convention on

the Law of the Sea, including sections 6, Enforcement, and 7, Safeguards, thereof. Subparagraph (6) also recognizes, through the use of the phrase *mutatis mutandis,* that the relevant articles of the Law of the Sea Convention refer to "discharge" while Annex VI addresses "emission".

Chapter III - Requirements for Control of Emissions from Ships

Regulation 12, Ozone-depleting Substances

Regulation 12 regulates the emission and disposal of ozone-depleting substances and installation of new equipment that contain ozone-depleting substances (except HCFCs).

Regulation 1(6) defines ozone-depleting substances by cross-reference to those controlled substances defined in article 1(4) of, and listed in Annexes A, B, C or E to, the Montreal Protocol on Substances that Deplete the Ozone Layer, 1987 (entered into force for the United States on January 1, 1989), Senate Treaty Doc. 100-10, Sen. Ex. Rep. 100-14, that are in force at the time of application or interpretation of Annex VI. Annexes B, C and E were added to the Montreal Protocol subsequent to its entry into force. Regulation 1(6) of Annex VI identifies some of the ozone-depleting substances that may be found on-board ship. They include, but are not limited to three halon compounds and five chloroflurocarbon compounds (CFCs).

Regulation 12 requires that the deliberate emission of ozone-depleting substances be prohibited. Regulation 12 defines "deliberate emissions" to include emissions occurring in the course of maintaining, servicing, repairing or disposing of systems or equipment.

Regulation 12 excludes from the definition of "deliberate emissions" minimal releases associated with the recapture or recycling of an ozone-depleting substance. As leaks are not included in the definition of "deliberate emissions", Regulation 12 permits Parties to the Protocol of 1997 to regulate emissions arising from leaks of an ozone-depleting substance, whether or not the leaks are deliberate.

Regulation 12 further requires that new installations that contain ozone-depleting substances also be prohibited on all ships, except that new installations containing

hydrochloroflurocarbons (HCFCs) are permitted until January 1, 2020.

Finally, Regulation 12 requires that ozone-depleting substances and equipment containing such substances be delivered to appropriate reception facilities when removed from ships. This provision is designed to prevent release of these substances into the atmosphere after they are removed from ships.

Ozone-depleting substances are currently regulated by 40 C.F.R. Part 82, which implements the Montreal Protocol, and sections 602-607, 614 and 616 of the Clean Air Act Amendments of 1990, Pub.L. 101-549.

Regulation 13, Nitrogen Oxides (NOx)

Regulation 13 specifies the NOx limits for marine diesel engines above 130 kW installed on vessels constructed on or after January 1, 2000, or engines above 130 kW that undergo a major conversion on or after that date.

Emergency diesel engines and engines on certain emergency equipment are exempted. An Administration can exempt engines on vessels under its flag that operate solely in waters subject to its sovereignty or jurisdiction (i.e., its internal waters, territorial sea and exclusive economic zone), provided that the engines are subject to alternative NOx requirements established by the Administration. This exemption could apply to U.S. flag ships operating, for example, between Norfolk and Miami, but not between Miami and The Bahamas or between San Francisco and Honolulu. The United States has established alternative standards for certain categories of marine diesel engines installed on U.S.-flag vessels that are more stringent than the Regulation 13 NOx limits. Those standards, which go into effect between 2004 and 2007 depending on engine size, are contained in 40 C.F.R. Part 94.

An Administration can also exempt engines on vessels under its flag if they were constructed, or undergo a major conversion, prior to the date of entry into force of Annex VI, provided the ship is solely engaged in voyages to ports or offshore terminals within the flag State. This exemption could apply to U.S. flag ships operating, for example, solely between Norfolk and Miami, between Miami and Puerto Rico, or between San Francisco and Anchorage, but not

between Miami and The Bahamas. The Administration has not yet determined whether it will exercise this exemption.

Chapter 6 of the NOx Technical Code sets forth procedures for demonstrating compliance by pre-certificated engines with NOx emission limits after they are installed on board ships.

Regulation 13(3)(a) prohibits the operation of each marine diesel engine to which Regulation 13 applies that is not within the limits set out in that subparagraph.

Regulation 13(3)(b) allows the use of after-treatment devices as an alternative NOx control measure, such as an exhaust gas cleaning system approved by the Administration in accordance with the NOx Technical Code, or any other equivalent method approved by the Administration taking into account guidelines to be developed by the IMO. These guidelines have not yet been developed by the IMO. Any such measure must reduce on-board NOx emission at least to the limit specified in Regulation 13(3)(a).

Regulation 14, Sulfur Oxides (SOx)

General requirements. These provisions set a global cap for the sulfur content of fuel oil used on-board ships at 4.5% m/m (i.e., 45,000 ppm). The worldwide average sulfur content of residual fuel oil is to be monitored pursuant to guidelines to be developed by the IMO. Those guidelines have been adopted by the IMO as resolution MEPC.82(43), July 1, 1999.

Requirements within SOx Emission Control Areas (SECA). Regulation 14(3) designates the Baltic Sea as a SECA and permits the designation of additional SECAs by the IMO in accordance with the procedures set out in Appendix III to Annex VI. The IMO has already approved the North East Atlantic (North Sea) Area as a SECA for adoption when Annex VI enters into force. The United States is contemplating asking the IMO to establish SECAs off certain U.S. coasts.

Pursuant to Regulation 14(4), ships operating in SECAs must use fuel that has a sulfur content not more than 1.5% m/m (i.e., 15,000 ppm), or must use an exhaust gas cleaning system that meets a standard of 6.0 g SOx/kW-hr, or some other equivalent SOx emission control technology approved by the Administration taking into account guidelines to be

developed by the IMO. The IMO has not yet developed these guidelines. The IMO Assembly has invited governments located in geographic regions where SECAs have been designated to ensure the availability of low sulfur bunker fuel oil within their jurisdiction and called on the oil and shipping industries to facilitate the availability and use of low sulfur bunker fuel oil (IMO Assembly resolution A.926(22), November 29, 2001).

As described in Regulation 14(4)(b), waste streams from exhaust gas cleaning systems may not be discharged into enclosed ports, harbors and estuaries unless it can be thoroughly documented by the ship that such waste streams have no adverse impact on the ecosystems of such marine areas, based on criteria communicated by the authorities of the port State to the IMO, which is to circulate the criteria to all MARPOL Parties. Waste streams not permitted to be discharged into the marine environment are to be disposed of in reception facilities as provided in Regulation 17.

Regulation 14(5) provides that the sulfur content of all fuel oil must be documented by the supplier as required by Regulation 18 of Annex VI.

Regulation 14(6) specifies requirements for fuel changeover if applicable.

As described in Regulation 14(7), the fuel sulfur content requirements in SECAs become applicable one year after entry into force of the Protocol of 1997 for SECAs designated prior to entry into force of the Protocol of 1997, and one year after designation for SECAs designated following entry into force of the Protocol of 1997.

Regulation 15, Volatile Organic Compounds

Volatile organic compounds (VOCs) are the aromatic vapors given off by liquid hydrocarbons such as crude oil and diesel fuel, which, unless they are captured while the liquid is being transferred from one container to another, will escape into the atmosphere. Annex VI does not require emissions of VOCs to be regulated. However, if emissions of VOCs from tankers are to be regulated in ports or terminals under the jurisdiction of a Party to the Protocol of 1997, the emissions are to be regulated in accordance with the provisions of Regulation 15. "Tanker" is defined by Regulation 1(12) as an oil tanker as defined in

Regulation 1(4) of MARPOL Annex I or a chemical tanker as defined in Regulation 1(1) of MARPOL Annex II.

A Party choosing to designate ports or terminals under its jurisdiction at which it intends to regulate VOC emissions is required to notify the IMO. The notification must include information on the size of tankers to be controlled, on cargoes requiring vapor emission control systems, and the effective date of such control. The notification is required to be submitted at least six months before the effective date.

In doing so the Party is required to ensure that vapor emission control systems approved by it, taking into account the IMO safety standards (MSC/Circ.585, Standards for vapor emission control systems), are provided in the designated ports and terminals, and are operated safely and in a manner so as to avoid undue delay to the ship. The United States has national VOC design, installation and operating standards for facilities transferring oil or hazardous materials in bulk (33 C.F.R. Part 154, Subpart E, Vapor Control Systems) which the Coast Guard advises are consistent with Regulation 15. The United States also has national emission standards for marine tank vessel operations (40 C.F.R. Part 63, Subpart Y, §§ 63.560-63.567).

Pending entry into force of the Protocol of 1997, the IMO has invited Member Governments to notify the IMO of those ports and terminals under its jurisdiction at which VOC emissions are to be regulated, and the requirements to be imposed on ships calling at these ports and terminals. The IMO has undertaken to circulate this information through MEPC circulars so that owners will have up-to-date information on existing or planned vapor recovery systems (MEPC/Circ.345, November 19, 1998, Notification to the Organization on ports or terminals where volatile organic compounds (VOCs) emissions are to be regulated). To date no such list has been promulgated by the IMO.

Within the United States, some states and local jurisdictions have required vapor recovery at certain ports and terminals in order to comply with national ambient air quality standards. Terminals in the United States where vapor recovery is required must be in compliance with 33 C.F.R. Part 154, Subpart E, Vapor Control Systems. As required by Annex VI, the United States will submit a listing of where in the country vapor recovery is required.

All tankers subject to vapor emission control in accordance with Regulation 15(2) are required to be provided with a vapor collection system approved by the Administration taking into account the IMO safety standards, and are required to use the system during the loading of such cargoes. Terminals that have installed vapor emission control systems in accordance with Regulation 15 may accept existing tankers that are not fitted with vapor collection systems for three years after the effective date identified in Regulation 15(2).

Regulation 15 also applies to gas carriers only when the type of loading and containment systems allow safe retention of non-methane VOCs on-board, or their safe return ashore.

The United States has national VOC design, installation and operating standards for tank vessels (but not gas carriers) operating in the navigable waters of the United States (46 C.F.R. Part 39, Vapor Control Systems) which the Coast Guard advises are consistent with Regulation 15.

As noted above, within the United States, some states and local jurisdictions have required vapor recovery for certain terminals within their jurisdiction in order to meet national ambient air quality standards. In general, tankers without vapor recovery systems installed on board are not permitted to operate at those terminals required to control VOCs. Where vapor recovery is installed at terminals and on tankers, the recovery system must comply with the Regulations in 33 C.F.R. Part 154, Subpart E, and 46 C.F.R. Part 39, respectively.

Regulation 16, Shipboard Incineration

Regulation 16 provides that shipboard incineration shall be allowed only in a shipboard incinerator (with certain exceptions noted below). "Shipboard incineration" is defined by Regulation 1(8) as the incineration of wastes or other matter on-board a ship, if such wastes or other matter were generated during the normal operation of that ship. A "shipboard incinerator" is defined by Regulation 1(9) as "a shipboard facility designed for the primary purpose of incineration".

Regulation 16(1) requires that each incinerator installed on-board a ship on or after January 1, 2000 meet the requirements contained in Appendix IV to Annex VI.

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Regulation 16 further requires each incinerator to be approved by the Administration taking into account the IMO standard specifications for shipboard incinerators, resolution MEPC 76(40), September 25, 1997, Standard specification for shipboard incinerators, as amended by resolution MEPC.93(45), October 5, 2000. In the United States, this requirement is implemented by 46 C.F.R. § 63.25-9.

Pursuant to Regulation 16(2)(b), the Administration may exclude any incinerator installed on-board a ship before the date of entry into force of the Protocol of 1997, provided that the ship is solely engaged in voyages within waters subject to the sovereignty or jurisdiction of the flag State. "Waters subject to the sovereignty or jurisdiction" refers to internal waters, the territorial sea and the exclusive economic zone of the flag State. This exclusion could apply to U.S. flag ships operating, for example, between Norfolk and Miami, but not between Miami and The Bahamas or between San Francisco and Honolulu. The United States currently does not intend to exercise this option.

Regulation 16(3) provides that nothing in that Regulation affects the prohibitions in, or other requirements of, the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, 26 U.S.T. 2403, T.I.A.S. No. 8165, 1046 U.N.T.S. 120, and the 1996 Protocol thereto (which is not in force).

Regulation 16(4) requires shipboard incineration of the following substances to be prohibited:

a. MARPOL Annex I, II and III cargo residues and related contaminated packing materials;

b. polychlorinated biphenyls (PCBs);

c. garbage as defined in MARPOL Annex V containing more than traces of heavy metals; and

d. refined petroleum products containing halogen compounds.

Pursuant to Regulation 16(5), shipboard incineration of sewage sludge and sludge oil generated during the normal operation of a ship may take place in a shipboard incinerator or in the main or auxiliary power plant or

boilers. In those cases, however, incineration may not take place inside ports, harbors or estuaries.

Regulation 16(6) requires shipboard incineration of polyvinyl chlorides (PVCs) to be prohibited except in shipboard incinerators for which IMO Type Approval Certificates have been issued.

Regulation 16(7) requires all ships with incinerators subject to this Regulation to possess a manufacturer's operating manual, which shall specify how to operate the incinerator within the limits described in paragraph 2 of Appendix IV to Annex VI.

Regulation 16(8) requires personnel responsible for operation of any incinerator to be trained and capable of implementing the guidance provided in the manufacturer's operating manual.

Regulation 16(9) requires monitoring of combustion flue gas outlet temperature at all times and waste not to be fed into a continuous-feed shipboard incinerator when the temperature is below the minimum allowed temperature of 850°C. "Continuous feeding" is defined by Regulation 1(2) as the process whereby waste is fed into a combustion chamber without human assistance while the incinerator is in normal operating conditions with the combustion chamber operative temperature between 850°C and 1200°C. For batch-loaded shipboard incinerators, the unit is required to be designed so that the temperature in the combustion chamber reaches 600°C within five minutes after start-up.

Regulation 16(10) provides that nothing in Regulation 16 precludes the development, installation and operation of alternative design shipboard thermal waste treatment devices that meet or exceed the requirements of this Regulation. Examples of thermal waste treatment technologies that could be considered for shipboard waste treatment include electric furnace, plasma arc pyrolysis, wet oxidation, hydrothermal oxidation, super critical water oxidation and super critical CO2.

Regulation 17, Reception Facilities

Each Party to the Protocol of 1997 undertakes to ensure the provision of facilities adequate to meet (a) the needs of ships using its repair ports for the reception of ozone-depleting substances and equipment containing such

substances when they are removed from ships, and (b) the needs of ships using its ports, terminals or repair ports for the reception of exhaust gas cleaning residues when their discharge into the marine environment is not permitted under Regulation 14. These facilities may not cause undue delay to ships.

Currently there are no domestic requirements for reception facilities to accept exhaust gas cleaning residues. However, the Administration believes the domestic reception facility infrastructure will be able to make the needed adjustments to accommodate this waste stream without causing undue delay to ships.

Parties also undertake to ensure the provision of facilities adequate to meet the needs in ship breaking facilities for the reception of ozone-depleting substances and equipment containing such substances when they are removed from ships. Removal and reception of ozone-depleting substances in the United States are regulated by 40 C.F.R. Part 82.

Pursuant to Regulation 17(2), each Party is required to notify the IMO for transmission to all IMO Members of all cases where the facilities are unavailable or alleged to be inadequate.

Regulation 18, Fuel Oil Quality

This Regulation contains the requirements for fuel oil for combustion purposes delivered to and used on-board ships to which Annex VI applies. Petroleum-based fuel oil is to be free from inorganic acid. It may not include any added substances or chemical wastes that (i) jeopardize safety; (ii) are harmful to the ship; (iii) are harmful to personnel; or (iv) result in additional air pollution.

In addition to these requirements, fuel oil derived from other processes may not exceed the Regulation 14 sulfur limits or cause an engine to exceed the Regulation 13 NOx limits.

As described in Regulation 18(3) and (4), compliance is to be ensured through bunker delivery notes which shall contain the information specified in Appendix V to Annex VI. These notes are required to be kept on-board ships that are subject to the Regulations 5 and 6 survey and certification provisions.

As set forth in Regulation 18(5) through 18(8), each Party is required to oversee certain aspects of the fuel delivery process with regard to the provision of bunker delivery notes. Each Party is also to take action against suppliers that deliver fuel that does not comply with Regulation 18. The IMO recently adopted guidelines for the sampling of fuel oil for determination of compliance with Annex VI which were appended to MEPC resolution MEPC.96(47), March 8, 2002.

As described in Regulation 18(2), Regulation 18 does not apply to coal in its solid form or to nuclear fuels.

Regulation 19, Requirements for Platforms and Drilling Rigs

This Regulation specifies that fixed and floating platforms and drilling rigs are to comply with the requirements of Annex VI. Consistent with MARPOL 1973 Article 2(3)(b)(ii), emissions directly arising from the exploration, exploitation and associated offshore processing of seabed minerals are exempt. In addition, the requirements do not apply to the use of hydrocarbons that are produced and subsequently used on site as fuel when approved by the Administration. Air emissions from U.S. outer continental shelf sources are currently regulated by 40 C.F.R. Part 55.

APPENDICES

Annex VI has five appendices.

Appendix I, Form of IAPP Certificate (Regulation 8)

Appendix I provides the form of the International Air Pollution Prevention (IAPP) Certificate. The Certificate records the fact that the named ship has been surveyed in accordance with Regulation 5 of Annex VI, and that the on-board equipment, systems, fittings, arrangements and materials fully comply with the applicable requirements of Annex VI. The form also provides for endorsements for annual and intermediate surveys, and a record of construction and equipment.

Appendix II, Test Cycles and Weighting Factors (Regulation 13)

Appendix II provides the test cycles and weighting factors that should be applied for verification of compliance of

marine diesel engines with the NOx emission limits in accordance with Regulation 13 of Annex VI using the test procedure and calculation methods specified in the NOx Technical Code.

Appendix III, Criteria and Procedures for Designation of SOx Emission Control Areas (Regulation 14)

Appendix III provides the criteria and procedures for designation of SOx Emission Control Areas in accordance with Regulation 14. An Administration must submit a proposal to the IMO that demonstrates a need to prevent, reduce and control SOx air pollution from ships. The proposal is to include a description of the area, a description of the land and sea areas at risk from SOx emissions, an assessment of the contribution of ships to SOx levels in these areas, relevant meteorological information, the nature of ship traffic in the area, and a description of land-based SOx emission control measures taken by the proposing State or States. Proposals are to be considered by the IMO and are to be designated by amendment to Annex VI.

Appendix IV, Type Approval and Operating Limits for Shipboard Incinerators (Regulation 16)

Appendix IV sets forth the type approval standards and operating limits for shipboard incinerators in accordance with Regulation 16.

Appendix V, Information to be Included in the Bunker Delivery Note (Regulation 18(3))

Appendix V details the information to be included in the bunker delivery note referred to in Regulation 18(3).

CONFERENCE RESOLUTION 2

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

THE CONFERENCE,

RECALLING resolution A.719(17) adopted by the Assembly of the International Maritime Organization, which indicates that the objective of prevention of air pollution from ships would best be achieved by establishing a new annex to the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78) to provide rules for restriction and control of emission of harmful substances from ships into the atmosphere,

RECOGNIZING that the emission of nitrogen oxides from marine diesel engines installed on board ships has an adverse effect on the environment causing acidification, formation of ozone, nutrient enrichment and contributes to adverse health effects globally,

BEING AWARE of the protocols and declarations to the 1979 Convention on Long-Range Transboundary Air Pollution concerning, inter alia, the reduction of emission of nitrogen oxides or its transboundary fluxes,

HAVING ADOPTED the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (the 1997 Protocol),

NOTING regulation 13 of Annex VI of MARPOL 73/78 which makes the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines mandatory under that regulation,

HAVING CONSIDERED the recommendations made by the Marine Environment Protection Committee at its thirty-ninth session,

1. ADOPTS the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines (NOx Technical Code), the text of which is set out at annex to the present resolution;

2. RESOLVES that the provisions of the NOx Technical Code shall enter into force, as mandatory requirements, for all Parties to the 1997 Protocol on the same date as the entry into force date of that Protocol;

3. INVITES Parties to MARPOL 73/78 to implement the provisions of the NOx Technical Code in accordance with the provisions of regulation 13 of Annex VI; and

4 URGES Parties to MARPOL 73/78 to bring the NOx Technical Code to the immediate attention of shipowners, ship operators, ship builders, marine diesel engine manufacturers and any other interested groups.

ANNEX

TECHNICAL CODE

ON CONTROL OF EMISSION OF NITROGEN OXIDES

FROM

MARINE DIESEL ENGINES

Foreword

On 26 September 1997, the Conference of Parties to the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78), adopted, by Conference resolution 2, the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines. Under the provisions of Annex VI - Regulations for the Prevention of Air Pollution from Ships, of MARPOL 73/78, and subsequent to the entry into force of Annex VI, each marine diesel engine to which regulation 13 of that annex applies, must comply with the provisions of this Code.

As general background information, the precursors to the formation of nitrogen oxides during the combustion process are nitrogen and oxygen. Together these compounds comprise 99% of the engine intake air. Oxygen will be consumed during the combustion process, with the amount of excess oxygen available being a function of the air/fuel ratio which the engine is operating under. The nitrogen remains largely unreacted in the combustion process, however a small percentage will be oxidized to form various oxides of nitrogen. The nitrogen oxides (NO_x) which can be formed include NO and NO_2, while the amounts are primarily a function of flame or combustion temperature and, if present, the amount of organic nitrogen available from the fuel. It is also a function of the time the nitrogen and the excess oxygen are exposed to the high temperatures associated with the diesel engine's combustion process. In other words, the higher the combustion temperature (e.g., high peak pressure, high compression ratio, high rate of fuel delivery, etc.), the greater the amount of NO_x formation. A slow speed diesel engine, in general, tends to have more NO_x formation than a high speed engine. NO_x has an adverse effect on the environment causing acidification, formation of ozone, nutrient enrichment and contributes to adverse health effects globally.

The purpose of this Code is to establish mandatory procedures for the testing, survey and certification of marine diesel engines which will enable engine manufacturers, shipowners and Administrations to ensure that all applicable marine diesel engines comply with the relevant limiting emission values of NO_x as specified within regulation 13 of Annex VI to MARPOL 73/78. The difficulties of establishing with precision, the actual weighted average NO_x emission of marine diesel engines in service on vessels have been recognised in formulating a simple, practical set of requirements in which the means to ensure compliance with the allowable NO_x emissions, are defined.

Administrations are encouraged to assess the emissions performance of propulsion and auxiliary diesel engines on a test bed where accurate tests can be carried out under properly controlled conditions. Establishing compliance with regulation 13 of Annex VI at this initial stage is an essential feature of this Code. Subsequent testing on board the ship may inevitably be limited in scope and accuracy and its purpose should be to infer or deduce the emission performance and to confirm that engines are installed, operated and maintained in accordance with the manufacturer's specifications and that any adjustments or modifications do not detract from the emissions performance established by initial testing and certification by the manufacturer.

CONTENTS

ABBREVIATIONS, SUBSCRIPTS AND SYMBOLS

Tables 1, 2, 3 and 4 below summarize the abbreviations, subscripts and symbols used throughout this Code, including specifications for the analytical instruments in appendix 3, calibration requirements for the analytic instruments contained in appendix 4 and the formulae for calculation of gas mass flow as contained in chapter 5 and appendix 6 of this Code.

.1 Table 1: symbols used to represent the chemical components of diesel engine gas emissions addressed throughout this Code;

.2 Table 2: abbreviations for the analysers used in the measurement of gas emissions from diesel engines, as specified in appendix 3 of this Code;

.3 Table 3: symbols and subscripts of terms and variables used in all formulae for the calculation of exhaust gas mass flow for the test bed measurement methods, as specified in chapter 5 of this Code; and

.4 Table 4: subscripts and descriptions of terms and variables used in all formulae for the calculation of exhaust gas mass flow following the carbon balance method, as specified in appendix 6 of this Code.

Table 1. Symbols for the chemical components of diesel engine emissions

Symbol	Chemical Component	Symbol	Chemical Component
C_3H_8	Propane	NO	Nitric Oxide
CO	Carbon monoxide	NO_2	Nitrogen Dioxide
CO_2	Carbon dioxide	NO_x	Oxides of nitrogen
HC	Hydrocarbons	O_2	Oxygen
H_2O	Water		

Table 2. Abbreviations for analysers in measurement of diesel engine gaseous emissions (refer to appendix 3 of this Code)

Abbreviation	Term	Abbreviation	Term
CFV	Critical flow venturi	HFID	Heated flame ionization detector
CLD	Chemiluminescent detector	NDIR	Non-dispersive infrared analyser
ECS	Electrochemical sensor	PDP	Positive displacement pump
FID	Flame ionization detector	PMD	Paramagnetic detector
FTIR	Fourier transform infrared analyser	UVD	Ultraviolet detector
HCLD	Heated chemiluminescent detector	ZRDO	Zirconiumdioxide sensor

Table 3. Symbols and subscripts for terms and variables used in the formulae for the test bed measurement methods (refer to chapter 8 of this Code)

Symbol	Term	Dimension
A_T	Cross sectional area of the exhaust pipe	m^2
C1	Carbon 1 equivalent hydrocarbon	-
conc	Concentration	ppm or Vol%
$conc_c$	Background corrected concentration	ppm or 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 (applicable only to an engine family)	-
F_{FCB}	Fuel specific factor for the carbon balance calculation	-
F_{FD}	Fuel specific factor for exhaust flow calculation on dry basis	-
F_{FH}	Fuel specific factor used for the calculations of wet concentrations from dry concentrations	-
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/kWh
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	-
$K_{W,a}$	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	%
mass	Emissions mass flow rate	g/h

Symbol	Term	Dimension
p_a	Saturation vapour pressure of the engine intake air (in ISO 3046-1, 1995: p_{sv} = PSY, test ambient vapour pressure)	kPa
p_B	Total barometric pressure (in ISO 3046-1, 1995: p_x = PX, site ambient total pressure; p_y = PY, test ambient total pressure)	kPa
p_s	Dry Atmospheric pressure	kPa
P	Power, brake uncorrected	kW
P_{AUX}	Declared total power absorbed by auxiliaries fitted for the test only, but not required on board the ship	kW
P_m	Maximum measured or declared power at the test engine speed under test conditions	kW
r	Ratio of cross sectional areas of isokinetic probe and exhaust pipe	-
R_a	Relative humidity of the intake air	%
R_f	FID response factor	-
R_{fM}	FID response factor for methanol	-
S	Dynamometer setting	kW
T_a	Absolute temperature of the intake air	K
T_{Dd}	Absolute dewpoint temperature	K
T_{SC}	Temperature of the intercooled 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	-

Table 4. Symbols and descriptions of terms and variables used in the formulae for the carbon balance measurement method (refer to appendix 6 of this Code)

Symbol	Description	Dimension	Remark
ALF	H content of fuel	% m/m	
AWC	Atomic weight of C		
AWH	Atomic weight of H		
AWN	Atomic weight of N		
AWO	Atomic weight of O		
AWS	Atomic weight of S		
BET	C content of fuel	% m/m	
CO2D	Concentration of CO_2	% V/V	in dry exhaust
CO2W	Concentration of CO_2	% V/V (wet)	in wet exhaust
COD	Concentration of CO	ppm	in dry exhaust
COW	Concentration of CO	ppm	in wet exhaust
CW	Soot	mg/m^3	in wet exhaust
DEL	N content of fuel	% m/m	
EAFCDO	Excess-air-factor based on the complete combustion and the CO_2-concentration, $l_{V,CO2}$	kg/kg	
EAFEXH	Excess-air-factor based on the exhaust gas concentration of carbon containing components, l_V	kg/kg	
EPS	O content of fuel	% m/m	
ETA	Nitrogen content of wet combustion air	% m/m	
EXHCPN	Exhaust gas ratio of components with carbon, c	V/V	
EXHDENS	Density of wet exhaust	kg/m^3	
FFCB	Fuel specific factor for the carbon balance calculation		
FFD	Fuel specific factor for exhaust flow calculation on dry basis		dry basis
FFH	Fuel specific factor used for calculation of wet concentration from dry concentration		
FFW	Fuel specific factor for exhaust flow calculation on wet basis		wet basis
GAIRD	Combustion air mass flow	kg/h	dry combustion air
GAIRW	Combustion air mass flow	kg/h	wet combustion air
GAM	S content of fuel	% m/m	
GCO	Emission of CO	g/h	
GCO2	Emission of CO_2	g/h	
GEXHD	Exhaust mass flow	kg/h	dry exhaust
gexhw	Exhaust mass flow, calculated by the carbon balance method, G_{EXHW}	kg/h	
GEXHW	Exhaust mass flow	kg/h	wet exhaust
GFUEL	Fuel mass flow	kg/h	
GHC	Emission of HC	g/h	hydrocarbons
GH2O	Emission of H_2O	g/h	
GN2	Emission of N_2	g/h	
GNO	Emission of NO	g/h	
GNO2	Emission of NO_2	g/h	

Symbol	Description	Dimension	Remark
GO2	Emission of O_2	g/h	
GSO2	Emission of SO_2	g/h	
HCD	Hydrocarbons	ppm C1	in dry exhaust
HCW	Hydrocarbons	ppm C1	in wet exhaust
HTCRAT	Hydrogen-to-Carbon ratio of the fuel, a	mol /mol	
MV...	Molecular volume of ...	l/mol	individual gas
MW...	Molecular weight of ...	g/mole	individual gas
NO2W	Concentration of NO_2	ppm	in wet exhaust
NOW	Concentration of NO	ppm	in wet exhaust
NUE	Water content of combustion air	% m/m	
O2D	Concentration of O_2	% V/V	in dry exhaust
O2W	Concentration of O_2	% V/V (wet)	in wet exhaust
STOIAR	Stoichiometric air demand for the combustion of 1 kg fuel	kg /kg	
TAU	Oxygen content of wet combustion air	% m/m	wet air
TAU1	Oxygen content of wet combustion air that is emitted	% m/m	wet air
TAU2	Oxygen content of wet combustion air that is combusted	% m/m	wet air
VCO	Volume flow of CO	m^3/h	(exhaust content)
VCO2	Volume flow of CO_2	m^3/h	(exhaust content)
VH2O	Volume flow of H_2O	m^3/h	(exhaust content)
VHC	Volume flow of HC	m^3/h	(exhaust content)
VN2	Volume flow of N_2	m^3/h	(exhaust content)
VNO	Volume flow of NO	m^3/h	(exhaust content)
VNO2	Volume flow of NO_2	m^3/h	(exhaust content)
VO2	Volume flow of O_2	m^3/h	(exhaust content)
VSO2	Volume flow of SO_2	m^3/h	(exhaust content)

Notes: - For STANDARD m^3, or STANDARD Litre, the dimensions std. m^3 and std. l are used. The STANDARD m^3 of a gas is related to 273:15 K and 101.3 kPa
Water gas equilibrium constant = 3.5

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

Chapter 1 - GENERAL

1.1 PURPOSE

The purpose of this Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines, hereunder referred to as the Code, is to specify the requirements for the testing, survey and certification of marine diesel engines to ensure they comply with the nitrogen oxides (NO_x) emission limits of regulation 13 of Annex VI of MARPOL 73/78.

1.2 APPLICATION

1.2.1 This Code applies to all diesel engines with a power output of more than 130 kW which are installed, or are designed and intended for installation, on board any ship subject to Annex VI, with the exception of those engines described in paragraph 1(b) of regulation 13. Regarding the requirements for survey and certification under regulation 5 of Annex VI, this Code addresses only those requirements applicable to an engine's compliance with the NO_x emission limits.

1.2.2 For the purpose of the application of this Code, Administrations are entitled to delegate all functions required of an Administration by this Code to an organization authorized to act on behalf of the Administration. In every case, the Administration assumes full responsibility for the survey and certificate.

1.2.3 For the purpose of this Code, an engine shall be considered to be operated in compliance with the NO_x limits of regulation 13 of Annex VI if it can be demonstrated that the weighted NO_x emissions from the engine are within those limits at the initial certification, intermediate surveys and such other surveys as are required

1.3 DEFINITIONS

1.3.1 *Nitrogen Oxide (NO_x) Emissions* means the total emission of nitrogen oxides, calculated as the total weighted emission of NO_2 and determined using the relevant test cycles and measurement methods as specified in this Code.

1.3.2 *Substantial modification* of a marine diesel engine means:

.1 For engines installed on ships constructed 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 regulation 13 of Annex VI. Routine replacement of engine components by parts specified in the Technical File 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 constructed before 1 January 2000, *substantial modification* means any modification made to an engine which increases its existing emission characteristics established by the simplified measurement method as described in 6.3 in excess of the allowances set out in 6.3.11. These changes include, but are not limited to, changes in its operations or in its technical parameters (e.g., changing camshafts, fuel injection systems, air systems, combustion chamber configuration, or timing calibration of the engine).

1.3.3 *Components* are those interchangeable parts which influence the NO_x emissions performance, identified by their design/parts number.

1.3.4 *Setting* means adjustment of an adjustable feature influencing the NO_x emissions performance of an engine.

1.3.5 *Operating values* are engine data, like cylinder peak pressure, exhaust gas temperature, etc., from the engine log which are related to the NO_x emission performance. These data are load-dependent.

1.3.6 The *EIAPP Certificate* is the Engine International Air Pollution Prevention Certificate which relates to NO_x emissions.

1.3.7 The *IAPP Certificate* is the International Air Pollution Prevention Certificate.

1.3.8 *Administration* has the same meaning as Article 2, sub-paragraph (5) of MARPOL 73/78.

1.3.9 *On-board NOx verification procedures* mean a procedure, which may include an equipment requirement, to be used on board at initial certification survey or at the periodical and intermediate surveys, as required, to verify compliance with any of the requirements of this Code, as specified by the engine manufacturer and approved by the Administration.

1.3.10 *Marine diesel engine* means any reciprocating internal combustion engine operating on liquid or dual fuel, to which regulations 5, 6 and 13 of Annex VI apply, including booster/compound systems if applied.

1.3.11 *Rated power* means the maximum continuous rated power output as specified on the nameplate and in the Technical File of the marine diesel engine to which regulation 13 of Annex VI and the NO_x Technical Code apply.

1.3.12 *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 the marine diesel engine.

1.3.13 *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 the test bed.

1.3.14 *On-board conditions* mean that an engine is:

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

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

1.3.15 A *technical file* is a record containing all details of parameters, including components and settings of an engine, which may influence the NO_x emission of the engine, in accordance with 2.4 of this Code.

1.3.16 A *record book of engine parameters* is the document for recording all parameter changes, including components and engine settings, which may influence NO_x emission of the engine.

Chapter 2 - SURVEYS AND CERTIFICATION

2.1 GENERAL

2.1.1 Each marine diesel engine specified in 1.2, except as otherwise permitted by this Code, shall be subject to the following surveys:

.1 A pre-certification survey which shall be such as to ensure that the engine, as designed and equipped, complies with the NO_x emission limits contained in regulation 13 of Annex VI. If this survey confirms compliance, the Administration shall issue an Engine International Air Pollution Prevention (EIAPP) Certificate.

.2 An initial certification survey which shall be conducted on board a ship after the engine is installed but before it is placed in service. This survey shall be such as to ensure that the engine, as installed on board the ship, including any modifications and/or adjustments since the pre-certification, if applicable, complies with the NO_x emission limits contained in regulation 13 of Annex VI. This survey, as part of the ship's initial survey, may lead to either the issuance of a ship's initial International Air Pollution Prevention (IAPP) Certificate or an amendment of a ship's valid IAPP Certificate reflecting the installation of a new engine.

.3 Periodical and intermediate surveys, which shall be conducted as part of a ship's surveys required by regulation 5 of Annex VI, to ensure the engine continues to fully comply with the provisions of this Code.

.4 An initial engine's certification survey which shall be conducted on board a ship every time a substantial modification is made to an engine to ensure that the modified engine complies with the NO_x emission limits contained in regulation 13 of Annex VI.

2.1.2 To comply with the survey and certification requirements described in 2.1.1, there are five alternative methods included in this Code from which the engine manufacturer, ship builder or ship-owner, as applicable, can choose to measure, calculate or test an engine for its NO_x emissions, as follows:

.1 test bed testing for the pre-certification survey in accordance with chapter 5;

.2 on-board testing for an engine not pre-certificated for a combined pre-certification and initial certification survey in accordance with the full test bed requirements of chapter 5;

.3 on-board engine parameter check method for confirmation of compliance at initial, periodical and intermediate surveys for pre-certified engines or engines that have undergone modifications or adjustments to the designated components and adjustable features since they were last surveyed, in accordance with 6.2;

.4 on-board simplified measurement method for confirmation of compliance at periodical and intermediate surveys or confirmation of pre-certified engines for initial certification surveys, in accordance with 6.3 when required; or

.5 on-board direct measurement and monitoring for confirmation of compliance at periodical and intermediate surveys only, in accordance with 2.3.4, 2.3.5. 2.3.7, 2.3.8, 2.3.11, 2.4.4 and 5.5.

2.2 PROCEDURES FOR PRE-CERTIFICATION OF AN ENGINE

2.2.1 Prior to installation on board, every marine diesel engine, except as allowed by 2.2.2 and 2.2.4, shall:

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

.2 have its NO_x emissions measured on a test bed in accordance with the procedures specified in chapter 5 of this Code, and

.3 be pre-certified by the Administration, as documented by issuance of an EIAPP Certificate.

2.2.2 For the pre-certification of serially manufactured engines, depending on the approval of the Administration, the engine family or the engine group concept may be applied (see chapter 4). In such a case, the testing specified in 2.2.1.2 is required only for the parent engine(s) of an engine group or engine family.

2.2.3 The method of obtaining pre-certification for an engine is for the Administration to:

.1 certify a test of the engine on a test bed;

.2 verify that all engines tested, including, if applicable, those to be delivered within an engine family or group, meet the NO_x limits; and

.3 if applicable, verify that the selected parent engine(s) is representative of an engine family or engine group.

2.2.4 There are engines which, due to their size, construction and delivery schedule, cannot be pre-certified on a test bed. In such cases, the engine manufacturer, shipowner or ship builder shall make application to the Administration requesting an on-board test (see 2.1.2.2). The applicant must demonstrate to the Administration that the on-board test fully meets all of the requirements of a test bed procedure as specified in chapter 5 of this Code. Such a 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 certification. In no case shall an allowance be granted for possible deviations of measurements if an initial survey is carried out on board a ship without any valid pre-certification test.

2.2.5 If the pre-certification test results show that an engine fails to meet the NO_x emission limits as required by regulation 13 of Annex VI, a NO_x reducing device may be installed. This device, when installed on the engine, must be recognized as an essential component of the engine and its presence will be recorded in the engine's Technical File. To receive an EIAPP Certificate for this assembly, the engine, including the reducing device, as installed, must be re-tested to show compliance with the NO_x emission limits. However, in this case, the assembly may be re-tested in accordance with the simplified measurement method addressed in 6.3. The NO_x reducing device shall be included on the EIAPP Certificate together with all other records requested by the Administration. The engine's Technical File shall also contain on-board NO_x verification procedures for the device to ensure it is operating correctly.

2.2.6 For pre-certification of engines within an engine family or engine group, an EIAPP Certificate shall be issued in accordance with procedures established by the Administration to the parent engine(s) and to every member engine produced under this certification to accompany the engines throughout their life whilst installed on ships under the authority of that Administration.

2.2.7.1 When an engine is manufactured outside the country of the Administration of the ship on which it will be installed, the Administration of the ship may request the Administration of the country in which

the engine is manufactured to survey the engine. Upon satisfaction that the requirements of regulation 13 of Annex VI are complied with pursuant to this NO_x Technical Code, the Administration of the country in which the engine is manufactured shall issue or authorize the issuance of the EIAPP Certificate.

2.2.7.2 A copy of the certificate(s) and a copy of the survey report shall be transmitted as soon as possible to the requesting Administration.

2.2.7.3 A certificate so issued shall contain a statement to the effect that it has been issued at the request of the Administration.

2.2.8 A flow chart providing guidance for compliance with the requirements of a pre-certification survey for marine diesel engines intended for installation on board of ships is provided in figure 1 of appendix 2 of this Code.

2.2.9 A model form of an EIAPP Certificate is attached as appendix 1 to this Code.

2.3 PROCEDURES FOR CERTIFICATION OF AN ENGINE

2.3.1 For those engines which have not been adjusted or modified relative to the original specification of the manufacturer, the provision of a valid EIAPP Certificate should suffice to demonstrate compliance with the applicable NO_x limits.

2.3.2 After installation on board, it shall be determined to what extent an engine has been subjected to further adjustments and/or modifications which could affect the NO_x emission. Therefore, the engine, after installation on board, but prior to issuance of the IAPP Certificate, shall be inspected for modifications and be approved using the on-board NO_x verification procedures and one of the methods described in 2.1.2.

2.3.3 There are engines which, after pre-certification, need final adjustment or modification for performance optimization. In such a case, the engine group concept could be used to ensure that the engine still complies with the limits.

2.3.4 The shipowner shall have the option of direct measurement of NO_x emissions during engine operation. Such data may take the form of spot checks logged with other engine operating data on a regular basis and over the full range of engine operation or may result from continuous monitoring and data storage. Data must be current (taken within the last 30 days) and must have been acquired using the test procedures cited in this NO_x Technical Code. These monitoring records shall be kept on board for three months for verification purposes by the Parties to the Protocol of 1997. Data shall also be corrected for ambient conditions and fuel specification, and measuring equipment must be checked for correct calibration and operation, in accordance with the procedures specified by the measurement equipment manufacturer in the engine's Technical File. Where exhaust gas after-treatment devices are fitted which influence the NO_x emissions, the measuring point(s) must be located downstream of such devices.

2.3.5 To demonstrate compliance by the direct measurement method, sufficient data shall be collected to calculate the weighted average NO_x emissions in accordance with this Code.

2.3.6 Every marine diesel engine installed on board a ship shall be provided with a Technical File. The Technical File shall be prepared by the engine manufacturer and approved by the Administration, and required to accompany an engine throughout its life on board ships. The Technical File shall contain information as specified in 2.4.1.

2.3.7 Where an after-treatment device is installed and needed to comply with the NO_x limits, one of the options providing a ready means for verifying compliance with regulation 13 of Annex VI is direct NO_x

measurement and monitoring in accordance with 2.3.4. However, depending on the technical possibilities of the device used, subject to the approval of the Administration, other relevant parameters could be monitored.

2.3.8 Where, for the purpose of achieving NO_x compliance, an additional substance is introduced, such as ammonia, urea, steam, water, fuel additives, etc., a means of monitoring the consumption of such substance shall be provided. The Technical File shall provide sufficient information to allow a ready means of demonstrating that the consumption of such additional substances is consistent with achieving compliance with the applicable NO_x limit.

2.3.9 If any adjustments or modifications are made to any engine after its pre-certification, a full record of such adjustments or modifications shall be recorded in the engine's record book of engine parameters.

2.3.10 If all of the engines installed on board are verified to remain within the parameters, components, and adjustable features recorded in the Technical File, the engines should be accepted as performing within the NO_x limits specified in regulation 13 of Annex VI. In this case, with respect to this Code, an IAPP Certificate should then be issued to the ship.

2.3.11 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: a direct on-board NO_x monitoring, as approved by the Administration; a simplified on-board NO_x measurement; or, reference to the test bed testing for the relevant engine group approval showing that the adjustments or modifications do not exceed the NO_x emissions limits.

2.3.12 The Administration may, at its own discretion, abbreviate or reduce all parts of the survey on board, in accordance with this Code, to an engine which has been issued an EIAPP Certificate. However, the entire survey on board must be completed for at least one cylinder and/or one engine in an engine family or engine group, or spare part, if applicable, and the abbreviation may be made only if all the other cylinders and/or engines or spare parts are expected to perform in the same manner as the surveyed engine and/or cylinder or spare part.

2.3.13 Flow charts providing guidance for compliance with the requirements of an initial, periodical and intermediate surveys for certification of marine diesel engines installed on board of ships are provided in figures 2 and 3 of appendix 2 of this Code.

2.4 TECHNICAL FILE AND ON-BOARD NO_x VERIFICATION PROCEDURES

2.4.1 To enable an Administration to perform the engine surveys described in 2.1, the Technical File required by 2.3.6 shall, at a minimum, contain the following information:

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

.2 identification of the full range of allowable adjustments or alternatives for the components of the engine;

.3 full record of the relevant engine's performance, including the 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 on-board verification surveys in accordance with chapter 6;

.5 a copy of the test report required in 5.10;

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

.7 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 NOx emission limits; and

.8 the EIAPP Certificate, as applicable.

2.4.2 To ensure that engines are in compliance with regulation 13 of Annex VI after installation, each engine with an EIAPP Certificate shall be checked at least once prior to issuance of the IAPP Certificate. Such check can be done using the on-board NO_x verification procedures specified in the engine's Technical File or one of the other methods if the owner's representative does not wish to check using the on-board NO_x verification procedures.

2.4.3 As a general principle, on-board NO_x verification procedures shall enable a surveyor to easily determine if an engine has remained in compliance with regulation 13 of Annex VI. At the same time, it shall not be so burdensome as to unduly delay the ship or to require in-depth knowledge of the characteristics of a particular engine or specialist measuring devices not available on board.

2.4.4 On-board NO_x verification procedures shall be determined by using one of the following methods:

.1 engine parameter check in accordance with 6.2 to verify that an engine's component, setting and operating values have not deviated from the specifications in the engine's Technical File;

.2 simplified measurement method in accordance with 6.3, or

.3 the direct measurement and monitoring method in accordance with 2.3.4, 2.3.5, 2.3.7, 2.3.8, 2.3.11, and 5.5.

2.4.5 When a NO_x monitoring and recording device is specified as on-board NO_x verification procedures, such device shall be approved by the Administration based on guidelines to be developed by the Organization. These guidelines shall include, but are not limited to, the following items:

.1 a definition of continuous NO_x monitoring, taking into account both steady state and transitional operations of the engine;

.2 data recording, processing and retention;

.3 a specification for the equipment to ensure that its reliability is maintained during service;

.4 a specification for environmental testing of the device;

.5 a specification for the testing of the equipment to demonstrate that it has a suitable accuracy, repeatability and cross sensitivity compared with the applicable sections of this Code; and

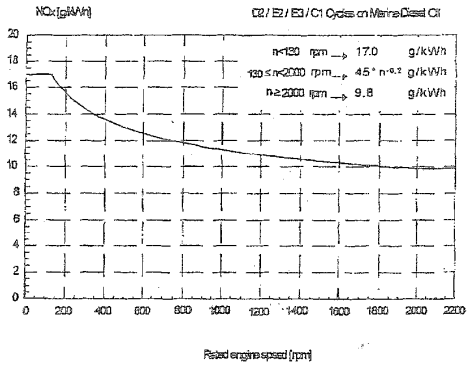
.6 the form of the approval certificate to be issued by the Administration.

2.4.6 When considering what on-board NO_x verification procedures should be included in an engine's Technical File to verify whether an engine complies with the NO_x emission limits during any of the required on-board verification surveys, subsequent to the issuance of an IAPP Certificate, an engine manufacturer or the shipowner may choose any of the three methods for on board NO_x verification procedures specified in 6.1.

Chapter 3 - NITROGEN OXIDES EMISSION STANDARDS

3.1 MAXIMUM ALLOWABLE NO_x EMISSION LIMITS FOR MARINE DIESEL ENGINES

3.1.1 The graph in figure 1 represents the maximum allowable NO_x emission limit values based on the formulae included in paragraph 3(a) of regulation 13 of Annex VI. The total weighted NO_x emissions, as measured and calculated in accordance with the procedures in this Code, shall be equal to or less than the applicable value from the graph corresponding to the rated speed of the engine.



where n = rated engine speed (crankshaft revolutions per minute)

Figure 1. Maximum Allowable NO_x Emissions for Marine Diesel Engines

3.1.2 When the engine operates on marine diesel oil 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 this Code.

3.1.3 An engine's applicable exhaust emissions limit value from figure 1 and the actual calculated exhaust emissions value for the engine shall be stated on the engine's EIAPP Certificate.

3.2 TEST CYCLES AND WEIGHTING FACTORS TO BE APPLIED

3.2.1 For every individual engine or parent engine of an engine group or family, one of the test cycles specified in 3.2.2 to 3.2.6 shall be applied for verification of compliance with the NO_x emission limits in accordance with regulation 13 of Annex VI.

3.2.2 For constant speed marine engines for ship main propulsion, including diesel electric drive, test cycle E2 shall be applied in accordance with table 1.

3.2.3 For variable pitch propeller sets, test cycle E2 shall be applied in accordance with table 1.

Table 1. Test cycle for "Constant Speed Main Propulsion" Application (including Diesel Electric Drive and 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

3.2.4 For propeller law operated main and propeller law operated auxiliary engines, test cycle E3 shall be applied in accordance with table 2.

Table 2. Test cycle for "Propeller Law operated Main and Propeller Law 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

3.2.5 For constant speed auxiliary engines, test cycle D2 shall be applied in accordance with table 3.

Table 3. 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

3.2.6 For variable speed, variable load auxiliary engines, not included above, test cycle C1 shall be applied in accordance with table 4.

Table 4. Test cycle for "Variable Speed, Variable Load Auxiliary Engine" Application

Test cycle type C1	Speed	Rated				Intermediate			Idle
	Torque %	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

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

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

.1 For engines which are designed to operate over a speed range on a full load torque curve, the intermediate speed shall be the 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 the rated speed, then the intermediate speed shall be 75% of rated speed.

.4 For 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.

3.2.9 If an engine manufacturer applies for a new test cycle application on an engine already certified under a different test cycle specified in 3.2.2 to 3.2.6, then it may not be necessary for that engine to undergo the full certification process for the new application. In this case, the engine manufacturer may demonstrate compliance by recalculation, by applying the measurement results from the specific modes of the first certification test to the calculation of the total weighted emissions for the new test cycle application, using the corresponding weighting factors from the new test cycle.

Chapter 4 - APPROVAL FOR SERIALLY MANUFACTURED ENGINES: ENGINE FAMILY AND ENGINE GROUP CONCEPTS

4.1 GENERAL

4.1.1 To avoid certification testing of every engine for compliance with the NO_x emission limits, one of two approval concepts may be adopted, namely the engine family or the engine group concept.

4.1.2 The engine family concept may be applied to any series produced 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.

4.1.3 The engine group concept may be applied to a smaller series of engines produced for similar engine application and which require minor adjustments and modifications during installation or in service on board. These engines are normally large power engines for main propulsion.

4.1.4 Initially the engine manufacturer may, at its discretion, determine whether engines should 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.

4.2 DOCUMENTATION

4.2.1 All documentation for certification must be completed and suitably stamped by the duly authorized Authority as appropriate. This documentation shall also include all terms and conditions, including replacement of spare parts, to ensure that the engines maintain compliance with the required emission standards.

4.2.2 For an engine within an engine group, the required documentation necessary for the engine parameter check method is specified in 6.2.3.6.

4.3 APPLICATION OF THE ENGINE FAMILY CONCEPT

4.3.1 The engine family concept provides the possibility of reducing the number of engines which must be submitted for approval testing, while providing safeguards that all engines within the family comply with the approval requirements. In the engine family concept, engines with similar emission characteristics and design are represented by a parent engine within the family.

4.3.2 Engines that are series produced and not intended to be modified may be covered by the engine family concept.

4.3.3 The selection procedure for the parent engine is such that the selected engine incorporates those features which will most adversely affect the NO_x emission level. This engine, in general, shall have the highest NO_x emission level among all of the engines in the family.

4.3.4 On the basis of tests and engineering judgement, the manufacturer shall propose which engines belong to an engine family, which engine(s) produce the highest NO_x emissions, and which engine(s) should be selected for certification testing.

4.3.5 The Administration shall review for certification approval the selection of the parent engine within the family and shall have the option of selecting a different engine, either for approval or production conformity testing, in order to have confidence that the complete family of engines complies with the NO_x emission limits.

4.3.6 The engine family concept does allow minor adjustments to the engines through adjustable features. Marine engines equipped with adjustable features must comply with all requirements for any adjustment within the physically available range. A feature is not considered adjustable if it is permanently sealed or otherwise not normally accessible. The Administration may require that adjustable features be set to any specification within its adjustable range for certification or in-use testing to determine compliance with the requirements.

4.3.7 Before granting an engine family approval, the Administration shall take the necessary measures to verify that adequate arrangements have been made to ensure effective control of the conformity of production.

4.3.8 Guidelines for the Selection of an Engine Family

4.3.8.1 The engine family shall be defined by basic characteristics which must be common to all engines within the family. In some cases there may be interaction of parameters; these effects must also be taken into consideration to ensure that only engines with similar exhaust emission characteristics are included within an engine family, e.g., the number of cylinders may become a relevant parameter on some engines due to the aspiration or fuel system used, but with other designs, exhaust emissions characteristics may be independent of the number of cylinders or configuration.

4.3.8.2 The engine manufacturer is responsible for selecting those engines from their different models of engines that are to be included in a family. The following basic characteristics, but not specifications, must be common among all engines within an engine family:

.1 combustion cycle
- 2 stroke cycle
- 4 stroke 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
- applicable in certain cases only, e.g., in combination with exhaust gas cleaning devices

.5 method of air aspiration
- naturally aspirated
- pressure charged

.6 fuel type
- distillate/heavy fuel oil
- dual fuel

.7 combustion chamber
- open chamber
- divided chamber

.8 valve and porting, configuration, size and number
- cylinder head
- cylinder wall

.9 fuel system type
- pump-line-injector
- in-line
- distributor
- single element
- 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

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

4.3.9 Guidelines for Selecting the Parent Engine of an Engine Family

4.3.9.1 The method of selection of the parent engine for NO_x measurement shall be agreed to and approved by the Administration. The method shall be based upon selecting an engine which incorporates engine features and characteristics which, from experience, are known to produce the highest NO_x emissions expressed in grammes per kilowatt hour (g/kWh). This requires detailed knowledge of the engines within the family. Under certain circumstances, the Administration may conclude that the worst case NO_x emission rate of the family can best be characterised by testing a second engine. Thus, the Administration may select an additional engine for test based upon features which indicate that it may have the highest NO_x emission levels of the engines within that family. If engines within the family incorporate other variable features which could be considered to affect NO_x emissions, these features must also be identified and taken into account in the selection of the parent engine.

4.3.9.2 The following criteria for selecting the parent engine for NO_x emission control shall be considered, but the selection process must take into account the combination of basic characteristics in the engine specification:

.1 main selection criteria
- higher fuel delivery rate

.2 supplementary selection criteria
- higher mean effective pressure
- higher maximum cylinder peak pressure
- higher charge air/ignition pressure ratio
- $dp/d\alpha$, the lower slope of the combustion curve
- higher charge air pressure
- higher charge air temperature

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

4.3.10 Certification of an Engine Family

4.3.10.1 The certification shall include a list, to be prepared and maintained by the engine manufacturer and approved by the Administration, of all engines and their specifications accepted under the same engine family, the limits of their operating conditions and the details and limits of engine adjustments that may be permitted.

4.3.10.2 A pre-certificate, or EIAPP Certificate, should be issued for a member engine of an entire family in accordance with this Code which certifies that the parent engine meets the NO_X levels specified in regulation 13 of Annex VI.

4.3.10.3 When the parent engine of an engine family is tested/measured under the most adverse conditions specified within this Code and confirmed as complying with the maximum allowable emission limits (see 3.1), the results of the test and NO_x measurement shall be recorded in the EIAPP Certificate issued for the particular parent engine and for all member engines of the engine family.

4.3.10.4 If two or more Administrations agree to accept each other's EIAPP's, then an entire engine family, certified by one of these Administrations, shall be accepted by the other Administrations which entered into that agreement with the original certifying Administration, unless the agreement specified otherwise. Certificates issued under such agreements shall be acceptable as prima facie evidence that all engines included in the certification of the engine family comply with the specific NO_x emission requirements. There is no need for further evidence of compliance with regulation 13 of Annex VI if it is verified that the installed engine has not been modified and the engine adjustment is within the range permitted in the engine family certification.

4.3.10.5 If the parent engine of an engine family is to be certified in accordance with an alternative standard or a different test cycle than allowed by this Code, the manufacturer must prove to the Administration that the weighted average NO_x emissions for the appropriate test cycles fall within the relevant limit values under regulation 13 of Annex VI and this Code before the Administration may issue an EIAPP Certificate.

4.3.10.6 Before granting an engine family approval for new, serially produced engines, the Administration shall take the necessary measures to verify that adequate arrangements have been made to ensure effective control of the conformity of production. This requirement may not be necessary for families established for the purpose of engine modifications on board after an EIAPP Certificate has been issued.

4.4 APPLICATION OF THE ENGINE GROUP CONCEPT

4.4.1 These are engines used primarily for main propulsion. They normally require adjustment or modification to suit the on-board operating conditions but which should not result in NO_x emissions exceeding the limits in 3.1 of this Code.

4.4.2 The engine group concept also provides the possibility for a reduction in approval testing for modifications to engines in production or in service.

4.4.3 In general, the engine group concept may be applied to any engine type having the same design features as specified in 4.4.5, but individual engine adjustment or modification after test bed measurement is allowed. The range of engines in an engine group and choice of parent engine shall be agreed to and approved by the Administration.

4.4.4 The application for the engine group concept, if requested by the engine manufacturer or another party, shall be considered for certification approval by the Administration. If the engine owner, with or without technical support from the engine manufacturer, decides to perform modifications on a number of similar engines in the owner's fleet, the owner may apply for an engine group certification. The engine group may include a test engine on the test bench. Typical applications are similar modifications of similar engines in service or similar engines in similar operational conditions.

4.4.5 Guidelines for the Selection of an Engine Group

4.4.5.1 The engine group may be defined by basic characteristics and specifications in addition to the parameters defined in 4.3.8 for an engine family.

4.4.5.2 The following parameters and specifications must be common to engines within an engine group:

.1 bore and stroke dimensions,

.2 method and design features of pressure charging and exhaust gas system,
- constant pressure
- pulsating system

.3 method of charge air cooling system,
- with/without charge air cooler

.4 design features of the combustion chamber that effect NO_x emission,

.5 design features of the fuel injection system, plunger and injection cam which may profile basic characteristics that effect NO_x emission, and

.6 maximum rated power per cylinder at maximum rated speed. The permitted range of derating within the engine group shall be declared by the manufacturer and approved by the Administration.

4.4.5.3 Generally, if the parameters required by 4.4.5.2 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 parameters or specifications is not common for all of the engines within a prospective engine group provided the engine manufacturer or the shipowner can, within the Technical File, prove to the Administration that such a transgression of that one parameter or specification would still result in all engines within the engine group complying with the NO_x emission limits.

4.4.6 Guidelines for Allowable Adjustment or Modification within an Engine Group

4.4.6.1 Minor adjustments and modifications in accordance with the engine group concept are allowed after pre-certification or final test bed measurement within an engine group upon agreement of the parties concerned and approval of the Administration, if:

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

.2 on-board measurement confirms that the adjusted or modified engine complies with the applicable NO_x emission limits.

4.4.6.2 Examples of adjustments and modifications within an engine group that may be permitted, but are not limited to those described below:

.1 For on-board conditions, adjustment of:
- injection timing for compensation of fuel property differences,
- injection timing for optimization of maximum cylinder pressure,
- fuel delivery differences between cylinders.

.2 For performance optimization, modification of:
- turbocharger,
- injection pump components,
  - plunger specification
  - delivery valve specification
- injection nozzles,
- cam profiles,
  - intake and/or exhaust valve
  - injection cam
- combustion chamber.

4.4.6.3 The above examples of modifications after a test-bed trial concern essential improvements of components or engine performance during the life of an engine. This is one of the main reasons for the existence of the engine group concept. The Administration, upon application, may accept the results from a demonstration test carried out on one engine, possibly a test engine, indicating the effects of the modifications on the NO_x level which may be accepted for all engines within that engine group without requiring certification measurements on each engine of the group.

4.4.7 **Guidelines for the Selection of the Parent Engine of an Engine Group**

The selection of the parent engine shall be in accordance with the criteria in 4.3.9, as applicable. It is not always possible to select a parent engine from small volume production engines in the same way as the mass produced engines (engine family). The first engine ordered may be registered as the parent engine. The method used to select the parent engine to represent the engine group shall be agreed to and approved by the Administration.

Chapter 5 - PROCEDURES FOR NO_x EMISSION MEASUREMENTS ON A TEST BED

5.1 GENERAL

5.1.1 This procedure shall be applied to every initial approval testing of a marine engine regardless of the location of that testing (the methods described in 2.1.2.1 and 2.1.2.2).

5.1.2 This chapter specifies the measurement and calculation methods for gaseous exhaust emissions from reciprocating internal combustion engines (RIC engines) under steady-state conditions, necessary for determining the average weighted value for the NO_x exhaust gas emission.

5.1.3 Many of the procedures described below are detailed accounts of laboratory methods, since determining an emissions value requires performing a complex set of individual measurements, rather than obtaining a single measured value. Thus, the results obtained depend as much on the process of performing the measurements as they depend on the engine and test method.

5.1.4 This chapter includes the test and measurement methods, test run and test report as a procedure for a test bed measurement.

5.1.5 In principle, during emission tests, an engine shall be equipped with its auxiliaries in the same manner as it would be used on board.

5.1.6 For many engine types within the scope of this Code, the auxiliaries which may be fitted to the engine in service may not be known at the time of manufacture or certification. It is for this reason that the emissions are expressed on the basis of brake power as defined in 1.3.13.

5.1.7 When it is not appropriate to test the engine under the conditions as defined in 5.2.3, e.g., if the engine and transmission form a single integral unit, the engine may only be tested with other auxiliaries fitted. In this case the dynamometer settings shall be determined in accordance with 5.2.3 and 5.9. The auxiliary losses shall not exceed 5% of the maximum observed power. Losses exceeding 5% shall be approved by the Administration involved prior to the test.

5.1.8 All volumes and volumetric flow rates shall be related to 273 K (0°C) and 101.3 kPa.

5.1.9 Except as otherwise specified, all results of measurements, test data or calculations required by this chapter shall be recorded in the engine's test report in accordance with 5.10.

5.2 TEST CONDITIONS

5.2.1 Test condition parameter and test validity for engine family approval

Parameter f_a shall be determined according to the following provisions:

.1 naturally aspirated and mechanically supercharged engines:

$$f_a = \left(\frac{99}{p_s}\right) \cdot \left(\frac{T_a}{298}\right)^{0.7} \qquad (1)$$

.2 turbocharged engine with or without cooling of the intake air:

$$f_a = \left(\frac{99}{p_s}\right)^{0.7} \cdot \left(\frac{T_a}{298}\right)^{1.5} \qquad (2)$$

and, for a test to be recognized as valid, parameter f_a shall be such that:

$$0.98 \leq f_a \leq 1.02 \qquad (3)$$

5.2.2 Engines with charge air cooling

5.2.2.1 The temperature of the cooling medium and the temperature of the charge air shall be recorded. The cooling system shall be set with the engine operating at the reference speed and load. The charge air temperature and cooler pressure drop shall be set to within ± 4 K and ± 2 kPa, respectively, of the manufacturer's specification.

5.2.2.2 All engines when equipped as intended for installation on board ships must be capable of operating within the allowable NO_x emission levels of regulation 13(3) of Annex VI at an ambient seawater temperature of 25°C.

5.2.3 Power

5.2.3.1 The basis for the measurement of specific emissions is uncorrected brake power.

5.2.3.2 Auxiliaries not necessary for the operation of the engine and which may be mounted on the engine may be removed for the test. See also 5.1.5 and 5.1.6.

5.2.3.3 Where non-essential auxiliaries have not been removed, the power absorbed by them at the test speeds shall be determined in order to calculate the uncorrected brake power in accordance with formula (18). See also 5.12.5.1.

5.2.4 Engine air inlet system

The test engine shall be equipped with an air inlet system which provides an air inlet restriction, specified by the manufacturer, to represent an unfouled air cleaner at the engine operating conditions, as specified by the manufacturer, and which results in maximum air flow in the respective engine application.

5.2.5 Engine exhaust system

The test engine shall be equipped with an exhaust system which provides an exhaust back pressure as specified by the manufacturer at the engine operating conditions and which results in the maximum declared power in the respective engine application.

5.2.6 Cooling system

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

5.2.7 **Lubricating oil**

Specifications of the lubricating oil used for the test shall be recorded.

5.3 TEST FUELS

5.3.1 Fuel characteristics may influence the engine exhaust gas emission. Therefore, the characteristics of the fuel used for the test shall be determined and recorded. Where reference fuels are used, the reference code or specifications and the analysis of the fuel shall be provided.

5.3.2 The selection of the fuel for the test depends on the purpose of the test. Unless otherwise agreed by the Administration and when a suitable reference fuel is not available, a DM-grade marine fuel specified in ISO 8217, 1996, with properties suitable for the engine type, shall be used.

5.3.3 The fuel temperature shall be in accordance with the manufacturer's recommendations. The fuel temperature shall be measured at the inlet to the fuel injection pump or as specified by the manufacturer, and the temperature and location of measurement recorded.

5.4 MEASUREMENT EQUIPMENT

5.4.1 The emission of gaseous components by the engine submitted for testing shall be measured by methods as analysers, whose specifications are set out in appendix 3 of this Code.

5.4.2 Other systems or analysers may, subject to the approval of the Administration, be accepted if they yield equivalent results to that of the equipment referenced in 5.4.1.

5.4.3 This Code does not contain details of flow, pressure, and temperature measuring equipment. Instead, only the accuracy requirements of such equipment necessary for conducting an emissions test are given in 1.3.1 of appendix 4 of this Code.

5.4.4 **Dynamometer specification**

5.4.4.1 An engine dynamometer with adequate characteristics to perform the appropriate test cycle described in 3.2 shall be used.

5.4.4.2 The instrumentation for torque and speed measurement shall allow the measurement of the shaft power over the range of the test bed operations as specified by the manufacturer. If this is not the case, then additional calculations shall be required and recorded.

5.4.4.3 The accuracy of the measuring equipment shall be such that the maximum tolerances of the values given in 1.3.1 of appendix 4 of this Code are not exceeded.

5.5 DETERMINATION OF EXHAUST GAS FLOW

The exhaust gas flow shall be determined by one of the methods specified in 5.5.1, 5.5.2, or 5.5.3.

5.5.1 **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 recognized international standard.

Note: Direct gaseous flow measurement is a difficult task. Precautions should be taken to avoid measurement errors which will impact emission value errors.

5.5.2 **Air and fuel measurement method**

5.5.2.1 The method for determining exhaust emission flow using the air and fuel measurement method shall be conducted in accordance with a recognized international standard.

5.5.2.2 Air flowmeters and fuel flowmeters with an accuracy defined in 1.3.1 of appendix 4 of this Code shall be used.

5.5.2.3 The exhaust gas flow shall be calculated as follows:

.1 $G_{EXHW} \quad G_{AIRW} \quad G_{FUEL}$ (for wet exhaust mass) (4)

or

.2 $V_{EXHD} \quad V_{AIRD} \quad F_{FD} \cdot G_{FUEL}$ (for dry exhaust volume) (5)

or

.3 $V_{EXHW} \quad V_{AIRW} \quad F_{FW} \cdot G_{FUEL}$ (for wet exhaust volume) (6)

Note: Values for F_{FD} and F_{FW} vary with the fuel type (see table 1 of appendix 6 of this Code)

5.5.3 **Carbon balance method**

This method involves exhaust gas mass flow calculation from fuel consumption and exhaust gas concentrations using the carbon and oxygen balance method as specified in appendix 6 of this Code.

5.6 PERMISSIBLE DEVIATIONS OF INSTRUMENTS FOR ENGINE RELATED PARAMETERS AND OTHER ESSENTIAL PARAMETERS

The calibration of all measuring instruments shall be traceable to recognized international standards and shall comply with the requirements as set out in 1.3.1 of appendix 4 of this Code.

5.7 ANALYSERS FOR DETERMINATION OF THE GASEOUS COMPONENTS

The analysers to determine the gaseous components shall meet the specifications as set out in appendix 3 of this Code.

5.8 CALIBRATION OF THE ANALYTICAL INSTRUMENTS

Each analyser used for the measurement of an engine's parameters, as discussed in appendix 3 of this Code, shall be calibrated as often as necessary as set out in appendix 4 of this Code.

5.9 TEST RUN

5.9.1 General

5.9.1.1 Detailed descriptions of the recommended sampling and analysing systems are contained in 5.9.2 to 5.9.4. Since various configurations may produce equivalent results, exact conformance with these figures is not required. Additional components, such as instruments, valves, solenoids, pumps, and switches, may be used to provide additional information and coordinate the functions of the component systems. Other components which are not needed to maintain the accuracy on some systems, may be excluded if their exclusion is based upon good engineering judgement.

5.9.1.2 The settings of inlet restriction and exhaust back pressure shall be adjusted to the upper limits as specified by the manufacturer in accordance with 5.2.4 and 5.2.5, respectively.

5.9.2 Main exhaust components to be analysed

5.9.2.1 An analytical system for the determination of the gaseous emissions (CO, CO_2, HC, NO_x, O_2) in the raw exhaust gas shall be based on the use of the following analysers:

.1 HFID analyser for the measurement of hydrocarbons;

.2 NDIR analyser for the measurement of carbon monoxide and carbon dioxide;

.3 HCLD or equivalent analyser for the measurement of nitrogen oxides; and

.4 PMD, ECS or ZRDO for the measurement of oxygen.

5.9.2.2 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. Care must be taken that no condensation of the exhaust components (including water and sulphuric acid) occurs at any point of the analytic system.

5.9.2.3 Specifications and calibration of these analysers shall be as set out in appendices 5 and 6 of this Code, respectively.

5.9.3 Sampling for gaseous emissions

5.9.3.1 The sampling probes for the gaseous emissions shall be fitted at least 0.5m or 3 times the diameter of the exhaust pipe - whichever is the larger - upstream of the exit of the exhaust gas system, as far as practicable, but sufficiently close to the engine so as to ensure an exhaust gas temperature of at least 343 K (70°C) at the probe.

5.9.3.2 In the case of a multi-cylinder 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 engines having distinct groups of manifolds, such as in a "Vee" engine configuration, it is permissible to acquire a sample from each group individually and calculate an average exhaust emission. Other methods which have been shown to correlate with the above methods may be used. For exhaust emission calculation, the total exhaust mass flow must be used.

5.9.3.3 If the composition of the exhaust gas is influenced by any exhaust after-treatment system, the exhaust sample must be taken downstream of this device.

5.9.4 Checking of the analysers

The emission analysers shall be set at zero and spanned.

5.9.5 Test cycles

All engines shall be tested in accordance with the test cycles as defined in 3.2. This takes into account the variations in engine application.

5.9.6 Test sequence

5.9.6.1 After the procedures in 5.9.1 to 5.9.5 have been completed, the test sequence shall be started. The engine shall be operated in each mode in accordance with the appropriate test cycles defined in 3.2.

5.9.6.2 During each mode of the test cycle after the initial transition period, the specified speed shall be held to within ± 1% of rated speed or ± 3 min^{-1}, whichever is greater, except for low idle which shall be within the tolerances declared by the manufacturer. 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.

5.9.7 Analyser response

The output of the analysers shall be recorded, both during the test and during all response checks (zero and span), on a strip chart recorder or measured with an equivalent data acquisition system with the exhaust gas flowing through the analysers at least during the last ten minutes of each mode.

5.9.8 Engine conditions

The engine speed and load, intake air temperature and fuel flow shall be measured at each mode once the engine has been stabilised. The exhaust gas flow shall be measured or calculated and recorded.

5.9.9 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 test shall be considered acceptable if the difference between the two calibration results is less than 2%.

5.10 TEST REPORT

5.10.1 For every engine tested for pre-certification or for initial certification on board without pre-certification, the engine manufacturer shall prepare a test report which shall contain, as a minimum, the data as set out in appendix 5 of this Code. The original of the test report shall be maintained on file with the engine manufacturer and a certified true copy shall be maintained on file by the Administration.

5.10.2 The test report, either an original or certified true copy, shall be attached as a permanent part of an engine's Technical File.

5.11 DATA EVALUATION FOR GASEOUS EMISSIONS

For the evaluation of the gaseous emissions, the chart reading of the last 60 seconds of each mode shall be averaged, and the average concentrations (conc) of CO, CO_2, HC, NO_x and O_2 during each mode shall be determined from the average chart readings and the corresponding calibration data.

5.12 CALCULATION OF THE GASEOUS EMISSIONS

The final results for the test report shall be determined by following the steps in 5.12.1 to 5.12.4.

5.12.1 Determination of the exhaust gas flow

The exhaust gas flow rate (G_{EXHW}, V_{EXHW}, or V_{EXHD}) shall be determined for each mode in accordance with one of the methods described in 5.5.1 to 5.5.3.

5.12.2 Dry/wet correction

When applying G_{EXHW} or V_{EXHW}, the measured concentration, if not already measured on a wet basis, shall be converted to a wet basis according to the following formulae.

$$conc\ (wet) \quad K_W \cdot conc\ (dry) \tag{7}$$

5.12.2.1 For the raw exhaust gas:

$$K_{W,r} \quad \left(1 \quad F_{FH} \cdot \frac{G_{FUEL}}{G_{AIRD}}\right) \quad K_{W2} \tag{8}$$

$$K_{W2} \quad \frac{1.608 \cdot H_a}{1000 \quad (1.608 \cdot H_a)} \tag{9}$$

$$H_a \quad \frac{6.220 \cdot R_a \cdot p_a}{p_B \quad p_a \cdot R_a \cdot 10^{-2}} \tag{10}$$

with:

H_a, H_d = g water per kg dry air

R_a = relative humidity of the intake air, %

p_a = saturation vapour pressure of the intake air, kPa

p_B = total barometric pressure, kPa

Note: Formulae using F_{FH} are simplified versions of those quoted in section 3.7 of appendix 6 of this Code (formulae (2-44) & (2-45)) which when applied give comparable results to those expected from the full formulae.

5.12.2.2 Alternatively:

$$K_{W,r} = \frac{1}{1 - H_{TCRAT} \cdot 0.005 \cdot (\%CO\ (dry) - \%CO_2(dry))} \quad K_{W2} \qquad (11)$$

5.12.2.3 For the intake air:

$$K_{W,a} = 1 - K_{W2} \qquad (12)$$

5.12.2.4 Formula (8) shall be accepted as the definition of the fuel specific factor F_{FH}. Defined this way, F_{FH} is a value for the water content of the exhaust in relationship to the fuel to air ratio.

5.12.2.5 Typical values for F_{FH} may be found in table 1 of appendix 6 of this Code. Table 1 of appendix 6 of this Code contains a list of F_{FH} values for different fuels. F_{FH} does not only depend on the fuel specifications, but also, to a lesser degree, on the fuel to air ratio of the engine.

5.12.2.6 Section 3.9 of appendix 6 of this Code contains formulae for calculating F_{FH} from the hydrogen content of the fuel and the fuel to air ratio.

5.12.2.7 Formula (8) considers the water from the combustion and from the intake air to be independent from each other and to be additive. Formula (2-45) in section 3.7 of appendix 6 of this Code shows that the two water terms are not additive. Formula (2-45) is the correct version but it is very complicated and, therefore, the more practical formulae (8) & (11) shall be used.

5.12.3 NO_x correction for humidity and temperature

5.12.3.1 As the NO_x emission depends on ambient air conditions, the NO_x concentration shall be corrected for ambient air temperature and humidity by multiplying with the factors given in formulae (13) and (14).

5.12.3.2 The standard value of 10.71 g/kg at the standard reference temperature of 25 °C shall be used for all calculations involving humidity correction throughout this Code. Other reference values for humidity instead of 10.71 g/kg must not be used.

5.12.3.3 Other correction formulae may be used if they can be justified or validated upon agreement of the parties involved and if approved by the Administration.

5.12.3.4 Water or steam injected into the air charger (air humidification) is considered an emission control device and shall therefore not be taken into account for humidity correction. Water that condensates in the charge cooler may change the humidity of the charge air and shall therefore be taken into account for humidity correction.

5.12.3.5 Diesel engines in general

For diesel engines in general, the following formula for calculating K_{HDIES} shall be used:

$$K_{HDIES} = \frac{1}{1 - A \cdot (H_a - 10.71) - B \cdot (T_a - 298)} \qquad (13)$$

where:

A = $0.309 \cdot G_{FUEL} / G_{AIRD} - 0.0266$

B = $-0.209 \cdot G_{FUEL} / G_{AIRD} - 0.00954$

T_a = temperature of the air in K

H_a = humidity of the intake air, g water per kg dry air (as determined by formula (10))

5.12.3.5 Diesel engines with intermediate air coolers

For diesel engines with intermediate air coolers, the following alternative formula (14) shall be used:

$$k_{HDIES} = \frac{1}{1 + 0.012 \cdot (H_a - 10.71) + 0.00275 \cdot (T_a - 298) + 0.00285 \cdot (T_{SC} - T_{SCRef})} \quad (14)$$

where:

T_{SC} = Temperature of the intercooled air

$T_{SC\,Ref}$ = Reference temperature of the intercooled air corresponding to a seawater temperature of 25°C. The $T_{SC\,Ref}$ to be specified by the manufacturer

.1 To take the humidity in the charge air into account, the following consideration is added.

Hsc = humidity of the charging air, g water per kg dry air in which:

$Hsc = 6.220 \cdot Psc \cdot 100 / (PC - Psc)$

where:

Psc = saturation vapour pressure of the charging air, kPa

PC = charging air pressure, kPa

.2 If Ha ≥ Hsc, then Hsc shall be used in place of Ha in formula (14). In this case, G_{EXHW} in 5.5.2.3 shall be corrected as follows:

$G_{EXHW\,Corrected} = G_{EXHW\,(5.5.2.3)} \cdot (1 - (Ha - Hsc) / 1000))$

.3 If Ha < Hsc, then Ha in formula (14) shall be used as it is.

Note: For an explanation of the other variables, see formula (13).

5.12.4 Calculation of the emission mass flow rates

5.12.4.1 The emission mass flow rates for each mode shall be calculated as follows (for the raw exhaust gas):

$$Gas\ mass = u \cdot conc \cdot G_{EXHW} \quad (15)$$

or

$$Gas\ mass = v \cdot conc \cdot V_{EXHD} \quad (16)$$

or

$$Gas\ mass = w \cdot conc \cdot V_{EXHW} \quad (17)$$

5.12.4.2 The coefficients u-wet, v-dry and w-wet shall be used as specified in table 5.

Table 5. Coefficients u, v, w

Gas	u	v	w	conc
NO_x	0.001587	0.002053	0.002053	ppm
CO	0.000966	0.00125	0.00125	ppm
HC	0.000479	-	0.000619	ppm
CO_2	15.19	19.64	19.64	percent
O_2	11.05	14.29	14.29	percent

Note: The coefficients for u given in table 5 are correct values for an exhaust density of 1.293 only; for exhaust density ≠ 1.293, u = w / density.

5.12.5 Calculation of the specific emissions

5.12.5.1 The emission shall be calculated for all individual components in the following way:

$$GAS_{\Sigma} = \frac{\sum_{i=1}^{i=n} M_{GAS_i} \cdot W_{F_i}}{\sum_{i=1}^{i=n} P_i \cdot W_{F_i}} \qquad (18)$$

where:

$$P_i = P_{M,i} + P_{AUX,i}$$

5.12.5.2 The weighting factors and the number of modes (n) used in the above calculation are according to the provisions of 3.2.

5.12.5.3 The resulting average weighted NO_x emission value for the engine as determined by formula (18) shall then be compared to figure 1 in 3.1 to determine if the engine is in compliance with regulation 13 of Annex VI.

Chapter 6 - PROCEDURES FOR DEMONSTRATING COMPLIANCE WITH NO_x EMISSION LIMITS ON BOARD

6.1 GENERAL

After installation of a pre-certificated engine on board a ship, every marine diesel engine shall have on-board verification surveys conducted as specified in 2.1.1.2 to 2.1.1.4 to verify that the engines continue to comply with the NO_x emission limits contained in regulation 13 of Annex VI. Such verification of compliance shall be determined by using one of the following methods:

.1 engine parameter check method in accordance with 6.2 to verify that an engine's component, settings and operating values have not deviated from the specifications in the engine's Technical File;

.2 simplified measurement method in accordance with 6.3; or

.3 the direct measurement and monitoring method in accordance with 2.3.4, 2.3.5, 2.3.7, 2.3.8, 2.3.11, 2.4.4, and 5.5.

6.2 ENGINE PARAMETER CHECK METHOD

6.2.1 General

6.2.1.1 Engines that meet the following conditions shall be eligible for an engine parameter check method:

.1 engines that have received a pre-certificate (EIAPP Certificate) on the test bed and those that received a certificate (IAPP Certificate) following an initial certification survey; and

.2 engines that have undergone modifications or adjustments to the designated engine components and adjustable features since they were last surveyed.

6.2.1.2 An engine parameter check method shall be conducted on engines, subject to 6.2.1.1, whenever there is a change of components and/or adjustable features of the engine that affect NO_x emission levels. This method shall be used to confirm compliance with the NO_x emission limits. Engines installed in ships shall be designed in advance for an easy check of components, adjustable features and engine parameters that affect NO_x emission levels.

6.2.1.3 In addition, when a diesel engine is designed to run within the prescribed NO_x emission limits, it is most likely that within the marine life of the engine, the NO_x emission limits may be adhered to. The prescribed NO_x emission limits may, however, be contravened by adjustments or modification to the engine. Therefore, an engine parameter check method shall be used to verify whether the engine is still within the prescribed NO_x emission limits.

6.2.1.4 Engine component checks, including checks of settings and an engine's operating values, are intended to provide an easy means of deducing the emissions performance of the engine for the purpose of verification that an engine with no, or minor, adjustments or modifications complies with the applicable NO_x emission limits.

6.2.1.5 The purpose of such checks is to provide a ready means of determining that an engine is correctly adjusted in accordance with the manufacturer's specification and remains in a condition of adjustment consistent with the initial certification by the Administration as compliant with regulation 13 of Annex VI.

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

6.2.1.7 For the purpose of assessing compliance with regulation 13 of Annex VI, it is not always necessary to measure the NO_x level to know that an engine, not equipped with an after-treatment device, is likely to comply with the NO_x emission limits. It may be sufficient to know that the present state of the engine corresponds to the specified components, calibration or parameter-adjustment state at the time of initial certification. If the results of an engine parameter check method indicate the likelihood that the engine complies with the NO_x emission limits, the engine may be re-certified without direct NO_x measurement.

6.2.1.8 For engines equipped with after-treatment devices, it will be necessary to check the operation of the after-treatment device as part of the parameter check.

6.2.2 Procedures for an engine parameter check method

6.2.2.1 An engine parameter check method shall be carried out using the two procedures as follows:

.1 a documentation inspection of engine parameter(s) shall be carried out in addition to other inspections and include inspection of record books covering engine parameters and verification that engine parameters are within the allowable range specified in an engine's Technical File; and

.2 an actual inspection of engine components and adjustable features shall be carried out in addition to the documentation inspection as necessary. It shall then be verified, referring to the results of the documentation inspection, that the engine adjustable features are within the allowable range specified in an engine's Technical File.

6.2.2.2 The surveyor shall have the option of checking one or all of the identified components, settings or operating values to ensure that the engine with no, or minor, adjustments or modifications complies with the applicable emission limits and that only components of the current specification are being used. Where adjustments and/or modifications in a specification are referenced in the Technical File, they must fall within the range recommended by the manufacturer and approved by the Administration.

6.2.3 Documentation for an engine parameter check method

6.2.3.1 Every marine diesel engine shall have a Technical File as required in 2.3.6 which identifies the engine's components, settings or operating values which influence exhaust emissions and must be checked to ensure compliance.

6.2.3.2 Shipowners or persons responsible for ships equipped with diesel engines required to undergo an engine parameter check method shall maintain on board the following documentation in relation to the on-board NO_x verification procedures:

.1 a record book of engine parameters for recording of all the changes made relative to an engine's components and settings;

.2 an engine parameter list of an engine's designated components and settings and/or the documentation of an engine's load-dependent operating values submitted by an engine manufacturer and approved by the Administration; and

.3 technical documentation of an engine component modification when such a modification is made to any of the engine's designated engine components.

6.2.3.3 Record book of engine parameters

Descriptions of any changes affecting the designated engine parameters, including adjustments, parts replacements and modifications to engine parts, shall be recorded chronologically in an engine's record book of engine parameters. These descriptions shall be supplemented with any other applicable data used for the assessment of the engine's NO_x levels.

6.2.3.4 List of NO_x influencing parameters sometimes modified on board

6.2.3.4.1 Dependent on the specific design of the particular engine, different NO_x influencing modifications and adjustments are possible and usual. These include the engine parameters as follows:

.1 injection timing,
.2 injection nozzle,
.3 injection pump,
.4 fuel cam,
.5 injection pressure for common rail systems,
.6 combustion chamber,
.7 compression ratio,
.8 turbocharger type and build,
.9 charge air cooler, charge air pre-heater,
.10 valve timing,
.11 NO_x abatement equipment "water injection",
.12 NO_x abatement equipment "emulsified fuel" (fuel water emulsion),
.13 NO_x abatement equipment "exhaust gas recirculation",
.14 NO_x abatement equipment "selective catalytic reduction", or
.15 other parameter(s) specified by the Administration.

6.2.3.4.2 The actual Technical File of an engine may, based on the recommendations of the engine manufacturer and the approval of the Administration, include less components and/or parameters than discussed above depending on the particular engine and the specific design.

6.2.3.5 Check list for the engine parameter check method

For some parameters, different survey possibilities exist. Approved by the Administration, the ship operator, supported by the engine manufacturer, may choose what method is applicable. Any one of, or a combination of, the methods listed in appendix 7 of this Code may be sufficient to show compliance.

6.2.3.6 Technical documentation of engine component modification

Technical documentation for inclusion in an engine's Technical File shall include details of modification and their influence on NO_x emissions, and it shall be supplied at the time when modifications are carried out. Test bed data obtained from a later engine, which is within the applicable range of the engine group concept, may be accepted.

6.2.3.7 Initial condition of engine components, adjustable features and parameters

An engine's Technical File shall contain all applicable information, relevant to the NO_x emission performance of the engine, on the designated engine's components, adjustable features and parameters at the time of the engine's pre-certification (EIAPP Certificate) or initial certification (IAPP Certificate), whichever occurred first.

6.3 SIMPLIFIED MEASUREMENT METHOD

6.3.1 General

6.3.1.1 The following simplified test and measurement procedure specified in this section shall be applied only for on-board confirmation tests and periodical and intermediate surveys when required. Every first engine testing on a test bed shall be carried out in accordance with the procedure specified in chapter 5 using a DM-grade marine diesel fuel. Corrections for ambient air temperature and humidity in accordance with 5.12.3 are essential as ships are sailing in cold/hot and dry/humid climates, which may cause a difference in NO_x emissions.

6.3.1.2 To gain meaningful results for on-board confirmation tests and on-board periodical and intermediate surveys, as an absolute minimum, the gaseous emission concentrations of NO_x, together with O_2 and/or CO_2 and CO, 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 3.2.

6.3.1.3 The engine torque and engine speed shall be measured but, to simplify the procedure, the permissible deviations of instruments (see 6.3.7) for measurement of engine-related parameters for on board verification purposes is different than from those permissible deviations allowed under the test bed testing method. If it is difficult to measure the torque directly, the brake power may be estimated by any other means recommended by the engine manufacturer and approved by the Administration.

6.3.1.4 In practical cases, it is often impossible to measure the fuel consumption once an engine has been installed on board a ship. To simplify the procedure on board, the results of the measurement of the fuel consumption from an engine's pre-certification test bed testing may be accepted. In such cases, especially concerning heavy fuel operation, an estimation with a corresponding estimated error shall be made. Since the oil fuel flow rate used in the calculation (G_{FUEL}) must relate to the oil fuel composition determined in respect of the fuel sample drawn during the test, the measurement of G_{FUEL} from the test bed testing shall be corrected for any difference in net calorific values between the test bed and test oil fuels. The consequences of such an error on the final emissions shall be calculated and reported with the results of the emission measurement.

6.3.1.5 Except as otherwise specified, all results of measurements, test data or calculations required by this chapter shall be recorded in the engine's test report in accordance with 5.10.

6.3.2 Engine parameters to be measured and recorded

Table 6 lists the engine parameters that shall be measured and recorded during on-board verification procedures.

Table 6. Engine parameters to be measured and recorded

Symbol	Parameter	Dimension
$b_{x,i}$	specific fuel consumption (if possible) (at the i^{th} mode during the cycle)	kg/kWh
H_a	absolute humidity (mass of engine intake air water content related to mass of dry air)	g/kg
$n_{d,i}$	engine speed (at the i^{th} mode during the cycle)	min^{-1}
$n_{turb,i}$	turbocharger speed (if applicable) (at the i^{th} mode during the cycle)	min^{-1}
p_B	total barometric pressure (in ISO 3046-1, 1995: p_x = Px = site ambient total pressure)	kPa
$p_{ba,i}$	air pressure after the charge air cooler (at the i^{th} mode during the cycle)	kPa
P_i	brake power (at the i^{th} mode during the cycle)	kW
s_i	fuel rack position (of each cylinder, if applicable) (at the i^{th} mode during the cycle)	
T_a	temperature at air inlet (in ISO 3046-1, 1995: T_x = TTx = site ambient thermodynamic air temperature)	K
$T_{ba,i}$	air temperature after the charge air cooler (if applicable) (at the i^{th} mode during the cycle)	K
T_{clin}	Coolant temperature inlet	K
T_{clout}	Coolant temperature outlet	K
$T_{Exh,i}$	Exhaust Gas Temperature at the sampling point (at the i^{th} mode during the cycle)	K
T_{Fuel}	Fuel oil temperature before the engine	K
T_{Sea}	Sea water temperature	K
$T_{oil\ out/in}$	Lubricating oil temperature, outlet / inlet	K

6.3.3 Brake power

6.3.3.1 The point regarding the ability to obtain the required data during on-board NO_x testing is particularly relevant to brake power. Although the case of directly coupled gearboxes is considered in chapter 5, the engines, as may be presented on board, could in many applications, be arranged such that the measurements of torque (as obtained from a specially installed strain gauge) may not be possible due to the absence of a clear shaft. Principal in this group would be generators, but engines may also be coupled to pumps, hydraulic units, compressors, etc.

6.3.3.2 The engines driving such machinery would typically have been tested against a water brake at the manufacture stage prior to the permanent connection of the power consuming unit when installed on board. For generators this should not pose a problem to use voltage and amperage measurements together with a manufacturer's declared generator efficiency. For propeller law governed equipment, a declared speed

power curve may be applied together with ensured capability to measure engine speed, either from the free end or by ratio of, for example, the camshaft speed.

6.3.4 Test fuels

6.3.4.1 Generally all emission measurements shall be carried out with the engine running on marine diesel fuel oil of an ISO 8217, 1996, DM-grade.

6.3.4.2 To avoid an unacceptable burden to the shipowner, the measurements for confirmation tests or re-surveys may, based on the recommendation of the engine manufacturer and the approval of the Administration, be allowed with an engine running on heavy fuel oil of an ISO 8217, 1996, RM-grade. In such a case the fuel bound nitrogen and the ignition quality of the fuel may have an influence on the NO_x emissions of the engine.

6.3.5 Sampling for gaseous emissions

6.3.5.1 The general requirements described in 5.9.3 shall be applied for on-board measurements as well.

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.

6.3.6 Measurement equipment and data to be measured

The emission of gaseous pollutants shall be measured by the methods described in chapter 5.

6.3.7 Permissible deviation of instruments for engine related parameters and other essential parameters

Tables 3 and 4 contained in paragraph 1.3.2 of appendix 4 of this Code list the permissible deviation of instruments to be used in the measurement of engine-related parameters and other essential parameters during on-board verification procedures.

6.3.8 Determination of the gaseous components

The analytical measuring equipment and the methods described in chapter 5 shall be applied.

6.3.9 Test cycles

6.3.9.1 Test cycles used on board shall conform to the applicable test cycles specified in 3.2.

6.3.9.2 Engine operation on board under a test cycle specified in 3.2 may not always be possible, but the test procedure shall, based on the recommendation of the engine manufacturer and approval by the Administration, be as close as possible to the procedure defined in 3.2. 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 is different than those on the test bed, the measuring points and the weighting factors shall be in accordance with the recommendations of the engine manufacturer and approved by the Administration.

6.3.10 Calculation of gaseous emissions

The calculation procedure specified in chapter 5 shall be applied, taking into account the special requirements of this simplified measurement procedure.

6.3.11 Allowances

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

6.3.11.2 The NO_x emission of an engine may vary depending on the ignition quality of the fuel and the fuel bound nitrogen. If there is insufficient information available on the influence of the ignition quality on the NO_x formation during the combustion process and the fuel bound nitrogen conversion rate also depends on the engine efficiency, an allowance of 10% may be granted for an on-board test run carried out on a RM-grade fuel (ISO 8217, 1996) except that there will be no allowance for the pre-certification test on board. The fuel oil used shall be analysed for its composition of carbon, hydrogen, nitrogen, sulphur and, to the extent given in ISO 8217, 1996, any additional components necessary for a clear specification of the fuel.

6.3.11.3 In no case shall the total granted allowance for both the simplification of measurements on board and the use of heavy fuel oil of an ISO 8217, 1996, RM-grade fuel, exceed 15% of the applicable limit value.

APPENDIX 1

Form of EIAPP Certificate
(Refer to 2.2.9 of the NO_x Technical Code)

ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

Issued under the provisions of the Protocol of 1997 to the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 related thereto (hereinafter referred to as "the Convention") under the authority of the Government of:

.....

(full designation of the country)

by.....

(full designation of the competent person or organization authorized under the provisions of the Convention)

Engine Manufacturer	Model number	Serial number	Test Cycle(s)	Rated Power (kW) and Speed (RPM)	Engine Approval number

THIS IS TO CERTIFY:

1. That the above-mentioned marine diesel engine has been surveyed for pre-certification in accordance with the requirements of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines made mandatory by Annex VI of the Convention; and

2. That the pre-certification survey shows that the engine, its components, adjustable features, and Technical File, prior to the engine's installation and/or service on board a ship, fully comply with the applicable regulation 13 of Annex VI of the Convention.

This certificate is valid for the life of the engine subject to surveys in accordance with regulation 5 of Annex VI of the Convention, installed in ships under the authority of this Government.

Issued at .....

(Place of issue of certificate)

.....20..

(Date of issue)

.....

(signature of duty authorized official issuing the certificate)

(Seal or Stamp of the authority, as appropriate)

Supplement to Engine International Air Pollution Prevention Certificate
(EIAPP Certificate)

RECORD OF CONSTRUCTION, TECHNICAL FILE AND MEANS OF VERIFICATION

In respect of the provisions of Annex VI of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocols of 1978 and 1997 relating thereto (hereinafter referred to as "the Convention") and of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines (hereinafter referred to as the "NO_x Technical Code").

Notes:

1 This Record and its attachments shall be permanently attached to the EIAPP Certificate. The EIAPP Certificate shall accompany the engine throughout its life and shall be available on board the ship at all times.

2 If the language of the original Record is neither English nor French, the text shall include a translation into one of these languages.

3 Unless otherwise stated, regulations mentioned in this Record refer to regulations of Annex VI of the Convention and the requirements for an engine's Technical File and means of verifications refer to mandatory requirements from the NO_x Technical Code.

1 **Particulars of the engine**

1.1 Name and address of manufacturer .....

1.2 Place of engine build .....

1.3 Date of engine build .....

1.4 Place of pre-certification survey .....

1.5 Date of pre-certification survey .....

1.6 Engine type and model number .....

1.7 Engine serial number .....
.....

1.8 If applicable, the engine is a parent engine ☐ or a member engine ☐ of the following engine family ☐ or engine group ☐ .....
.....

1.9 Test cycle(s) (see chapter 3 of the NO_x Technical Code) .....

1.10 Rated Power (kW) and Speed (RPM) .....

1.11 Engine approval number .....

1.12 Specification(s) of test fuel .....

1.13 NO_x reducing device designated approval number (if installed) .....

1.14 Applicable NO_x Emission Limit (g/kWh) (regulation 13 of Annex VI) .....
.....

1.15 Engine's actual NO_x Emission Value (g/kWh) .....
.....

2 **Particulars of the Technical File**

2.1 Technical File identification/approval number .....
.....

2.2 Technical File approval date .....
.....

2.3 The Technical File, as required by chapter 2 of the NO_x Technical Code, is an essential part of the EIAPP Certificate and must always accompany an engine throughout its life and always be available on board a ship.

3 **Specifications for the On-board NO_x Verification Procedures for the Engine Parameter Survey**

3.1 On-board NO_x verification procedures identification/approval number .....
.....

3.2 On-board NO_x verification procedures approval date .....
.....

3.3 The specifications for the on-board NO_x verification procedures, as required by chapter 6 of the NO_x Technical Code, is an essential part of the EIAPP Certificate and must always accompany an engine through its life and always be available on board a ship.

THIS IS TO CERTIFY that this Record is correct in all respects.

Issued at .....
(Place of issue of the record)

.....20..
(Date of issue)

.....
(signature of duly authorized official issuing the Record)

(Seal or Stamp of the authority, as appropriate)

APPENDIX 2

FLOW CHARTS FOR SURVEY AND CERTIFICATION OF MARINE DIESEL ENGINES
(Refer to 2.2.8 and 2.3.13 of the NO_x Technical Code)

Guidance for compliance with survey and certification of marine diesel engines, as described in chapter 2 of this Code, are shown in the flow charts on the next three pages as follows:

Figure 1. Flow Chart, Step 1 - Pre-certification Survey at the manufacturer's shop

Figure 2. Flow Chart, Step 2 - Initial Survey on board the ship

Figure 3. Flow Chart, Step 3 - Periodical Survey on board a ship

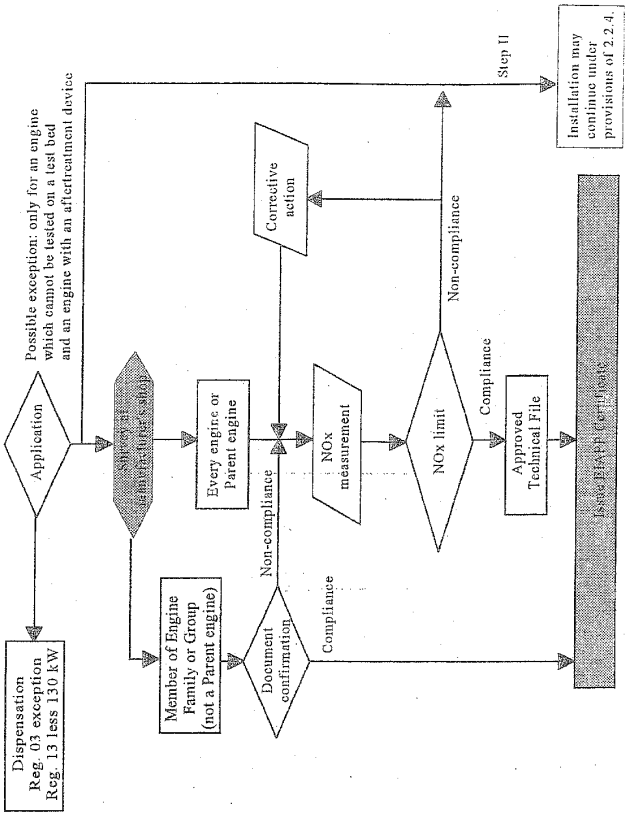


Figure 1. Flow Chart, Step I - Pre-certification Survey at the manufacturer's shop

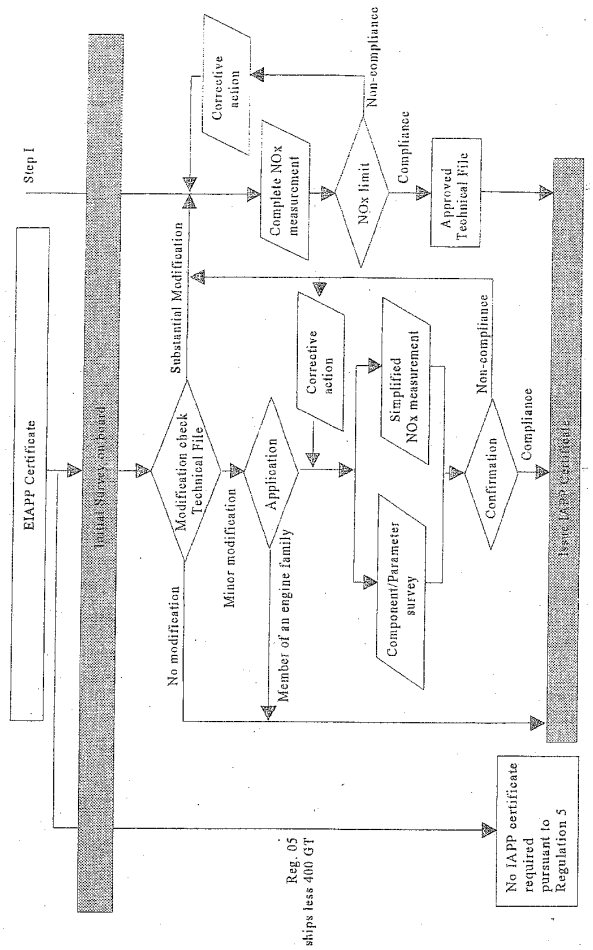


Figure 2. Flow Chart, Step II - Initial Survey on board a ship

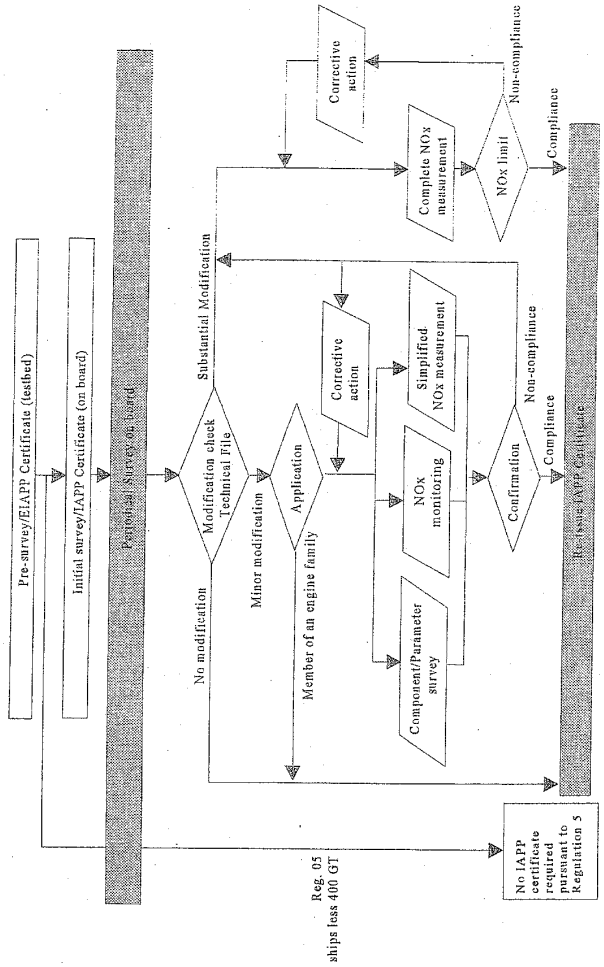


Figure 3. Flow Chart, Step III - Periodical Survey on board a ship

APPENDIX 3

SPECIFICATIONS FOR ANALYSERS TO BE USED IN THE DETERMINATION OF GASEOUS COMPONENTS OF DIESEL ENGINE EMISSIONS
(Refer to chapter 5 of the NO_x Technical Code)

1 General

1.1 The analysers shall have a measuring range appropriate for the accuracy required to measure the concentrations of the exhaust gas components (see 1.5). 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 concentration falls between 15% and 100% of full scale.

1.2 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 (see 5.5.2 of appendix 4 of this Code).

1.3 The electromagnetic compatibility (EMC) of the equipment shall be on a level to minimise additional errors.

1.4 Definitions

.1 The *repeatability* of an analyser is defined as 2.5 times the standard deviation of 10 repetitive responses to a given calibration or span gas.

.2 The *zero response* of an analyser is defined as the mean response, including noise, to a zero gas during a 30 seconds time interval.

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

.4 The *span response* is defined as the mean response, including noise, to a span gas during a 30 seconds time interval.

1.5 Measurement error

The total measurement error of an analyser, including the cross sensitivity to other gases (see section 8 of appendix 4 of this Code), 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.

1.6 Repeatability

The repeatability of an analyser shall be no greater than ± 1% of full scale concentration for each range used above 155 ppm (or ppm C) or ± 2% of each range used below 155 ppm (or ppm C).

1.7 Noise

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

1.8 Zero drift

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

1.9 Span drift

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

2 Gas drying

The optional gas drying device shall have a minimal effect on the concentration of the measured gases. Chemical dryers are not an acceptable method of removing water from the sample.

3 Analysers

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) analysis

The carbon monoxide analyser shall be of the Non-Dispersive InfraRed (NDIR) absorption type.

.2 Carbon dioxide (CO_2) analysis

The carbon dioxide analyser shall be of the Non-Dispersive InfraRed (NDIR) absorption type.

.3 Oxygen (O_2) analysis

Oxygen analysers shall be of the ParaMagnetic Detector (PMD), ZiRconium DiOxide (ZRDO) or ElectroChemical Sensor (ECS) type.

Note: Electrochemical sensors shall be compensated for CO_2 and NO_x interference.

.4 Oxides of nitrogen (NO_x) analysis

The oxides of nitrogen 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, an HCLD with converter maintained above 333 K (60°C) shall be used, provided the water quench check (see 8.2.2 of appendix 4 of this Code) is satisfied.

APPENDIX 4

CALIBRATION OF THE ANALYTICAL INSTRUMENTS
(Refer to chapter 5 of the NO_x Technical Code)

1 **Introduction**

1.1 Each analyser used for the measurement of an engine's parameters shall be calibrated as often as necessary in accordance with the requirements of this appendix.

1.2 Except as otherwise specified, all results of measurements, test data or calculations required by this appendix shall be recorded in the engine's test report in accordance with section 5.10 of this Code.

1.3 Accuracy of analytical instruments

1.3.1 Permissible deviation of instruments for measurements on a test bed

The calibration of all measuring instruments shall comply with the requirements as set out in tables 1 and 2 and shall be traceable to national or international standards.

Table 1. Engine related permissible deviations for measurements on a test bed

No.	Item	Permissible Deviation (±% values based on engines' maximum values)	Calibration Intervals (months)
1	Engine speed	2%	3
2	Torque	2%	3
3	Power	2%	not applicable
4	Fuel consumption	2%	6
5	Air consumption	2%	6
6	Exhaust gas flow	4%	5

Table 2. Permissible deviations of essential measured parameters for measurements on a test bed

No.	Item	Permissible Deviation ± absolute values	Calibration Intervals (months)
1	Coolant temperature	2 K	3
2	Lubricant temperature	2 K	3
3	Exhaust gas pressure	5% of maximum	3
4	Inlet manifold depressions	5% of maximum	3
5	Exhaust gas temperature	15 K	3
6	Air inlet temperature (combustion air)	2 K	3
7	Atmospheric pressure	0.5% of reading	3
8	Intake air humidity (relative)	3%	1
9	Fuel temperature	2 K	3

1.3.2 Permissible deviation of instruments for measurements on board a ship for verification purposes

The calibration of all measuring instruments shall comply with the requirements as set out in tables 3 and 4 and shall be traceable to national or international standards.

Table 3. **Permissible deviation of instruments for engine related parameters for measurements on board a ship**

No.	Item	Permissible Deviation (±% based on maximum engines' values)	Calibration Intervals (month)
1	engine speed	2%	3
2	torque	5%	3
3	power	5%	not applicable
4	fuel consumption	4% / 6% diesel/residual	6
5	specific fuel consumption	not applicable	not applicable
6	air consumption	5%	6
7	exhaust gas flow	5% calculated	6

Table 4. Permissible deviations of instruments for other essential parameters for measurements on board a ship

No.	Item	Permissible Deviation ± absolute values or "of reading"	Calibration Intervals (months)
1	coolant temperature	2 K	3
2	lubricating oil temperature	2 K	3
3	exhaust gas pressure	5% of maximum	3
4	inlet manifold depressions	5% of maximum	3
5	exhaust gas temperature	15 K	3
6	air inlet temperature	2 K	3
7	atmospheric pressure	0.5% of reading	3
8	intake air humidity (relative)	3%	1
9	fuel temperature	2 K	3

2 Calibration gases

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.

2.1 Pure gases

2.1.1 The required purity of the gases is defined by the contamination limits given below. The following gases shall be available for operation of the test bed measurement procedures:

.1 purified nitrogen (contamination ≤ 1 ppm C, ≤ 1 ppm CO, ≤ 400 ppm CO_2, ≤ 0.1 ppm NO);

.2 purified oxygen (purity > 99.5% volume O_2);

.3 hydrogen-helium mixture (40 ± 2% hydrogen, balance helium), (contamination ≤ 1 ppm C, ≤ 400 ppm CO); and

.4 purified synthetic air (contamination ≤ 1 ppm C, ≤ 1 ppm CO, ≤ 400 CO_2, ≤ 0.1 ppm NO), (oxygen content between 18-21% volume).

2.2 Calibration and span gases

2.2.1 Mixtures of gases having the following chemical compositions shall be available:

.1 CO and purified nitrogen;

.2 NO_x and purified nitrogen (the amount of NO_2 contained in this calibration gas must not exceed 5% of the NO content);

.3 O_2 and purified nitrogen; and

.4 CO_2 and purified nitrogen.

Note: Other gas combinations are allowed provided the gases do not react with one another.

2.2.2 The true concentration of a calibration and 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 volume ppm).

2.2.3 The gases used for calibration and span may also be obtained by means of a gas divider, diluting with purified N_2 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%.

3 Operating procedure for analysers and sampling system

The operating procedure for analysers shall follow the start-up and operating instructions specified by the instrument manufacturer. The minimum requirements given in sections 4 to 9 shall be included.

4 Leakage test

4.1 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.

4.2 The maximum allowable leakage rate on the vacuum side shall be 0.5% of the in-use flow rate for the portion of the system being checked. The analyser flows and bypass flows may be used to estimate the in-use flow rates.

4.3 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 should show a lower concentration compared to the introduced concentration; this points to calibration or leakage problems.

5 Calibration procedure

5.1 Instrument assembly

The instrument assembly shall be calibrated and the calibration curves checked against standard gases. The same gas flow rates shall be used as when sampling exhaust.

5.2 Warming-up time

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

5.3 NDIR and HFID analyser

The NDIR analyser shall be tuned, as necessary.

5.4 Calibration

5.4.1 Each normally used operating range shall be calibrated.

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

5.4.3 The appropriate calibration gases shall be introduced to the analysers, the value recorded, and the calibration curve established according to 5.5 below.

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

5.5 Establishment of the calibration curve

5.5.1 General guidelines

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

5.5.1.2 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.

5.5.1.3 The calibration curve shall not differ by more than ± 2% from the nominal value of each calibration point and by more than ± 1% of full scale at zero.

5.5.1.4 From the calibration curve and the 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, and

.3 the date of carrying out the calibration.

5.5.2 Calibration below 15% of full scale

5.5.2.1 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.

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

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

5.5.3 Alternative methods

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

6 Verification of the calibration

Each normally used operating range shall be checked prior to each analysis in accordance 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; and

.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 5.5 above.

7 Efficiency test of the NO_x converter

The efficiency of the converter used for the conversion of NO_2 into NO shall be tested as given in 7.1 to 7.8 below.

7.1 Test set-up

Using the test set-up as shown in figure 1 below (see also 3.4 of appendix 3 of this Code) and the procedure below, the efficiency of converters shall be tested by means of an ozonator.

7.2 Calibration

The CLD and the HCLD 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 must be in the NO mode so that the span gas does not pass through the converter. The indicated concentration shall be recorded.

7.3 Calculation

The efficiency of the NO_x converter shall be calculated as follows:

$$Efficiency\ (\%) \left(1 \frac{a\ b}{c\ d}\right) \cdot 100 \qquad (1)$$

where:

a = NO_x concentration according to 7.6 below
b = NO_x concentration according to 7.7 below
c = NO concentration according to 7.4 below
d = NO concentration according to 7.5 below

7.4 Adding of oxygen

7.4.1 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 7.2 above (the analyser must be in the NO mode).

7.4.2 The indicated concentration "c" shall be recorded. The ozonator must be kept deactivated throughout the process.

7.5 Activation of the ozonator

The ozonator shall now be activated to generate enough ozone to bring the NO concentration down to about 20% (minimum 10%) of the calibration concentration given in 7.2 above. The indicated concentration (d) shall be recorded (the analyser must be in the NO mode).

7.6 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 passes through the converter. The indicated concentration "a" shall be recorded (the analyser must be in the NO_x mode).

7.7 Deactivation of the ozonator

The ozonator shall now be deactivated. The mixture of gases described in 7.6 above passes through the converter into detector. The indicated concentration "b" shall be recorded (the analyser must be in the NO_x mode).

7.8 NO mode

Switched to 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 7.2 above (the analyser must be in the NO_x mode).

7.9 Test interval

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

7.10 Efficiency requirement

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

Note: If, with the analyser in the most common range, the NO_x converter cannot give a reduction from 80% to 20% according to 7.2 above, then the highest range which will give the reduction shall be used.

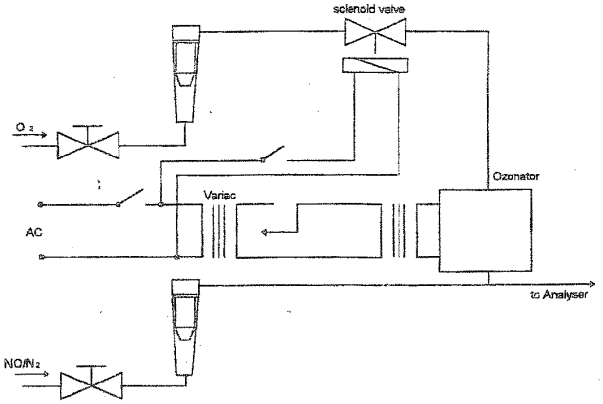


Figure 1. Schematic of NO_2 converter efficiency device

8 Interference effects with CO, CO_2, NO_x and O_2 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 instruments by the interfering gas broadening the absorption band of the measured gas, and in CLD instruments by the interfering gas quenching the radiation. The interference checks in 8.1 and 8.2 below shall be performed prior to an analyser's initial use and after major service intervals.

8.1 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 shall not be more than 1% of full scale for ranges greater than or equal to 300 ppm or more than 3 ppm for ranges below 300 ppm.

8.2 NO_x analyser quench checks

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 experienced during testing.

8.2.1 CO_2 quench check

8.2.1.1 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 the 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.

8.2.1.2 The quench shall be calculated as follows:

$$\%\,Quench \quad \left[1 - \left(\frac{(C \cdot A)}{(D \cdot A) \quad (D \cdot B)}\right)\right] \cdot 100 \qquad (2)$$

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

where:

A	= Undiluted CO_2 concentration measured with NDIR	%
B	= Diluted CO_2 concentration measured with NDIR	%
C	= Diluted NO concentration measured with (H)CLD	ppm
D	= Undiluted NO concentration measured with (H)CLD	ppm

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

8.2.2 Water quench check

8.2.2.1 This check applies to 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.

8.2.2.2 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 as follows:

$$H \quad 100 \cdot \left(\frac{G}{E}\right) \qquad (3)$$

and recorded as H. The expected diluted NO span gas (in water vapour) concentration shall be calculated as follows:

$$De \quad D \cdot \left(1 \quad \frac{H}{100} \right) \tag{4}$$

and recorded as De. For diesel 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 8.2.1 above) as follows:

$$Hm \quad 0.9 \cdot A \tag{5}$$

and recorded as Hm.

8.2.2.3 The water quench shall be calculated as follows:

$$\%\,Quench \quad 100 \cdot \frac{(De \quad C)}{De} \cdot \frac{Hm}{H} \tag{6}$$

and shall not be greater than 3%.

where:

De	=	Expected diluted NO concentration	ppm
C	=	Diluted NO concentration	ppm
Hm	=	Maximum water vapour concentration	%
H	=	Actual water vapour concentration	%

Note: 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 in the quench calculations.

8.3 O_2 analyser interference

8.3.1 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 shown in table 5.

Table 5. Oxygen equivalents

100% gas concentration	Equivalent % O_2
Carbon dioxide, CO_2	- 0.623
Carbon monoxide, CO	- 0.354
Nitric oxide, NO	+ 44.4
Nitrogen dioxide, NO_2	+ 28.7
Water, H_2O	- 0.381

8.3.2 The observed oxygen concentration shall be corrected by the following formula if high precision measurements are to be done:

$$Interference \quad (Equivalent\ \%O_2 \cdot Observed\ Concentration\ )/100 \qquad (7)$$

8.3.3 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.

9 Calibration intervals

The analysers shall be calibrated according to section 5 at least every 3 months or whenever a system repair or change is made that could influence calibration.

APPENDIX 5 - SAMPLE TEST REPORT
(Refer to 5.10 of the NO_x Technical Code)

Emissions Test Report No. ..... Engine Information* Sheet 1/5

Engine					
Manufacturer					
Engine type					
Family or Group identification					
Serial number					
Rated speed					rpm
Rated power					kW
Intermediate speed					rpm
Maximum torque at intermediate speed					Nm
Static injection timing					deg CA BTDC
Electronic injection control			no:	yes:	
Variable injection timing			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			no:	yes:	
Cooling system spec. charge air stages					
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:	Aux:	
Emissions test results:					
Cycle					
NO_x					g/kWh
Test identification					

Date/time	
Test site/bench	
Test number	
Surveyor	
Date and Place of report	
Signature	

* If applicable

Emissions Test Report No. ..... Engine Family Information* Sheet 2/5

Engine Family Information/Group Information (Common specifications)	
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	natural aspired/pressure charged
Fuel type to be used on board	distillate/distillate or heavy fuel/dual
Combustion chamber	Open chamber/divided chamber
Valve port configuration	Cylinder head/cylinder wall
Valve port size and number	
Fuel system type	

Miscellaneous features:	
Exhaust gas recirculation	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 test)					
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 cylinder					
Max. rated power per cylinder					
Rated speed					
Injection timing (range)					
Max. fuel parent engine					
Selected parent engine					Parent
Application					

* If applicable

Emissions Test Report No. ..... Test Cell Information* Sheet 3/5

Exhaust Pipe	
Diameter	mm
Length	m
Insulation	no: yes:
Probe location	
Remark	

Measurement equipment					
	Manufacturer	Model	Measurement ranges	Calibration	
				Span gas conc.	Deviation
Analyser					
NO_x Analyser			ppm		%
CO Analyser			ppm		%
CO2 Analyser			%		%
O2 Analyser			%		%
HC Analyser			ppm		%
Speed			rpm		%
Torque			Nm		%
Power, if applicable			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			%		%

Fuel Characteristics

Fuel type				
Fuel properties:			**Fuel elemental analysis**	
Density	ISO 3675	kg/l	Carbon	% mass
Viscosity	ISO 3104	mm^2/s	Hydrogen	% mass
			Nitrogen	% mass
			Oxygen	% mass
			Sulphur	% mass
			LHV/Hu	MJ/kg

* if applicable

Emissions Test Report No. ..... **Ambient and Gaseous Emissions Data*** **Sheet 4/5**

Mode		1	2	3	4	5	6	7	8	9	10
Power/Torque	%										
Speed	%										
Time at beginning of mode											

Ambient Data											
Atmospheric pressure	kPa										
Intake air temperature	°C										
Intake air humidity	g/kg										
Atmospheric factor (fa)											

Gaseous Emissions Data:											
NO_x concentration dry/wet	ppm										
CO concentration dry/wet	ppm										
CO2 concentration dry/wet	%										
O2 concentration dry/wet	%										
HC concentration dry/wet	ppm										
NO_x humidity correction factor											
Fuel specification factor (FFH)											
Dry/wet correction factor											
NO_x mass flow	kg/h										
CO mass flow	kg/h										
CO2 mass flow	kg/h										
O2 mass flow	kg/h										
HC mass flow	kg/h										
SO2 mass flow	kg/h										
NO_x specific	g/kWh										

* If applicable

Mode	1	2	3	4	5	6	7	8	9	10
Power/Torque %										
Speed %										
Time at beginning of mode										

Engine Data											
Speed	rpm										
Auxiliary power	kW										
Dynamometer setting	kW										
Power	kW										
Mean effective pressure	bar										
Fuel rack	mm										
Uncorrected spec. fuel consumption	g/kWh										
Fuel flow	kg/h										
Air flow	kg/h										
Exhaust flow (gexhw)	kg/h										
Exhaust temperature	°C										
Exhaust back pressure	mbar										
Cylinder Coolant temperature out	°C										
Cylinder Coolant temperature in	°C										
Cylinder Coolant pressure	bar										
Temperature intercooled air	°C										
Lubricant temperature	°C										
Lubricant pressure	bar										
Inlet depression	mbar										

* If applicable

APPENDIX 6

CALCULATION OF EXHAUST GAS MASS FLOW
(CARBON BALANCE METHOD)
(Refer to chapter 5 of the NO_x Technical Code)

1 INTRODUCTION

1.1 This appendix addresses the calculation of the exhaust gas mass flow and/or of the combustion air consumption. Both methods given in the following are based on exhaust gas concentration measurement, and on the knowledge of the fuel consumption. Symbols and descriptions of terms and variables used in the formulae for the carbon balance measurement method are summarized in table 4 of the Abbreviations, Subscripts, and Symbols of this Code.

1.2 This appendix includes two methods for calculating the exhaust gas mass flow as follows: Method 1 (Carbon balance) is only valid using fuels without oxygen and nitrogen content; and, Method 2 (Universal, carbon/oxygen-balance) is applicable for fuels containing H, C, S, O, N in known composition.

1.3 Method 2 provides an easy understandable but universal derivation of all formulae including all constants. This method is provided because there are many cases where the present available constants, neglecting essential parameters, may lead to results with avoidable errors. Using the formulae within Method 2, it may also be possible to calculate the essential parameters under conditions deviating from standard conditions.

1.4 Examples of parameters for some selected fuels are offered in table 1. The values for fuel composition are for reference purposes only and shall not be used in place of the composition values of the oil fuel actually used.

Table 1. Parameters for some selected fuels (examples)

Fuel	C %	H %	S %	O %	I	FFH	FFW	FFD	EXH DENS
Diesel	86.2	13.6	0.17	0	1 1.35 3.5	1.835 1.865 1.920	0.749	-0.767	1.294 1.293 1.292
RME	77.2	12.0		10.8	1 1.35 3.5	1.600 1.63 1.685	0.734	-0.599	1.296 1.295 1.292
Methanol	37.5	12.6	0	50.0	1 1.35 3.5	1.495 1.565 1.705	1.046	-0.354	1.233 1.246 1.272
Ethanol	52.1	13.1	0	34.7	1 1.35 3.5	1.65 1.704 1.807	0.965	-0.49	1.26 1.265 1.281

Fuel	C %	H %	S %	O %	λ	FFH	FFW	FFD	EXH DENS
Natural Gas *	60.6	19.3	0	1.9	1 1.35 3.5	2.509 2.572 2.689	1.078	-1.065	1.257 1.265 1.28
Propane	81.7	18.3	0	0	1 1.35 3.5	2.423 2.473 2.564	1.007	-1.025	1.268 1.273 1.284
Butane	82.7	17.3	0	0	1 1.35 3.5	2.298 2.343 2.426	0.952	-0.97	1.273 1.277 1.285

* Volumetric composition: CO_2 1.10%; N_2 12.10%; CH_4 84.20%; C_2H_6 3.42%; C_3H_8 0.66%; C_4H_{10} 0.22%; C_5H_{12} 0.05%; C_6H_{14} 0.05%

1.5 Except as otherwise specified, all results of calculations required by this appendix shall be reported in the engine's test report in accordance with section 5.10 of this Code.

2 METHOD 1, CARBON BALANCE

2.1 This method includes six steps that shall be used in the calculation of the exhaust gas concentrations with regard to the fuel characteristics.

2.2 The given formulae of Method 1 are only valid in the absence of oxygen in the fuel.

2.3 **First step:** Calculation of the stoichiometric air demand

2.3.1 Process of complete combustion:

$$C + O_2 \rightarrow CO_2 \quad (1\text{-}1)$$

$$4H + O_2 \rightarrow 2H_2O \quad (1\text{-}2)$$

$$S + O_2 \rightarrow SO_2 \quad (1\text{-}3)$$

$$STOIAR = (BET / 12.011 + ALF / (4 \cdot 1.00794) + GAM / 32.060) \cdot 31.9988 / 23.15 \quad (1\text{-}4)$$

2.4 **Second step:** Calculation of the excess-air-factor based on complete combustion and the CO_2 - concentration

$$EAFCDO = ((BET \cdot 10 \cdot 22.262 / (12.011 \cdot 1000)) / (CO2D / 100) + STOIAR \cdot 0.2315 / 1.42895 - BET \cdot 10 \cdot 22.262 / (12.011 \cdot 1000) - GAM \cdot 10 \cdot 21.891 / (32.060 \cdot 1000)) / (STOIAR \cdot (0.7685 / 1.2505 + 0.2315 / 1.42895)) \quad (1\text{-}5)$$

2.5 **Third step:** Calculation of the hydrogen-to-carbon ratio

$$HTCRAT = ALF \cdot 12.011 / (1.00794 \cdot BET) \quad (1\text{-}6)$$

2.6 **Fourth step**: Calculation of the dry hydrocarbon-concentration based on the ECE R49-procedure with respect to fuel characteristics and air fuel ratio

2.6.1 The conversion of dry to wet concentration is given by:

$$conc_{wet} = conc_{dry} \cdot (1 - FFH \cdot (fuel\ consumption / dry\ air\ consumption)) \quad (1\text{-}7)$$

$$FFH \cdot \frac{Fuel\ consumption}{Dry\ air\ consumption} \cdot \frac{Volume\ of\ water\ of\ the\ combustion\ process}{Total\ wet\ exhaust\ volume} \quad (1\text{-}8)$$

Total wet exhaust volume = Nitrogen of combustion air +
excess oxygen +
argon of the combustion air +
water of the combustion air +
water of the combustion process +
CO_2 of the combustion process +
SO_2 of the combustion process (1-9)

$$FFH \cdot \frac{GFUEL}{GAIRD} = (10 \cdot ALF \cdot MVH2O / (2 \cdot 1.0079 \cdot 1000)) \cdot GFUEL / ((0.7551 / 1.2505 \cdot (GAIRD / (GFUEL \cdot STOIAR)) \cdot STOIAR + 0.2315 / 1.42895 \cdot ((GAIRD / (GFUEL \cdot STOIAR)) -1) \cdot STOIAR + 0.0129 / 1.7840 \cdot (GAIRD / (GFUEL \cdot STOIAR)) \cdot STOIAR + 0.0005 / 1.9769 \cdot (GAIRD / (GFUEL \cdot STOIAR)) \cdot STOIAR + (ALF \cdot 10 \cdot MVCO2 /(2 \cdot 1.0079 \cdot 1000)) + (BET \cdot 10 \cdot MVCO2/(12.001 \cdot 1000)) + (GAM \cdot 10 \cdot MVSO2 /(32.060 \cdot 1000))) \cdot GFUEL) \quad (1\text{-}10)$$

where:

MVH2O = 22.401 dm^3/mol
MVCO2 = 22.262 dm^3/mol
MVSO2 = 21.891 dm^3/mol

2.6.2 The formula results:

$$FFH \cdot \frac{GFUEL}{GAIRD} = (0.111127 \cdot ALF) / (0.0555583 \cdot ALF - 0.000109 \cdot BET - 0.000157 \cdot GAM + 0.773329 \cdot (GAIRD / GFUEL)) \quad (1\text{-}11)$$

and

$$FFH = (0.111127 \cdot ALF) / (0.773329 + (0.0555583 \cdot ALF - 0.000109 \cdot BET - 0.000157 \cdot GAM) \cdot (GFUEL / GAIRD)) \quad (1\text{-}12)$$

2.6.3 The excess air factor is defined as:

$$l_v = \text{air consumption} / (\text{fuel consumption} \cdot \text{stoichiometric air demand}) \quad (1\text{-}13)$$

$$EAFCDO = GAIRD / (GFUEL \cdot STOIAR) \quad (1\text{-}14)$$

$$GAIRD = EAFCDO \cdot GFUEL \cdot STOIAR \quad (1\text{-}15)$$

$$\begin{aligned} CWET &= CDRY \cdot (1 - FFH \cdot GFUEL / GAIRD) \\ &= CDRY \cdot (1 - FFH \cdot GFUEL / (EAFCDO \cdot GFUEL \cdot STOIAR)) \\ &= CDRY \cdot (1 - FFH / (EAFCDO \cdot STOIAR)) \end{aligned} \quad (1\text{-}16)$$

$$\begin{aligned} CDRY &= CWET / (1 - FFH / (EAFCDO \cdot STOIAR)) \\ &= CWET \cdot EAFCDO \cdot STOIAR / (EAFCDO \cdot STOIAR - FFH) \end{aligned} \quad (1\text{-}17)$$

$$HCD = HCW \cdot EAFCDO \cdot STOIAR / (EAFCDO \cdot STOIAR - FFH) \quad (1\text{-}18)$$

2.7 **Fifth step**: Calculation of the excess air factor based on the procedures specified in Title 40, United States Code of Federal Regulations (40CFR86.345-79).

$$EXHCPN = (CO2D / 100) + (COD / 10^6) + (HCD / 10^6) \quad (1\text{-}19)$$

$$\begin{aligned} l_v = EAFEXH = (1 / EXHCPN - COD / (10^6 \cdot 2 \cdot EXHCPN) - HCD / (10^6 \cdot EXHCPN) + \\ HTCRAT / 4 \cdot (1 - HCD / (10^6 \cdot EXHCPN)) - 0.75 \cdot HTCRAT / \\ (3.5 / (COD / (10^6 \cdot EXHCPN)) + ((1 - 3.5) / (1 - HCD / \\ (10^6 \cdot EXHCPN))))) / (4.77 \cdot (1 + HTCRAT / 4)) \end{aligned} \quad (1\text{-}20)$$

2.8 **Sixth step**: Calculation of the exhaust mass

$$\text{Exhaust mass flow} = \text{Fuel consumption} + \text{combustion air consumption} \quad (1\text{-}21)$$

(with the excess air factor defined in step four)

$$\text{air consumption} = l_v \cdot \text{fuel consumption} \cdot \text{stoichiometric air demand} \quad (1\text{-}22)$$

$$\text{Exhaust mass flow} = \text{Fuel consumption} \cdot (1 + l_v \cdot \text{stoichiometric air demand}) \quad (1\text{-}23)$$

$$GEXHW = GFUEL \cdot (1 + EAFEXH \cdot STOIAR) \quad (1\text{-}24)$$

3 METHOD 2, UNIVERSAL, CARBON/OXYGEN-BALANCE

3.1 Introduction

The described method gives an easily understandable description of the carbon and oxygen balance method. It may be used when the fuel consumption is measurable and when the fuel composition and the concentrations of the exhaust components are known.

3.2 Calculation of the exhaust mass flow on the basis of the carbon balance

$$GEXHW = \frac{GFUEL \cdot BET \cdot EXHDENS \cdot 10^4}{AWC} \cdot \frac{1}{\left(\frac{CO2W \cdot 10^4}{MVCO2} + \frac{COW}{MVCO} + \frac{HCW}{MVHC} + \frac{CW}{AWC} \right)} \quad (2\text{-}1)$$

3.2.1 Simplification with complete combustion:

$$GEXHW = \frac{GFUEL \cdot BET \cdot EXHDENS \cdot MVCO2}{AWC \cdot (CO2W - CO2AIR)} \quad (2\text{-}2)$$

3.3 **Calculation of exhaust mass flow on the basis of oxygen balance**

$$GEXHW = GFUEL \cdot \left(\frac{\frac{Factor1}{1000 \cdot EXHDENS} \cdot 10 \cdot Factor2 - 10 \cdot EPS}{10 \cdot TAU - \frac{Factor1}{1000 \cdot EXDENS}} + 1 \right) \quad (2\text{-}3)$$

where:

$$Factor\ 1 = 10^4 \cdot \frac{MWO2 \cdot O2W}{MVO2} + \frac{AWO}{MVCO} \cdot COW + \frac{AWO}{MVNO} \cdot NOW + \frac{2 \cdot AWO}{MVNO2} \cdot NO2W + \frac{3 \cdot AWO}{MVHC} \cdot HCW + \frac{2 \cdot AWO}{AWC} \cdot CW \quad (2\text{-}4)$$

and

$$Factor2 = ALF \cdot \frac{AWO}{2 \cdot AWH} + BET \cdot \frac{2 \cdot AWO}{AWC} + GAM \cdot \frac{AWO}{AWS} \quad (2\text{-}5)$$

3.3.1 Simplification with complete combustion:

$$Factor1_{compl} = 10^4 \cdot \frac{MWO2}{MVO2} \cdot O2W \quad (2\text{-}6)$$

3.4 **Derivation of the oxygen balance for incomplete combustion**

3.4.1 The oxygen input in g/h is:

$$GAIRW \cdot TAU \cdot 10 + GFUEL \cdot EPS \cdot 10 \quad (2\text{-}7)$$

3.4.2 The oxygen output in g/h is:

$$GO2 = GCO2 \cdot \frac{2 \cdot AWO}{MWCO\ 2} + GCO \cdot \frac{AWO}{MWCO} + GNO \cdot \frac{AWO}{MWNO} + GNO2 \cdot \frac{2 \cdot AWO}{MWNO\ 2} + GSO2 \cdot \frac{2 \cdot AWO}{MWSO\ 2} + GH2O \cdot \frac{AWO}{MWH2O} \quad (2\text{-}8)$$

based on the following definitions and formulae, the individual gas components are calculated in g/h related on wet exhaust gas (GC is the soot in g/h).

$$GO2 = \frac{MWO2 \cdot 10}{MVO2 \cdot EXHDENS} \cdot O2W \cdot GEXHW \quad (2\text{-}9)$$

$$GCO = \frac{MWCO}{MVCO \cdot EXHDENS \cdot 1000} \cdot COW \cdot GEXHW \quad (2\text{-}10)$$

$$GNO = \frac{MWNO}{MVNO \cdot EXHDENS \cdot 1000} \cdot NOW \cdot GEXHW \quad (2\text{-}11)$$

$$GNO2 = \frac{MWNO2}{MVNO2 \cdot EXHDENS \cdot 1000} \cdot NO2W \cdot GEXHW \quad (2\text{-}12)$$

$$GCO2 = \frac{MWCO2}{AWC} \cdot GFUEL \cdot BET \cdot 10 - GCO \cdot \frac{MWCO2}{MWCO} - GHC \cdot \frac{MWCO2}{MWHC} - GC \cdot \frac{MWCO2}{AWC} \quad (2\text{-}13)$$

$$GH2O = \frac{MWH2O}{2 \cdot AWH} \cdot GFUEL \cdot ALF \cdot 10 - GHC \cdot \frac{MWH2O}{MWHC} \quad (2\text{-}14)$$

$$GSO2 = \frac{MWSO2}{AWS} \cdot GFUEL \cdot GAM \cdot 10 \quad (2\text{-}15)$$

$$GHC = \frac{MWHC}{MVHC \cdot EXHDENS \cdot 1000} \cdot HCW \cdot GEXHW \quad (2\text{-}16)$$

$$GC = \frac{1}{EXHDENS \cdot 1000} \cdot CW \cdot GEXHW \quad (2\text{-}17)$$

3.4.3 EXHDENS is calculated using formula (2-42) in 3.6 of this section.

$$GAIRW \cdot TAU \cdot 10 + GFUEL \cdot EPS \cdot 10 =$$

$$= \frac{GEXHW}{10^3 \cdot EXHDENS} \cdot \left(\frac{MWO2 \cdot O2W \cdot 10^4}{MVO2} + \frac{AWO \cdot COW}{MVCO} + \frac{AWO \cdot NOW}{MVNO} + \frac{2 \cdot AWO \cdot NO2W}{MVNO2} + \frac{3 \cdot AWO \cdot HCW}{MVHC} + \frac{2 \cdot AWO \cdot CW}{AWC} \right) +$$

$$+ 10 \cdot GFUEL \cdot \left(\frac{ALF \cdot AWO}{2 \cdot AWH} + \frac{BET \cdot 2 \cdot AWO}{AWC} + \frac{GAM \cdot AWO}{AWS} \right) \quad (2\text{-}18)$$

3.4.4 The first bracket is defined as Factor 1, the second one as Factor 2 (see also formulae (2-4) and (2-5)).

where:

$$GEXHW \quad GAIR \quad GFUEL \quad (2\text{-}19)$$

3.4.5 The consumed air mass and the exhaust gas mass may be calculated using the following formulae:

$$GAIRW = GFUEL \cdot \left(\frac{\frac{Factor1}{1000 \cdot EXHDENS} \cdot 10 \cdot Factor2 - 10 \cdot EPS}{TAU \cdot 10 - \frac{Factor1}{1000 \cdot EXHDENS}} \right) \quad (2\text{-}20)$$

and accordingly:

$$GEXHW = GFUEL \cdot \left(\frac{\frac{Factor1}{1000 \cdot EXHDENS} \cdot 10 \cdot Factor2 - 10 \cdot EPS}{TAU \cdot 10 - \frac{Factor1}{1000 \cdot EXHDENS}} - 1 \right) \quad (2\text{-}21)$$

3.5 **Derivation of the carbon balance for the incomplete combustion**

3.5.1 Carbon input in g/h:

$$GFUEL \cdot BET \cdot 10 \quad (2\text{-}22)$$

3.5.2 Carbon output in g/h:

$$GCO2 \cdot \frac{AWC}{MWCO2} + GCO \cdot \frac{AWC}{MWCO} + GHC \cdot \frac{AWC}{MWHC} + GC \cdot \frac{AWC}{AWC} \quad (2\text{-}23)$$

3.5.3 Based on the following definitions and formulae, the individual gas components are calculated in g/h related on wet exhaust gas (GC is the soot in g/h).

$$GCO2 = \frac{MWCO2 \cdot 10}{MVCO2 \cdot EXHDENS} \cdot CO2W \cdot GEXHW \quad (2\text{-}24)$$

$$GCO = \frac{MWCO}{MVCO \cdot EXHDENS \cdot 1000} \cdot COW \cdot GEXHW \quad (2\text{-}25)$$

$$GHC = \frac{MWHC}{MVHC \cdot EXHDENS \cdot 1000} \cdot HCW \cdot GEXHW \quad (2\text{-}26)$$

$$GC = \frac{1}{EXHDENS} \cdot CW \cdot GEXHW \quad (2\text{-}27)$$

3.5.4 For the balance condition:

Carbon input = Carbon output

$$GFUEL \cdot BET \cdot 10 = \frac{GEXHW \cdot AWC}{EXHDENS \cdot 1000} \cdot \left(\frac{CO2W}{MVCO2} \cdot 10^4 + \frac{COW}{MVCO} + \frac{HCW}{MVHC} + \frac{CW}{AWC} \right) \quad (2\text{-}28)$$

3.5.5 Calculation of the exhaust mass flow on the basis of the carbon balance:

$$GEXHW = \frac{GFUEL \cdot BET \cdot EXHDENS \cdot 10^3}{AWC} \cdot \frac{1}{\left(\frac{CO2W \cdot 10^4}{MVCO2} + \frac{COW}{MVCO} + \frac{HCW}{MVHC} + \frac{CW}{AWC} \right)} \quad (2\text{-}29)$$

3.6 Calculation of the volumetric exhaust composition and exhaust density with incomplete combustion

$$VCO = COW \cdot 10^{-6} \cdot VEXHW \tag{2-30}$$

$$VNO = NOW \cdot 10^{-6} \cdot VEXHW \tag{2-31}$$

$$VNO2 = NO2W \cdot 10^{-6} \cdot VEXHW \tag{2-32}$$

$$VHC = HCW \cdot 10^{-6} \cdot VEXHW \tag{2-33}$$

$$VH2O = \frac{\left(\frac{GAIRW \cdot NUE \cdot MVH2O}{MWH2O} + \frac{GFUEL \cdot ALF \cdot MVH2O}{2 \cdot AWH} \right)}{100} - VHC \tag{2-34}$$

$$VCO2 = \left(\frac{GAIRW \cdot CO2AIR}{1.293} + GFUEL \cdot BET \cdot \frac{MVCO2}{AWC} \right) \cdot \frac{1}{100} - VCO - VHC \tag{2-35}$$

with $CO2AIR = CO_2$ - concentration in the combustion air (vol %).

$$TAU2 = \frac{GFUEL}{GAIRW} \cdot \left(ALF \cdot \frac{AWO}{2 \cdot AWH} + BET \cdot \frac{2 \cdot AWO}{AWC} + GAM \cdot \frac{2 \cdot AWO}{AWS} - 1 \right) \tag{2-36}$$

$$VO2 = \frac{GAIRW \cdot (TAU - TAU2)}{100} \cdot \frac{MVO2}{MWO2} + (1/2) \cdot (VHC + VCO) - (1/2) \cdot (VNO + VNO2) - \frac{CW \cdot GEXHW}{EXHDENS} \cdot \frac{2 \cdot AWO \cdot MVO2}{AWC \cdot MWO2} \tag{2-37}$$

$$VN2 = \frac{GAIRW \cdot ETA \cdot \frac{MVN2}{MWN2} \cdot GFUEL \cdot DEL \cdot \frac{MVN2}{MWN2}}{100} - (1/2) \cdot VNO - (1/2) \cdot VNO2 \tag{2-38}$$

$$VSO2 = \frac{GFUEL \cdot GAM \cdot \frac{MVSO\ 2}{AWS}}{100} \tag{2-39}$$

$$VEXHW = VH\ 20 + VCO2 + VO2 + VN2 + VSO2 + VCO + VNO + VNO2 + VHC \tag{2-40}$$

$$VEXHD = VEXHW - VH20 \tag{2-41}$$

$$EXHDENS = GEXHW / VEXHW \tag{2-42}$$

$$KEXH = VEXHD / VEXHW \tag{2-43}$$

3.7 Program for the calculation of the exhaust mass flow

3.7.1 The results of both stoichiometric calculations for carbon and oxygen calculations give the total exhaust composition and the exhaust mass flow including the water content.

3.7.2 The formulae in the program are mainly based on wet exhaust.

3.7.3 If dry concentrations (O_2 and CO_2) are measured, the dry to wet correction factor KWEXH (= $K_{W,r}$) shall be used.

3.7.4 The program calculates the exhaust mass flow with known KWEXH and calculates the KWEXH with known exhaust gas flow. When both values are unknown, the program takes a preliminary value for KWEXH (= $K_{W,r}$) and performs iterative calculation, until both values fit together and do not change any more.

3.7.5 If the mass balance formula is used without the program, the following dry to wet correction factor shall be used:

$$K_{W,r3} = \left(\frac{100}{\frac{ALF \cdot MVH20 \cdot AWC \cdot (CO2D)}{BET \cdot MVCO2 \cdot 2 \cdot AWH} \cdot NUE \cdot 1.608 \cdot 100} \right) \qquad (2\text{-}44)$$

3.7.6 The formula in another prepared form:

$$K_{W,r3} = \left(\frac{100}{\frac{ALF \cdot 5.995 \cdot (CO2D)}{BET} \cdot NUE \cdot 1.608 \cdot 100} \right) \qquad (2\text{-}44a)$$

3.7.7 The general formula for dry / wet correction KWEXH = $K_{W,r}$, different versions are possible.

3.7.8 Formulae (2-44) and (2-44a) and also formula (12) from 5.12.2.3 of this Code are not absoluteiy exact, because the correction for the combustion water and for the air intake water are not additive.

3.7.9 The exact formula is:

$$K_{W,r4} = \frac{GFUEL \cdot GAIRD - \frac{GFUEL \cdot ALF \cdot MWH\ 20}{200 \cdot AWH} \cdot \frac{RhoEXH\ \ DAC}{Rho\ H\ 20}}{GFUEL \cdot GAIRD + \frac{Ha \cdot GAIRD}{1000} \cdot \frac{RhoEXH\ \ DAC}{Rho\ H20}} \qquad (2\text{-}45)$$

where:

RhoEXH DAC = exhaust density with combustion by dry air (kg / stdm^3)
Rho H2O = water vapour density (kg / stdm^3) MW H_2O / MV H_2O)

3.7.10 A comparison of formula (12) from 5.12.2.3 of this Code with formula (2-45) shows very small differences of the factor $K_{W,r}$ as shown in the following examples:

Humidity	Deviations of $K_{W,r}$ (compared with (2-45))
g/kg	%
10.0	0.2
25.0	0.5

3.7.11 The formula given as (2-45) is not very practical because in many cases RhoEXH DAC is not known and because the use of the fuel specific factor F_{FH} is excluded. Therefore the more practical formulae (9), (10), (12) & (13) from 5.12.2.1 to 5.12.3.5 of this Code shall be used; the resulting error of < 0.2% (in most cases) may be neglected.

3.8 Calculation of the fuel specific factors FFD and FFW for exhaust flow calculation

$$FFD = \frac{(VEXHD - VAIRD)}{GFUEL} \tag{2-46}$$

$$FFW = \frac{(VEXHW - VAIRW)}{GFUEL} \tag{2-47}$$

3.8.1 By means of the following formulae:

$$VEXHW = VH20 + VCO2 + VO2 + VN2 + VSO2 \tag{2-48}$$

$$VEXHD = VCO2 + VO2 + VN2 + VSO2 \tag{2-49}$$

and, according to the formulae (2-34), (2-35), (2-37), (2-38), and (2-39), the factors may be given by formula (2-50) and (2-52), respectively:

$$FFW = (ALF/100)\cdot\left(\frac{MVH20}{2\cdot AWH}-\frac{MVO2}{4\cdot AWH}\right)+(BET/100)\cdot\left(\frac{MVCO2}{AWC}-\frac{MVO2}{AWC}\right)+ (GAM/100)\cdot\left(\frac{MVSO2}{AWS}-\frac{MVO2}{AWS}\right)+(DEL/100)\cdot\left(\frac{MVN2}{MWN2}\right)+(EPS/100)\cdot\left(\frac{MVO2}{MWO2}\right) \tag{2-50}$$

3.8.2 The same formula with numbers:

$$FFW = 0.05557\cdot ALF - 0.00011\cdot BET - 0.00017\cdot GAM + 0.0080055\cdot DEL + 0.006998\cdot EPS \tag{2-51}$$

3.8.3 The formula for FFD is very similar; the only difference is with the coefficient ALF concerning the water:

$$FFD = -(ALF/100)\cdot\left(\frac{MVO2}{4\cdot AWH}\right)+(BET/100)\cdot\left(\frac{MVCO2}{AWC}-\frac{MVO2}{AWC}\right)+(GAM/100)\cdot\left(\frac{MVSO2}{AWS}-\frac{MVO2}{AWS}\right)+(DEL/100)\cdot\left(\frac{MVN2}{MWN2}\right)+(EPS/100)\cdot\left(\frac{MVO2}{MWO2}\right) \tag{2-52}$$

3.8.4 The same formula with numbers:

$$FFD = -0.05564\cdot ALF - 0.00011\cdot BET - 0.00017\cdot GAM + 0.0080055\cdot DEL + 0.006998\cdot EPS \tag{2-53}$$

3.9 **Derivation of the fuel specific factor F_{FH}**

3.9.1 Used for the calculation of wet concentration from dry concentration according to 5.12.2 of this Code.

$$conc\ (wet) = K_{W,r} \cdot conc\ (dry) \tag{2-54}$$

Note: In the following derivation, the symbols for the originally indicated variables differ from the symbols given in the abbreviations because of the names of the variables in the mentioned program, e.g., $K_{W,r}$ = K_{WEXH} = KWEXH.

3.9.2 The derivation of FFH considers dry intake air because formula (2-17) handles water in the intake air separately.

$$KWEXH = \left(1 - FFH \cdot \frac{GFUEL}{GAIR}\right) \tag{2-55}$$

and where:

$$conc\ (wet) \cdot VEXHW = conc\ (dry) \cdot VEXHD \tag{2-56}$$

(Balance of the volumes)

$$KWEXH = \frac{VEXHD}{VEXHW} = \frac{VEXHW - VH2O}{VEXHW}$$

$$= 1 - \frac{VH2O}{VEXHW} = 1 - \frac{\frac{GH2O}{1000} \cdot EXHDENS}{\frac{MWH2O}{MVH2O} \cdot GEXHW} \tag{2-57}$$

and where:

$$GH2O = \frac{MWH2O}{2 \cdot AWH} \cdot GFUEL \cdot ALF \cdot 10 \tag{2-58}$$

and:

$$GEXHW = GAIRW + GFUEL \tag{2-59}$$

$$KEXHW = 1 - \frac{GFUEL \cdot ALF \cdot EXHDENS \cdot MVH2O}{200 \cdot AWH \cdot (GAIRW + GFUEL)}$$

$$= 1 - \frac{GFUEL \cdot ALF \cdot EXHDENS \cdot MVH2O}{GAIRW \cdot 200 \cdot AWH \cdot \left(1 + \frac{GFUEL}{GAIRW}\right)} \tag{2-60}$$

$$F_{FH} = FFH = \frac{ALF \cdot EXHDENS \cdot MVH2O}{200 \cdot AWH \cdot \left(1 + \frac{GFUEL}{GAIRW}\right)} \tag{2-61}$$

3.9.3 This universal formula, applicable for all fuels (with known exhaust density), may be simplified for diesel fuels as follows:

$$F_{FH} = ALF \cdot 0.1448 \cdot \frac{1}{1 + \frac{GFUEL}{GAIRW}} \tag{2-62}$$

APPENDIX 7

CHECK LIST FOR AN ENGINE PARAMETER CHECK METHOD
(Refer to 6.2.3.5 of the NO_x Technical Code)

1 For some of the parameters listed below, more than one survey possibility exists. In such cases, as a guideline, any one of, or a combination of, the below listed methods may be sufficient to show compliance. Approved by the Administration, the ship operator, supported by the engine manufacturer, may choose what method is applicable.

.1 parameter "injection timing"

.1 fuel cam position (individual cam or camshaft if cams are not adjustable),

- optional (dependent on design): position of a link between the cam and the pump drive,
- optional for sleeve metered pumps: VIT index and cam position or position of the barrel, or
- other sleeve metering device;

.2 start of delivery for certain fuel rack positions (dynamic pressure measurement);

.3 opening of injection valve for certain load points, e.g., using a Hall sensor or acceleration pick-up;

.4 load-dependent operating values for charge air pressure, combustion peak pressure, charge air temperature, exhaust gas temperature versus graphs showing the correlation with NO_x. Additionally, it shall be ensured that the compression ratio corresponds to the initial certification value (see 1.7);

Note: To assess the actual timing, it is necessary to know the allowable limits for meeting the emission limits or even graphs showing the influence of timing on NO_x, based on the test bed NO_x measurement results.

.2 parameter "injection nozzle"

.1 specification and component identification number

.3 parameter "injection pump"

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

.4 parameter "fuel cam"

.1 component identification number (specifying shape)

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

.5 parameter "injection pressure"

.1 only for common rail systems: load-dependent pressure in the rail, graph showing the correlation with NO_x

.6 parameter "combustion chamber"

.1 component identification numbers for the cylinder head and piston head

.7 parameter "compression ratio"

.1 check for actual clearance

.2 check for shims in piston rod or connecting rod

.8 parameter "turbocharger type and build"

.1 model and specification (identification numbers)

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

.9 parameter "charge air cooler, charge air pre-heater"

.1 model and specification

.2 load-dependent charge air temperature corrected to reference conditions, graph showing the correlation with NO_x

.10 parameter "valve timing" (only for 4-stroke engines with inlet valve closure before BDC)

.1 cam position

.2 check actual timing

.11 parameter "water injection" (for assessment: graph showing the influence on NO_x)

.1 load-dependent water consumption (monitoring)

.12 parameter "emulsified fuel" (for assessment: graph showing the influence on NO_x)

.1 load-dependent fuel rack position (monitoring)

.2 load-dependent water consumption (monitoring)

.13 parameter "exhaust gas recirculation" (for assessment: graph showing the influence on NO_x)

.1 load-dependent mass flow of recirculated exhaust gas (monitoring)

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

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

.14 parameter "selective catalytic reduction" (SCR)

.1 load-dependent mass flow of reducing agent (monitoring) and additional periodical spot checks on NO_x concentration after SCR (for assessment, graph showing the influence on NO_x)

2 For engines with selective catalytic reduction (SCR) without feedback control, 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.

PROTOCOL OF 1997 TO AMEND THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973, AS MODIFIED BY THE PROTOCOL OF 1978 RELATING THERETO

PROTOCOLE DE 1997 MODIFIANT LA CONVENTION INTERNATIONALE DE 1973 POUR LA PRÉVENTION DE LA POLLUTION PAR LES NAVIRES, TELLE QUE MODIFIÉE PAR LE PROTOCOLE DE 1978 Y RELATIF

PROTOCOLO DE 1997 QUE ENMIENDA EL CONVENIO INTERNACIONAL PARA PREVENIR LA CONTAMINACIÓN POR LOS BUQUES, 1973, MODIFICADO POR EL PROTOCOLO DE 1978

PROTOCOL OF 1997 TO AMEND THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973, AS MODIFIED BY THE PROTOCOL OF 1978 RELATING THERETO

THE PARTIES TO THE PRESENT PROTOCOL,

BEING Parties to the Protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973,

RECOGNIZING the need to prevent and control air pollution from ships,

RECALLING Principle 15 of the Rio Declaration on Environment and Development which calls for the application of a precautionary approach,

CONSIDERING that this objective could best be achieved by the conclusion of a Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto,

HAVE AGREED as follows:

Article 1

Instrument to be amended

The instrument which the present Protocol amends is the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (hereinafter referred to as the "Convention").

Article 2

Addition of Annex VI to the Convention

Annex VI entitled Regulations for the Prevention of Air Pollution from Ships, the text of which is set out in the annex to the present Protocol, is added.

Article 3

General Obligations

1 The Convention and the present Protocol shall, as between the Parties to the present Protocol, be read and interpreted together as one single instrument.

2 Every reference to the present Protocol constitutes at the same time a reference to the Annex hereto.

Article 4

Amendment procedure

In applying article 16 of the Convention to an amendment to Annex VI and its appendices, the reference to "a Party to the Convention" shall be deemed to mean the reference to a Party bound by that Annex.

FINAL CLAUSES

Article 5

Signature, ratification, acceptance, approval and accession

1 The present Protocol shall be open for signature at the Headquarters of the International Maritime Organization (hereinafter referred to as the "Organization") from 1 January 1998 until 31 December 1998 and shall thereafter remain open for accession. Only Contracting States to the Protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973 (hereinafter referred to as the "1978 Protocol") may become Parties to the present Protocol by:

(a) signature without reservation as to ratification, acceptance or approval; or

(b) signature, subject to ratification, acceptance or approval, followed by ratification, acceptance or approval; or

(c) accession.

2 Ratification, acceptance, approval or accession shall be effected by the deposit of an instrument to that effect with the Secretary-General of the Organization (hereinafter referred to as the "Secretary-General").

Article 6

Entry into force

1 The present Protocol shall enter into force twelve months after the date on which not less than fifteen States, the combined merchant fleets of which constitute not less than 50 per cent of the gross tonnage of the world's merchant shipping, have become Parties to it in accordance with article 5 of the present Protocol.

2 Any instrument of ratification, acceptance, approval or accession deposited after the date on which the present Protocol enters into force shall take effect three months after the date of deposit.

3 After the date on which an amendment to the present Protocol is deemed to have been accepted in accordance with article 16 of the Convention, any instrument of ratification, acceptance, approval or accession deposited shall apply to the present Protocol as amended.

Article 7

Denunciation

1 The present Protocol may be denounced by any Party to the present Protocol at any time after the expiry of five years from the date on which the Protocol enters into force for that Party.

2 Denunciation shall be effected by the deposit of an instrument of denunciation with the Secretary-General.

3 A denunciation shall take effect twelve months after receipt of the notification by the Secretary-General or after the expiry of any other longer period which may be indicated in the notification.

4 A denunciation of the 1978 Protocol in accordance with article VII thereof shall be deemed to include a denunciation of the present Protocol in accordance with this article. Such denunciation shall take effect on the date on which denunciation of the 1978 Protocol takes effect in accordance with article VII of that Protocol.

Article 8

Depositary

1 The present Protocol shall be deposited with the Secretary-General (hereinafter referred to as the "Depositary").

2 The Depositary shall:

(a) inform all States which have signed the present Protocol or acceded thereto of:

(i) each new signature or deposit of an instrument of ratification, acceptance, approval or accession, together with the date thereof;

(ii) the date of entry into force of the present Protocol; and

(iii) the deposit of any instrument of denunciation of the present Protocol, together with the date on which it was received and the date on which the denunciation takes effect; and

(b) transmit certified true copies of the present Protocol to all States which have signed the present Protocol or acceded thereto.

3 As soon as the present Protocol enters into force, a certified true copy thereof shall be transmitted by the Depositary to the Secretariat of the United Nations for registration and publication in accordance with Article 102 of the Charter of the United Nations.

Article 9

Languages

The present Protocol is established in a single copy in the Arabic, Chinese, English, French, Russian and Spanish languages, each text being equally authentic.

IN WITNESS WHEREOF the undersigned, being duly authorized by their respective Governments for that purpose, have signed the present Protocol.

DONE AT LONDON this twenty-sixth day of September, one thousand nine hundred and ninety-seven.

ANNEX

ADDITION OF ANNEX VI TO THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973, AS MODIFIED BY THE PROTOCOL OF 1978 RELATING THERETO

The following new Annex VI is added after the existing Annex V:

"ANNEX VI

REGULATIONS FOR THE PREVENTION OF AIR POLLUTION FROM SHIPS

CHAPTER I - GENERAL

REGULATION 1

Application

The provisions of this Annex shall apply to all ships, except where expressly provided otherwise in regulations 3, 5, 6, 13, 15, 18 and 19 of this Annex.

REGULATION 2

Definitions

For the purpose of this Annex:

(1) "A similar stage of construction" means the stage at which:

(a) construction identifiable with a specific ship begins; and

(b) assembly of that ship has commenced comprising at least 50 tonnes or one per cent of the estimated mass of all structural material, whichever is less.

(2) "Continuous feeding" is defined as the process whereby waste is fed into a combustion chamber without human assistance while the incinerator is in nomal operating conditions with the combustion chamber operative temperature between 850°C and 1200°C.

(3) "Emission" means any release of substances , subject to control by this Annex from ships into the atmosphere or sea.

(4) "New installations", in relation to regulation 12 of this Annex, means the installation of systems, equipment, including new portable fire extinguishing units, insulation, or other material on a ship after the date on which this Annex enters into force, but excludes repair or recharge of previously installed systems, equipment, insulation, or other material, or recharge of portable fire extinguishing units.

(5) "NOx Technical Code" means the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines adopted by Conference resolution 2, as may be amended by the Organization, provided that such amendments are adopted and brought into force in accordance with the provisions of article 16 of the present Convention concerning amendment procedures applicable to an appendix to an Annex.

(6) "Ozone depleting substances" means controlled substances defined in paragraph 4 of article 1 of the Montreal Protocol on Substances that Deplete the Ozone Layer, 1987, listed in Annexes A, B, C or E to the said Protocol in force at the time of application or interpretation of this Annex.

"Ozone depleting substances" that may be found on board ship include, but are not limited to:

Halon 1211 Bromochlorodifluoromethane
Halon 1301 Bromotrifluoromethane
Halon 2402 1,2-Dibromo-1,1,2,2-tetrafluoroethane (also known as Halon 114B2)
CFC-11 Trichlorofluoromethane
CFC-12 Dichlorodifluoromethane
CFC-113 1,1,2-Trichloro-1,2,2-trifluoroethane
CFC-114 1,2-Dichloro-1,1,2,2-tetrafluoroethane
CFC-115 Chloropentafluoroethane

(7) "Sludge oil" means sludge from the fuel or lubricating oil separators, waste lubricating oil from main or auxiliary machinery, or waste oil from bilge water separators, oil filtering equipment or drip trays.

(8) "Shipboard incineration" means the incineration of wastes or other matter on board a ship, if such wastes or other matter were generated during the normal operation of that ship.

(9) "Shipboard incinerator" means a shipboard facility designed for the primary purpose of incineration.

(10) "Ships constructed" means ships the keels of which are laid or which are at a similar stage of construction.

(11) "SOx Emission Control Area" means an area where the adoption of special mandatory measures for SOx emissions from ships is required to prevent, reduce and control air pollution from SOx and its attendant adverse impacts on land and sea areas. SOx Emission Control Areas shall include those listed in regulation 14 of this Annex.

(12) "Tanker" means an oil tanker as defined in regulation 1(4) of Annex I or a chemical tanker as defined in regulation 1(1) of Annex II of the present Convention.

(13) "The Protocol of 1997" means the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as amended by the Protocol of 1978 relating thereto.

REGULATION 3

General Exceptions

Regulations of this Annex shall not apply to:

(a) any emission necessary for the purpose of securing the safety of a ship or saving life at sea; or

(b) any emission resulting from damage to a ship or its equipment:

(i) provided that all reasonable precautions have been taken after the occurrence of the damage or discovery of the emission for the purpose of preventing or minimizing the emission; and

(ii) except if the owner or the master acted either with intent to cause damage, or recklessly and with knowledge that damage would probably result.

REGULATION 4

Equivalents

(1) The Administration may allow any fitting, material, appliance or apparatus to be fitted in a ship as an alternative to that required by this Annex if such fitting, material, appliance or apparatus is at least as effective as that required by this Annex.

(2) The Administration which allows a fitting, material, appliance or apparatus as an alternative to that required by this Annex shall communicate to the Organization for circulation to the Parties to the present Convention particulars thereof, for their information and appropriate action, if any.

CHAPTER II - SURVEY, CERTIFICATION AND MEANS OF CONTROL

REGULATION 5

Surveys and Inspections

(1) Every ship of 400 gross tonnage or above and every fixed and floating drilling rig and other platforms shall be subject to the surveys specified below:

(a) an initial survey before the ship is put into service or before the certificate required under regulation 6 of this Annex is issued for the first time. This survey shall be such as to ensure that the equipment, systems, fittings, arrangements and material fully comply with the applicable requirements of this Annex;

(b) periodical surveys at intervals specified by the Administration, but not exceeding five years, which shall be such as to ensure that the equipment, systems, fittings, arrangements and material fully comply with the requirements of this Annex; and

(c) a minimum of one intermediate survey during the period of validity of the certificate which shall be such as to ensure that the equipment and arrangements fully comply with the requirements of this Annex and are in good working order. In cases where only one such intermediate survey is carried out in a single certificate validity period, and where the period of the certificate exceeds 2½ years, it shall be held within six months before or after the halfway date of the certificate's period of validity. Such intermediate surveys shall be endorsed on the certificate issued under regulation 6 of this Annex.

(2) In the case of ships of less than 400 gross tonnage, the Administration may establish appropriate measures in order to ensure that the applicable provisions of this Annex are complied with.

(3) Surveys of ships as regards the enforcement of the provisions of this Annex shall be carried out by officers of the Administration. The Administration may, however, entrust the surveys either to surveyors nominated for the purpose or to organizations recognized by it. Such organizations shall comply with the guidelines adopted by the Organization. In every case the Administration concerned shall fully guarantee the completeness and efficiency of the survey.

(4) The survey of engines and equipment for compliance with regulation 13 of this Annex shall be conducted in accordance with the NOx Technical Code.

(5) The Administration shall institute arrangements for unscheduled inspections to be carried out during the period of validity of the certificate. Such inspections shall ensure that the equipment remains in all respects satisfactory for the service for which the equipment is intended. These inspections may be carried out by their own inspection service, nominated surveyors, recognized organizations, or by other Parties upon request of the Administration. Where the Administration, under the provisions of paragraph (1) of this regulation, establishes mandatory annual surveys, the above unscheduled inspections shall not be obligatory.

(6) When a nominated surveyor or recognized organization determines that the condition of the equipment does not correspond substantially with the particulars of the certificate, they shall ensure that corrective action is taken and shall in due course notify the Administration. If such corrective action is not taken, the certificate should be withdrawn by the Administration. If the ship is in a port of another Party, the appropriate authorities of the port State shall also be notified immediately. When an officer of the Administration, a nominated surveyor or recognized organization has notified the appropriate authorities of the port State, the Government of the port State concerned shall give such officer, surveyor or organization any necessary assistance to carry out their obligations under this regulation.

(7) The equipment shall be maintained to conform with the provisions of this Annex and no changes shall be made in the equipment, systems, fittings, arrangements, or material covered by the survey, without the express approval of the Administration. The direct replacement of such equipment and fittings with equipment and fittings that conform with the provisions of this Annex is permitted.

(8) Whenever an accident occurs to a ship or a defect is discovered, which substantially affects the efficiency or completeness of its equipment covered by this Annex, the master or owner of the ship shall report at the earliest opportunity to the Administration, a nominated surveyor, or recognized organization responsible for issuing the relevant certificate.

REGULATION 6

Issue of International Air Pollution Prevention Certificate

(1) An International Air Pollution Prevention Certificate shall be issued, after survey in accordance with the provisions of regulation 5 of this Annex, to:

(a) any ship of 400 gross tonnage or above engaged in voyages to ports or offshore terminals under the jurisdiction of other Parties; and

(b) platforms and drilling rigs engaged in voyages to waters under the sovereignty or jurisdiction of other Parties to the Protocol of 1997.

(2) Ships constructed before the date of entry into force of the Protocol of 1997 shall be issued with an International Air Pollution Prevention Certificate in accordance with paragraph (1) of this regulation no later than the first scheduled drydocking after entry into force of the Protocol of 1997, but in no case later than 3 years after entry into force of the Protocol of 1997.

(3) Such certificate shall be issued either by the Administration or by any person or organization duly authorized by it. In every case the Administration assumes full responsibility for the certificate.

REGULATION 7

Issue of a Certificate by another Government

(1) The Government of a Party to the Protocol of 1997 may, at the request of the Administration, cause a ship to be surveyed and, if satisfied that the provisions of this Annex are complied with, issue or authorize the issuance of an International Air Pollution Prevention Certificate to the ship in accordance with this Annex.

(2) A copy of the certificate and a copy of the survey report shall be transmitted as soon as possible to the requesting Administration.

(3) A certificate so issued shall contain a statement to the effect that it has been issued at the request of the Administration and it shall have the same force and receive the same recognition as a certificate issued under regulation 6 of this Annex.

(4) No International Air Pollution Prevention Certificate shall be issued to a ship which is entitled to fly the flag of a State which is not a Party to the Protocol of 1997.

REGULATION 8

Form of Certificate

The International Air Pollution Prevention Certificate shall be drawn up in an official language of the issuing country in the form corresponding to the model given in appendix I to this Annex. If the language used is not English, French, or Spanish, the text shall include a translation into one of these languages.

REGULATION 9

Duration and Validity of Certificate

(1) An International Air Pollution Prevention Certificate shall be issued for a period specified by the Administration, which shall not exceed five years from the date of issue.

(2) No extension of the five-year period of validity of the International Air Pollution Prevention Certificate shall be permitted, except in accordance with paragraph (3).

(3) If the ship, at the time when the International Air Pollution Prevention Certificate expires, is not in a port of the State whose flag it is entitled to fly or in which it is to be surveyed, the Administration may extend the certificate for a period of no more than 5 months. Such extension shall be granted only for the purpose of allowing the ship to complete its voyage to the State whose flag it is entitled to fly or in which it is to be surveyed, and then only in cases where it appears proper and reasonable to do so. After arrival in the State whose flag it is entitled to fly or in which it is to be surveyed, the ship shall not be entitled by virtue of such extension to leave the port or State without having obtained a new International Air Pollution Prevention Certificate.

(4) An International Air Pollution Prevention Certificate shall cease to be valid in any of the following circumstances:

(a) if the inspections and surveys are not carried out within the periods specified under regulation 5 of this Annex;

(b) if significant alterations have taken place to the equipment, systems, fittings, arrangements or material to which this Annex applies without the express approval of the Administration, except the direct replacement of such equipment or fittings with equipment or fittings that conform with the requirements of this Annex. For the purpose of regulation 13, significant alteration shall include any change or adjustment to the system, fittings, or arrangement of a diesel engine which results in the nitrogen oxide limits applied to that engine no longer being complied with; or

(c) upon transfer of the ship to the flag of another State. A new certificate shall be issued only when the Government issuing the new certificate is fully satisfied that the ship is in full compliance with the requirements of regulation 5 of this Annex. In the case of a transfer between Parties, if requested within three months after the transfer has taken place, the Government of the Party whose flag the ship was formerly entitled to fly shall, as soon as possible, transmit to the Administration of the other Party a copy of the International Air Pollution Prevention Certificate carried by the ship before the transfer and, if available, copies of the relevant survey reports.

REGULATION 10

Port State Control on Operational Requirements

(1) A ship, when in a port or an offshore terminal under the jurisdiction of another Party to the Protocol of 1997, is subject to inspection by officers duly authorized by such Party concerning operational requirements under this Annex, where there are clear grounds for believing that the master or crew are not familiar with essential shipboard procedures relating to the prevention of air pollution from ships.

(2) In the circumstances given in paragraph (1) of this regulation, the Party shall take such steps as will ensure that the ship shall not sail until the situation has been brought to order in accordance with the requirements of this Annex.

(3) Procedures relating to the port State control prescribed in article 5 of the present Convention shall apply to this regulation.

(4) Nothing in this regulation shall be construed to limit the rights and obligations of a Party carrying out control over operational requirements specifically provided for in the present Convention.

REGULATION 11

Detection of Violations and Enforcement

(1) Parties to this Annex shall co-operate in the detection of violations and the enforcement of the provisions of this Annex, using all appropriate and practicable measures of detection and environmental monitoring, adequate procedures for reporting and accumulation of evidence.

(2) A ship to which the present Annex applies may, in any port or offshore terminal of a Party, be subject to inspection by officers appointed or authorized by that Party for the purpose of verifying whether the ship has emitted any of the substances covered by this Annex in violation of the provision of this Annex. If an inspection indicates a violation of this Annex, a report shall be forwarded to the Administration for any appropriate action.

(3) Any Party shall furnish to the Administration evidence, if any, that the ship has emitted any of the substances covered by this Annex in violation of the provisions of this Annex. If it is practicable to do so, the competent authority of the former Party shall notify the master of the ship of the alleged violation.

(4) Upon receiving such evidence, the Administration so informed shall investigate the matter, and may request the other Party to furnish further or better evidence of the alleged contravention. If the Administration is satisfied that sufficient evidence is available to enable proceedings to be brought in respect of the alleged violation, it shall cause such proceedings to be taken in accordance with its law as soon as possible. The Administration shall promptly inform the Party which has reported the alleged violation, as well as the Organization, of the action taken.

(5) A Party may also inspect a ship to which this Annex applies when it enters the ports or offshore terminals under its jurisdiction, if a request for an investigation is received from any Party together with sufficient evidence that the ship has emitted any of the substances covered by the Annex in any place in violation of this Annex. The report of such investigation shall be sent to the Party requesting it and to the Administration so that the appropriate action may be taken under the present Convention.

(6) The international law concerning the prevention, reduction, and control of pollution of the marine environment from ships, including that law relating to enforcement and safeguards, in force at the time of application or interpretation of this Annex, applies, *mutatis mutandis*, to the rules and standards set forth in this Annex.

CHAPTER III - REQUIREMENTS FOR CONTROL OF EMISSIONS FROM SHIPS

REGULATION 12

Ozone Depleting Substances

(1) Subject to the provisions of regulation 3, any deliberate emissions of ozone depleting substances shall be prohibited. Deliberate emissions include emissions occurring in the course of maintaining, servicing, repairing or disposing of systems or equipment, except that deliberate emissions do not include minimal releases associated with the recapture or recycling of an ozone depleting substance. Emissions arising from leaks of an ozone depleting substance, whether or not the leaks are deliberate, may be regulated by Parties to the Protocol of 1997.

(2) New installations which contain ozone depleting substances shall be prohibited on all ships, except that new installations containing hydro-chlorofluorocarbons (HCFCs) are permitted until 1 January 2020.

(3) The substances referred to in this regulation, and equipment containing such substances, shall be delivered to appropriate reception facilities when removed from ships.

REGULATION 13

Nitrogen Oxides (NOx)

(1) (a) This regulation shall apply to:

(i) each diesel engine with a power output of more than 130 kW which is installed on a ship constructed on or after 1 January 2000; and

(ii) each diesel engine with a power output of more than 130 kW which undergoes a major conversion on or after 1 January 2000.

(b) This regulation does not apply to:

(i) emergency diesel engines, engines installed in lifeboats and any device or equipment intended to be used solely in case of emergency; and

(ii) engines installed on ships solely engaged in voyages within waters subject to the sovereignty or jurisdiction of the State the flag of which the ship is entitled to fly, provided that such engines are subject to an alternative NOx control measure established by the Administration.

(c) Notwithstanding the provisions of sub-paragraph (a) of this paragraph, the Administration may allow exclusion from the application of this regulation to any diesel engine which is installed on a ship constructed, or on a ship which undergoes a major conversion, before the date of entry into force of the present Protocol, provided that the ship is solely engaged in voyages to ports or offshore terminals within the State the flag of which the ship is entitled to fly.

(2) (a) For the purpose of this regulation, "major conversion" means a modification of an engine where:

(i) the engine is replaced by a new engine built on or after 1 January 2000, or

(ii) any substantial modification, as defined in the NOx Technical Code, is made to the engine, or

(iii) the maximum continuous rating of the engine is increased by more than 10%.

(b) The NOx emission resulting from modifications referred to in the sub-paragraph (a) of this paragraph shall be documented in accordance with the NOx Technical Code for approval by the Administration.

(3) (a) Subject to the provision of regulation 3 of this Annex, the operation of each diesel engine to which this regulation applies is prohibited, except when the emission of nitrogen oxides (calculated as the total weighted emission of NO_2) from the engine is within the following limits:

(i)	17.0g/kWh	when n is less than 130 rpm
(ii)	$45.0*n^{(-0.2)}$ g/kWh	when n is 130 or more but less than 2000 rpm
(iii)	9.8 g/kWh	when n is 2000 rpm or more

where n = rated engine speed (crankshaft revolutions per minute).

When using fuel composed of blends from hydrocarbons derived from petroleum refining, test procedure and measurement methods shall be in accordance with the NOx Technical Code, taking into consideration the Test Cycles and Weighting Factors outlined in appendix II to this Annex.

(b) Notwithstanding the provisions of sub-paragraph (a) of this paragraph, the operation of a diesel engine is permitted when:

(i) an exhaust gas cleaning system, approved by the Administration in accordance with the NOx Technical Code, is applied to the engine to reduce onboard NOx emissions at least to the limits specified in sub-paragraph (a), or

(ii) any other equivalent method, approved by the Administration taking into account relevant guidelines to be developed by the Organization, is applied to reduce onboard NOx emissions at least to the limit specified in sub-paragraph (a) of this paragraph.

REGULATION 14

Sulphur Oxides (SOx)

General requirements

(1) The sulphur content of any fuel oil used on board ships shall not exceed 4.5% m/m.

(2) The worldwide average sulphur content of residual fuel oil supplied for use on board ships shall be monitored taking into account guidelines to be developed by the Organization.

Requirements within SOx Emission Control Areas

(3) For the purpose of this regulation, SOx Emission Control Areas shall include:

(a) the Baltic Sea area as defined in regulation 10(1)(b) of Annex I; and

(b) any other sea area, including port areas, designated by the Organization in accordance with criteria and procedures for designation of SOx Emission Control Areas with respect to the prevention of air pollution from ships contained in appendix III to this Annex.

(4) While ships are within SOx Emission Control Areas, at least one of the following conditions shall be fulfilled:

(a) the sulphur content of fuel oil used on board ships in a SOx Emission Control Area does not exceed 1.5% m/m;

(b) an exhaust gas cleaning system, approved by the Administration taking into account guidelines to be developed by the Organization, is applied to reduce the total emission of sulphur oxides from ships, including both auxiliary and main propulsion engines, to 6.0 g SOx/kWh or less calculated as the total weight of sulphur dioxide emission. Waste streams from the use of such equipment shall not be discharged into enclosed ports, harbours and estuaries unless it can be thoroughly documented by the ship that such waste streams have no adverse impact on the ecosystems of such enclosed ports, harbours and estuaries, based upon criteria communicated by the authorities of the port State to the Organization. The Organization shall circulate the criteria to all Parties to the Convention; or

(c) any other technological method that is verifiable and enforceable to limit SOx emissions to a level equivalent to that described in sub-paragraph (b) is applied. These methods shall be approved by the Administration taking into account guidelines to be developed by the Organization.

(5) The sulphur content of fuel oil referred to in paragraph (1) and paragraph (4)(a) of this regulation shall be documented by the supplier as required by regulation 18 of this Annex.

(6) Those ships using separate fuel oils to comply with paragraph (4)(a) of this regulation shall allow sufficient time for the fuel oil service system to be fully flushed of all fuels exceeding 1.5% m/m sulphur content prior to entry into a SOx Emission Control Area. The volume of low sulphur fuel oils (less than or equal to 1.5% sulphur content) in each tank as well as the date, time, and position of the ship when any fuel-changeover operation is completed, shall be recorded in such log-book as prescribed by the Administration.

(7) During the first twelve months immediately following entry into force of the present Protocol, or of an amendment to the present Protocol designating a specific SOx Emission Control Area under paragraph (3)(b) of this regulation, ships entering a SOx Emission Control Area referred to in paragraph (3)(a) of this regulation or designated under paragraph (3)(b) of this regulation are exempted from the requirements in paragraphs (4) and (6) of this regulation and from the requirements of paragraph (5) of this regulation insofar as they relate to paragraph (4)(a) of this regulation.

REGULATION 15

Volatile Organic Compounds

(1) If the emissions of volatile organic compounds (VOCs) from tankers are to be regulated in ports or terminals under the jurisdiction of a Party to the Protocol of 1997, they shall be regulated in accordance with the provisions of this regulation.

(2) A Party to the Protocol of 1997 which designates ports or terminals under its jurisdiction in which VOCs emissions are to be regulated, shall submit a notification to the Organization. This notification shall include information on the size of tankers to be controlled, on cargoes requiring vapour emission control systems, and the effective date of such control. The notification shall be submitted at least six months before the effective date.

(3) The Government of each Party to the Protocol of 1997 which designates ports or terminals at which VOCs emissions from tankers are to be regulated shall ensure that vapour emission control systems, approved by that Government taking into account the safety standards developed by the Organization, are provided in ports and terminals designated, and are operated safely and in a manner so as to avoid undue delay to the ship.

(4) The Organization shall circulate a list of the ports and terminals designated by the Parties to the Protocol of 1997 to other Parties to the Protocol of 1997 and Member States of the Organization for their information.

(5) All tankers which are subject to vapour emission control in accordance with the provisions of paragraph (2) of this regulation shall be provided with a vapour collection system approved by the Administration taking into account the safety standards developed by the Organization, and shall use such system during the loading of such cargoes. Terminals which have installed vapour emission control systems in accordance with this regulation may accept existing tankers which are not fitted with vapour collection systems for a period of three years after the effective date identified in paragraph (2).

(6) This regulation shall only apply to gas carriers when the type of loading and containment systems allow safe retention of non-methane VOCs on board, or their safe return ashore.

REGULATION 16

Shipboard Incineration

(1) Except as provided in paragraph (5), shipboard incineration shall be allowed only in a shipboard incinerator.

(2) (a) Except as provided in sub-paragraph (b) of this paragraph, each incinerator installed on board a ship on or after 1 January 2000 shall meet the requirements contained in appendix IV to this Annex. Each incinerator shall be approved by the Administration taking into account the standard specifications for shipboard incinerators developed by the Organization.

(b) The Administration may allow exclusion from the application of sub-paragraph (a) of this paragraph to any incinerator which is installed on board a ship before the date of entry into force of the Protocol of 1997, provided that the ship is solely engaged in voyages within waters subject to the sovereignty or jurisdiction of the State the flag of which the ship is entitled to fly.

(3) Nothing in this regulation affects the prohibition in, or other requirements of, the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, as amended, and the 1996 Protocol thereto.

(4) Shipboard incineration of the following substances shall be prohibited:

(a) Annex I, II and III cargo residues of the present convention and related contaminated packing materials;

(b) polychlorinated biphenyls (PCBs);

(c) garbage, as defined in Annex V of the present Convention, containing more than traces of heavy metals; and

(d) refined petroleum products containing halogen compounds.

(5) Shipboard incineration of sewage sludge and sludge oil generated during the normal operation of a ship may also take place in the main or auxiliary power plant or boilers, but in those cases, shall not take place inside ports, harbours and estuaries.

(6) Shipboard incineration of polyvinyl chlorides (PVCs) shall be prohibited, except in shipboard incinerators for which IMO Type Approval Certificates have been issued.

(7) All ships with incinerators subject to this regulation shall possess a manufacturer's operating manual which shall specify how to operate the incinerator within the limits described in paragraph 2 of appendix IV to this Annex.

(8) Personnel responsible for operation of any incinerator shall be trained and capable of implementing the guidance provided in the manufacturer's operating manual.

(9) Monitoring of combustion flue gas outlet temperature shall be required at all times and waste shall not be fed into a continuous-feed shipboard incinerator when the temperature is below the minimum allowed temperature of 850°C. For batch-loaded shipboard incinerators, the unit shall be designed so that the temperature in the combustion chamber shall reach 600°C within 5 minutes after start-up.

(10) Nothing in this regulation precludes the development, installation and operation of alternative design shipboard thermal waste treatment devices that meet or exceed the requirements of this regulation.

REGULATION 17

Reception Facilities

(1) The Government of each Party to the Protocol of 1997 undertakes to ensure the provision of facilities adequate to meet the:

(a) needs of ships using its repair ports for the reception of ozone depleting substances and equipment containing such substances when removed from ships;

(b) needs of ships using its ports, terminals or repair ports for the reception of exhaust gas cleaning residues from an approved exhaust gas cleaning system when discharge into the marine environment of these residues is not permitted under regulation 14 of this Annex;

without causing undue delay to ships, and

(c) needs in ship breaking facilities for the reception of ozone depleting substances and equipment containing such substances when removed from ships.

(2) Each Party to the Protocol of 1997 shall notify the Organization for transmission to the Members of the Organization of all cases where the facilities provided under this regulation are unavailable or alleged to be inadequate.

REGULATION 18

Fuel Oil Quality

(1) Fuel oil for combustion purposes delivered to and used on board ships to which this Annex applies shall meet the following requirements:

(a) except as provided in sub-paragraph (b):

(i) the fuel oil shall be blends of hydrocarbons derived from petroleum refining. This shall not preclude the incorporation of small amounts of additives intended to improve some aspects of performance;

(ii) the fuel oil shall be free from inorganic acid;

(iii) the fuel oil shall not include any added substance or chemical waste which either:

(1) jeopardizes the safety of ships or adversely affects the performance of the machinery, or

(2) is harmful to personnel, or

(3) contributes overall to additional air pollution; and

(b) fuel oil for combustion purposes derived by methods other than petroleum refining shall not:

(i) exeed the sulphur content set forth in regulation 14 of this Annex;

(ii) cause an engine to exceed the NOx emission limits set forth in regulation 13(3)(a) of this Annex;

(iii) contain inorganic acid; and

(iv) (1) jeopardize the safety of ships or adversely affect the performance of the machinery, or

(2) be harmful to personnel, or

(3) contribute overall to additional air pollution.

(2) This regulation does not apply to coal in it's solid form or nuclear fuels.

(3) For each ship subject to regulations 5 and 6 of this Annex, details of fuel oil for combustion purposes delivered to and used on board shall be recorded by means of a bunker delivery note which shall contain at least the information specified in appendix V to this Annex.

(4) The bunker delivery note shall be kept on board the ship in such a place as to be readily available for inspection at all reasonable times. It shall be retained for a period of three years after the fuel oil has been delivered on board.

(5) (a) The competent authority of the Government of a Party to the Protocol of 1997 may inspect the bunker delivery notes on board any ship to which this Annex applies while the ship is in its port or offshore terminal, may make a copy of each delivery note, and may require the master or person in charge of the ship to certify that each copy is a true copy of such bunker delivery note. The competent authority may also verify the contents of each note through consultations with the port where the note was issued.

(b) The inspection of the bunker delivery notes and the taking of certified copies by the competent authority under this paragraph shall be performed as expeditiously as possible without causing the ship to be unduly delayed.

(6) The bunker delivery note shall be accompanied by a representative sample of the fuel oil delivered taking into account guidelines to be developed by the Organization. The sample is to be sealed and signed by the supplier's representative and the master or officer in charge of the bunker operation on completion of bunkering operations and retained under the ship's control until the fuel oil is substantially consumed, but in any case for a period of not less than twelve months from the time of delivery.

(7) Parties to the Protocol of 1997 undertake to ensure that appropriate authorities designated by them:

(a) maintain a register of local suppliers of fuel oil;

(b) require local suppliers to provide the bunker delivery note and sample as required by this regulation, certified by the fuel oil supplier that the fuel oil meets the requirements of regulations 14 and 18 of this Annex;

(c) require local suppliers to retain a copy of the bunker delivery note for at least 3 years for inspection and verification by the port State as necessary;

(d) take action as appropriate against fuel oil suppliers that have been found to deliver fuel oil that does not comply with that stated on the bunker delivery note;

(e) inform the Administration of any ship receiving fuel oil found to be noncompliant with the requirements of regulations 14 or 18 of this Annex; and

(f) inform the Organization for transmission to Parties to the Protocol of 1997 of all cases where fuel oil suppliers have failed to meet the requirements specified in regulations 14 or 18 of this Annex.

(8) In connection with port State inspections carried out by Parties to the Protocol of 1997, the Parties further undertake to:

(a) inform the Party or non-Party under whose jurisdiction bunker delivery note was issued of cases of delivery of noncompliant fuel oil, giving all relevant information; and

(b) ensure that remedial action as appropriate is taken to bring noncompliant fuel oil discovered into compliance.

REGULATION 19

Requirements for Platforms and Drilling Rigs

(1) Subject to the provisions of paragraphs (2) and (3) of this regulation, fixed and floating platforms and drilling rigs shall comply with the requirements of this Annex.

(2) Emissions directly arising from the exploration, exploitation and associated offshore processing of sea-bed mineral resources are, consistent with article 2(3)(b)(ii) of the present Convention, exempt from the provisions of this Annex. Such emissions include the following:

(a) emissions resulting from the incineration of substances that are solely and directly the result of exploration, exploitation and associated offshore processing of sea-bed mineral resources, including but not limited to the flaring of hydrocarbons and the burning of cuttings, muds, and/or stimulation fluids during well completion and testing operations, and flaring arising from upset conditions;

(b) the release of gases and volatile compounds entrained in drilling fluids and cuttings;

(c) emissions associated solely and directly with the treatment, handling, or storage of sea-bed minerals; and

(d) emissions from diesel engines that are solely dedicated to the exploration, exploitation and associated offshore processing of sea-bed mineral resources.

(3) The requirements of regulation 18 of this Annex shall not apply to the use of hydrocarbons which are produced and subsequently used on site as fuel, when approved by the Administration.

APPENDIX I

Form of IAPP Certificate
(Regulation 8)

INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

Issued under the provisions of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified of the Protocol of 1978 related thereto (hereinafter referred to as "the Convention") under the authority of the Government of:

.....

(full designation of the country)

by.....

(full designation of the competent person or organization authorized under the provisions of the Convention)

Name of ship	Distinctive number or letters	IMO number	Port of registry	Gross tonnage

Type of ship: ☐ tanker
☐ ships other than a tanker

THIS IS TO CERTIFY:

1. That the ship has been surveyed in accordance with regulation 5 of Annex VI of the Convention; and

2. That the survey shows that the equipment, systems, fittings, arrangements and materials fully comply with the applicable requirements of Annex VI of the Convention.

This certificate is valid until .....
subject to surveys in accordance with regulation 5 of Annex VI of the Convention.

Issued at .....

(Place of issue of certificate)

.....
(Date of issue)

.....
(signature of duty authorized official issuing the certificate)

(Seal or stamp of the authority, as appropriate)

ENDORSEMENT FOR ANNUAL AND INTERMEDIATE SURVEYS

THIS IS TO CERTIFY that at a survey required by regulation 5 of Annex VI of the Convention the ship was found to comply with the relevant provisions of the Convention:

Annual survey:

Signed.....
(Signature of duly authorized official)

Place.....

Date.....

(Seal or stamp of the authority, as appropriate)

Annual*/Intermediate* survey:

Signed.....
(Signature of duly authorized official)

Place.....

Date.....

(Seal or stamp of the authority, as appropriate)

Annual*/Intermediate* survey:

Signed.....
(Signature of duly authorized official)

Place.....

Date.....

(Seal or stamp of the authority, as appropriate)

Annual survey:

Signed.....
(Signature of duly authorized official)

Place.....

Date.....

(Seal or stamp of the authority, as appropriate)

* Delete as appropriate

Supplement to International Air Pollution Prevention Certificate
(IAPP Certificate)

RECORD OF CONSTRUCTION AND EQUIPMENT

In respect of the provisions of Annex VI of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (hereinafter referred to as "the Convention").

Notes:

1 This Record shall be permanently attached to the IAPP Certificate. The IAPP Certificate shall be available on board the ship at all times.

2 If the language of the original Record is not English, French or Spanish, the text shall include a translation into one of these languages.

3 Entries in boxes shall be made by inserting either a cross (x) for the answer "yes" and "applicable" or a (-) for the answers "no" and "not applicable" as appropriate.

4 Unless otherwise stated, regulations mentioned in this Record refer to regulations of Annex VI of the Convention and resolutions or circulars refer to those adopted by the International Maritime Organization.

1 **Particulars of ship**

1.1 Name of ship .....

1.2 Distinctive number or letters .....

1.3 IMO number .....

1.4 Port of registry .....

1.5 Gross tonnage .....

1.6 Date on which keel was laid or ship was at a similar stage of construction .....

1.7 Date of commencement of major engine conversion (if applicable)(regulation 13) :

.....

2 **Control of emissions from ships**

2.1 Ozone depleting substances (regulation 12)

2.1.1 The following fire extinguishing systems and equipment containing halons may continue in service: ..... ☐

System Equipment	Location on board

2.1.2 The following systems and equipment containing CFCs may continue in service:

..... ☐

System Equipment	Location on board

2.1.3 The following systems containing hydro-chlorofluorocarbons (HCFCs) installed before 1 January 2020 may continue in service: ..... ☐

System Equipment	Location on board

2.2 Nitrogen oxides (NOx) (regulation 13)

2.2.1 The following diesel engines with power output greater than 130 kW, and installed on a ship constructed on or after 1 January 2000, comply with the emission standards of regulation 13(3)(a) in accordance with the NOx Technical Code: ..... ☐

Manufacturer and Model	Serial Number	Use	Power Output (kW)	Rated Speed (RPM)

2.2.2 The following diesel engines with power output greater than 130 kW, and which underwent major conversion per regulation 13(2) on or after 1 January 2000, comply with the emission standards of regulation 13(3)(a) in accordance with the NOx Technical Code: . . . . . ☐

Manufacturer and Model	Serial number	Use	Power Output (kW)	Rated Speed (RPM)

2.2.3 The following diesel engines with a power output greater than 130 kW and installed on a ship constructed on or after 1 January 2000, or with a power output greater than 130 kW and which underwent major conversion per regulation 13(2) on or after 1 January 2000, are fitted with an exhaust gas cleaning system or other equivalent methods in accordance with regulation 13(3), and the NOx Technical Code: . . . . . ☐

Manufacturer and Model	Serial Number	Use	Power Output (kW)	Rated Speed (RPM)

2.2.4 The following diesel engines from 2.2.1, 2.2.2 and 2.2.3 above are fitted with NOx emission monitoring and recording devices in accordance with the NOx Technical Code: . . . . . ☐

Manufacturer and Model	Serial Number	Use	Power Output (kW)	Rated Speed (RPM)

2.3 Sulphur oxides (SOx) (regulation 14)

2.3.1 When the ship operates within an SOx Emission Control Area specified in regulation 14(3), the ship uses:

.1 fuel oil with a sulphur content that does not exceed 1.5% m/m as documented by bunker delivery notes; or . . . . . ☐

.2 an approved exhaust gas cleaning system to reduce SOx emissions below 6.0g SOx/kWh; or ..... ☐

.3 other approved technology to reduce SOx emissions below 6.0g SOx/kWh. ... ☐

2.4 Volatile organic compounds (VOCs) (regulation 15)

2.4.1 The tanker has a vapour collection system installed and approved in accordance with MSC/Circ. 585. ..... ☐

2.5 The ship has an incinerator:

.1 which complies with resolution MEPC.76(40) as amended ..... ☐

.2 installed before 1 January 2000 which does not comply with resolution MEPC.76(40) as amended ..... ☐

THIS IS TO CERTIFY that this Record is correct in all respects.

Issued at .....
(Place of issue of the Record)

.....
Date of Issue

.....
(Signature of duly authorized official issuing the Record)

Seal or Stamp of the authority, as appropriate

APPENDIX II

TEST CYCLES AND WEIGHTING FACTORS
(Regulation 13)

The following test cycles and weighing factors should be applied for verification of compliance of marine diesel engines with the NO_x limits in accordance with regulation 13 of this Annex using the test procedure and calculation method as specified in the NO_x Technical Code.

.1 For constant speed marine engines for ship main propulsion, including diesel electric drive, test cycle E2 should be applied.
.2 For variable pitch propeller sets test cycle E2 should be applied.
.3 For propeller law operated main and propeller law operated auxiliary engines the test cycle E3 should be applied.
.4 For constant speed auxiliary engines test cycle D2 should be applied.
.5 For variable speed, variable load auxiliary engines, not included above, test cycle C1 should be applied.

Test cycle for "Constant Speed Main Propulsion" Application
(incl. 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

Test cycle for "Propeller Law operated Main and Propeller Law 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

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

Test cycle for "Variable Speed and Load Auxiliary Engine" Application

Test cycle type C1	Speed	Rated				Intermediate			Idle
	Torque %	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

APPENDIX III

CRITERIA AND PROCEDURES FOR DESIGNATION OF SO_x EMISSION CONTROL AREAS
(Regulation 14)

1 OBJECTIVES

1.1 The purpose of this appendix is to provide the criteria and procedures for the designation of SOx Emission Control Areas. The objective of SOx Emission Control Areas is to prevent, reduce, and control air pollution from SOx emissions from ships and their attendant adverse impacts on land and sea areas.

1.2 A SOx Emission Control Area should be considered for adoption by the Organization if supported by a demonstrated need to prevent, reduce, and control air pollution from SOx emissions from ships.

2 PROPOSAL CRITERIA FOR DESIGNATION OF A SOx EMISSION CONTROL AREA

2.1 A proposal to the Organization for designation of a SOx Emission Control Area may be submitted only by contracting States to the Protocol of 1997. Where two or more contracting States have a common interest in a particular area, they should formulate a coordinated proposal.

2.2 The proposal shall include:

.1 a clear delineation of the proposed area of application of controls on SOx emissions from ships, along with a reference chart on which the area is marked;

.2 a description of the land and sea areas at risk from the impacts of ship SOx emissions;

.3 an assessment that SOx emissions from ships operating in the proposed area of application of the SOx emission controls are contributing to air pollution from SOx, including SOx deposition, and their attendant adverse impacts on the land and sea areas under consideration. Such assessment shall include a description of the impacts of SOx emissions on terrestrial and aquatic ecosystems, areas of natural productivity, critical habitats, water quality, human health, and areas of cultural and scientific significance, if applicable. The sources of relevant data including methodologies used, shall be identified;

.4 relevant information pertaining to the meteorological conditions in the proposed area of application of the SOx emission controls and the land and sea areas at risk, in particular prevailing wind patterns, or to topographical, geological, oceanographic, morphological, or other conditions that may lead to an increased probability of higher localized air pollution or levels of acidification;

.5 the nature of the ship traffic in the proposed SOx Emission Control Area, including the patterns and density of such traffic; and

.6 a description of the control measures taken by the proposing contracting State or contracting States addressing land-based sources of SOx emissions affecting the area at risk that are in place and operating concurrent with the consideration of measures to be adopted in relation to provisions of regulation 14 of Annex VI of the present Convention.

2.3 The geographical limits of an SOx Emission Control Area will be based on the relevant criteria outlined above, including SOx emission and deposition from ships navigating in the proposed area, traffic patterns and density, and wind conditions.

2.4 A proposal to designate a given area as an SOx Emission Control Area should be submitted to the Organization in accordance with the rules and procedures established by the Organization.

3 PROCEDURES FOR THE ASSESSMENT AND ADOPTION OF SOx EMISSION CONTROL AREAS BY THE ORGANIZATION

3.1 The Organization shall consider each proposal submitted to it by a contracting State or contracting States.

3.2 A SOx Emission Control Area shall be designated by means of an amendment to this Annex, considered, adopted and brought into force in accordance with article 16 of the present Convention.

3.3 In assessing the proposal, the Organization shall take into account the criteria which are to be included in each proposal for adoption as set forth in section 2 above, and the relative costs of reducing sulphur depositions from ships when compared with land-based controls. The economic impacts on shipping engaged in international trade should also be taken into account.

4 OPERATION OF SOx EMISSION CONTROL AREAS

4.1 Parties which have ships navigating in the area are encouraged to bring to the Organization any concerns regarding the operation of the area.

APPENDIX IV

TYPE APPROVAL AND OPERATING LIMITS
FOR SHIPBOARD INCINERATORS
(Regulation 16)

(1) Shipboard incinerators described in regulation 16(2) shall possess an IMO type approval certificate for each incinerator. In order to obtain such certificate, the incinerator shall be designed and built to an approved standard as described in regulation 16(2). Each model shall be subject to a specified type approval test operation at the factory or an approved test facility, and under the responsibility of the Administration, using the following standard fuel/waste specification for the type approval test for determining whether the incinerator operates within the limits specified in paragraph (2) of this appendix:

Sludge Oil Consisting of:	75% SLUDGE OIL FROM HFO; 5% WASTE LUBRICATING OIL; and 20% EMULSIFIED WATER.
Solid Waste consisting of:	50% Food Waste 50% Rubbish Containing Approx. 30% Paper, " 40% Cardboard, " 10% Rags, " 20% Plastic The mixture will have up to 50% moisture and 7% incombustible solids.

(2) Incinerators described in regulation 16(2) shall operate within the following limits:

O_2 in Combustion Chamber:	6 - 12 %
CO in Flue Gas Maximum Average:	200 mg/MJ
Soot Number Maximum Average:	BACHARACH 3 or RINGELMAN 1 (20% opacity) (A higher soot number is acceptable only during very short periods such as starting up)
Unburned Components in Ash Residues:	Maximum 10% by Weight
Combustion Chamber Flue Gas Outlet Temperature Range:	850 - 1200 degrees Celsius.

APPENDIX V

INFORMATION TO BE INCLUDED IN THE BUNKER DELIVERY NOTE

(Regulation 18(3))

Name and IMO Number of receiving ship

Port

Date of commencement of delivery

Name, address, and telephone number of marine fuel oil supplier

Product name(s)

Quantity in metric tons

Density at 15°C, kg/m^3

Sulphur content (%m/m)

A declaration signed and certified by the fuel oil supplier's representative that the fuel oil supplied is in conformity with regulation 14 (1) or (4)(a) and regulation 18(1) of this Annex.

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