MARPOL Annex VI

Regulations – Prevention of Air Pollution from Ships

Chapters 1 - 3

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MARPOL Annex VI
Regulations – Prevention of Air Pollution from Ships

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1. Introduction
Introduction

Air emissions from combustion of fuels

Energy use is the major source of man-made air emissions
Introduction

Shipping air emissions and its impacts

Source: IMO 2nd GHG study 2009
Overall consequences and solutions

• **Consequences:**
  - Damage to environment and eco-system
  - Damage to agriculture and properties
  - Damage to human health
  - Additional cost to society and individuals (healthcare, accidents, etc.)

• **Solutions (mitigation aspects):**
  - Either to reduce the air emissions (Technical and operational measures); or
  - Pay for the associated costs (market based measures); or
  - A combination of the above two

• **Mechanisms:**
  - Regulations (on technical and operational measures)
  - Market-Based Measures (MBM)
2. MARPOL Annex VI overview
MARPOL Annex VI - Overview

- **MARPOL Annex VI:**
  - Entered into force on 19 May 2005

- **Revisions of Annex VI:**
  - Adopted in October 2008
  - Entered into force on 1 July 2010

- **Chapter 4 on Energy Efficiency**
  - Adopted in July 2011
  - Entered into force on 1 January 2013

- **Number of Contracting States:** 83

- The combined merchant fleets of which constitute approximately 95.32% of the gross tonnage of the world’s merchant fleet
MARPOL Annex VI - Overview

- Ozone Depleting Substances
- Nitrogen Oxides
- Energy Efficiency
- Sulphur Oxides
- Volatile Organic Compounds
- Incineration Emissions
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- Application: Reg.19
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- Required EEDI: Reg.21
- Ship Energy Efficiency Management Plan (SEEMP): Reg.22
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## MARPOL Annex VI – Regulations –

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*IMCO* International Maritime Organization
3. MARPOL Annex VI
Chapter 1
– 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, 16, 18, 19, 20, 21 and 22 of this Annex.

Application  ➔  All Ships

Does not apply ➔

• When suffering damage to ship or equipment
• When saving life at sea
• When securing safety of ship
• Ship trials for research, emissions from sea bed
Regulation 2 – Definitions

Typical terms that are defined:

- **Emission control area** means an area where the adoption of special mandatory measures .... is required to control NOx or SOx and particulate matter or all three types of emissions .......

- **Fuel oil** means any fuel delivered to and intended for combustion ... including gas, distillate and residual fuels

- **NOx Technical Code** means the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines ..... 

- **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 ........

- **Marine diesel engine** means any reciprocating internal combustion engine operating on liquid or dual fuel .... In addition, a gas fuelled engine installed on a ship constructed on or after 1 March 2016 ......
Regulation 3 – Exceptions and Exemptions

General
1. Regulations of this Annex shall not apply to:
   .1 any emission necessary for the purpose of securing the safety of a ship or saving life at sea; or
   
   .2 any emission resulting from damage to a ship or its equipment:
      .2.1 provided that all reasonable precautions have been taken after the occurrence of the damage ............; and
      
      .2.2 except if the owner or the master acted either with intent to cause damage, or .........................

Trials for Ship Emission Reduction and Control Technology Research

Emissions from Sea-bed Mineral Activities
3.1 Emissions directly arising from the exploration, exploitation and associated offshore processing of sea-bed mineral resources
Regulation 4 – Equivalents

- The Administration of a Party may allow any fitting, material, appliance or apparatus to be fitted in a ship or other procedures, alternative fuel oils, or compliance methods used as an alternative to that required by MARPOL Annex VI, if such fitting, etc. are at least as effective in terms of emissions reductions as that required by Annex VI.

- The Administration of a Party that allows the equivalent shall communicate to the IMO for circulation to the Parties.
  
  - Notifications from Parties are available through the IMO Global Integrated Shipping Information System (GISIS)

http://gisis.imo.org/Public/
Welcome to the Public Area

Ship Particulars
Ship identification and particulars.

Recognized Organizations
Information submitted by Member States under MSC/Circ.1010-MEPC/Circ.382.

Port Reception Facilities
Data on the available port reception facilities for the reception of ship-generated waste.

Pollution Prevention Equipment
Pollution prevention equipment required by MARPOL 73/78.

Facilitation of International Maritime Traffic
Reports on stowaway incidents (FAL.2/Circ.50/Rev.2); Reports on unsafe practices associated with the trafficking or transport of migrants by sea (MSC/Circ.896/Rev.1).

Radiocommunications and Search and Rescue
Information on the availability of Search and Rescue (SAR) Services.

MARPOL Annex VI
Notifications communicated under the provisions of MARPOL Annex VI (Regulations for the Prevention of Air Pollution from Ships).
MARPOL Annex VI

In 1997 a new annex was added to the International Convention for the Prevention of Pollution from Ships (MARPOL). The Regulations for the Prevention of Air Pollution from Ships (Annex VI) seek to minimize airborne emissions from ships (SOx, NOx, ODS, VOC) and their contribution to global air pollution and environmental problems. Annex VI entered into force on 19 May 2005 and a revised Annex VI was adopted in October 2008 which entered into force on 1 July 2010.

Administrations are required to make notifications to the Organization under the following regulations of MARPOL Annex VI:

- **Regulation 4.2**: equivalent compliance method;
- **Regulation 11.4**: detection of violations and enforcement;
- **Regulation 13.7.1**: approved methods for certain marine diesel engines installed on a ship constructed prior to 1 January 2000;
- **Regulation 15.2**: ports or terminals regulating the emissions of Volatile Organic Compounds (VOCs);
- **Regulations 17.2**: ports, terminals or ship-breaking facilities where reception facilities are available;
- **Regulations 17.3**: ports, terminals or ship-breaking facilities where reception facilities are alleged to be inadequate;
- **Regulation 18.1**: fuel oil availability;
- **Regulation 18.2.5**: evidence of non-availability of compliant fuel oil;
- **Regulation 18.9.6**: failure of fuel oil suppliers to meet the requirements specified in regulation 14 or 18 of Annex VI;
- **Regulation 19.6**: allowance, suspension, withdrawal or declination of application of regulation 19.4 of Annex VI;
- **Regulation 19.6**: allowance, suspension, withdrawal or declination of application of regulation 19.4 of Annex VI and;
- **Specimens**: specimens of certificates.
Regulation 4 – Equivalents

The Administration of a Party should take into account any relevant guidelines developed by the IMO* pertaining to the equivalent.

* 2015 Guidelines for exhaust gas cleaning systems (resolution MEPC.259(68))
4. MARPOL Annex VI
Chapter 2
– Survey / Certification –
Regulation 5 – Surveys

- Every ship of 400 gross tonnage and above shall be subject to the following surveys:
  - An initial survey (during construction);
  - An annual survey;
  - An intermediate survey;
  - A renewal survey; and
  - An additional survey

- By Administration (ship’s flag State)
  - The Administration may entrust the surveys to a recognized organizations (such as, classification societies)
Regulation 6 – Issue or Endorsement of Certificate

1. An International Air Pollution Prevention (IAPP) Certificate shall be issued, after an initial or renewal survey .........., to:
   .1. any ship of 400 gross tonnage and above engaged in voyages to ports or offshore terminals under the jurisdiction of other Parties; and
   .2. platforms and drilling rigs engaged in voyages to waters under the sovereignty or jurisdiction of other Parties.

2. A ship constructed before the date of entry into force of Annex VI shall be issued with an IAPP Certificate in accordance with paragraph 1 of this regulation no later than the first scheduled dry-docking after the date of such entry into force, but in no case later than three years after this date.

3. ............
Survey and certification summary

- All ships of ≥ 400 gross tonnage
- Fixed or floating platforms (drilling rigs)
- Floating craft and submersibles

• Ships constructed before date of entry into force of Annex VI for non-Parties.
• Comply by 1st scheduled dry-dock but no later than 3 years after entry into force.

International Air Pollution Prevention (IAPP) Certificate

Subject to Initial, Periodic (renewal) and Intermediate surveys
Regulation 7 – Issue of a Certificate by another Party

1. A Party may, at the request of the Administration, survey a ship and, …, shall issue or authorize the issuance of an IAPP Certificate ……..

2. A copy of certificate and a copy of the survey report shall be transmitted 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 …………..

4. No IAPP Certificate shall be issued to a ship which is entitled to fly the flag of a State which is not a Party.
Regulation 8 – Form of Certificates

The IAPP Certificate shall be drawn up in a form corresponding to the model given in appendix I to this Annex ............
Regulation 9 – Duration and Validity of Certificate

1. An IAPP Certificate shall be issued for a period specified by the Administration, which shall not exceed five years.

2. Renewal of the certificate:
   .1. when the renewal survey is completed within three months before the expiry date, the new certificate shall be valid ... to a date not exceeding five years from the date of expiry of the existing certificate;
   .2. when the renewal survey is completed after the expiry date of the existing certificate, the new certificate shall be valid from the date of the renewal survey to a date not exceeding five years from expiry date of existing one.
   .3. when the renewal survey is completed more than three months before the expiry date of the existing certificate, the new certificate shall be valid from the date of completion of the renewal survey to a date not exceeding five years from the date of completion of the renewal survey.

4. If a renewal survey has been completed and a new certificate cannot be issued ... before the expiry date of the existing one, the person or organization authorized by the Administration may endorse the existing certificate ...
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, is subject to inspection by officers duly authorized by such Party … where there are clear grounds for believing that the master or crew are not familiar with essential shipboard procedures relating to prevention of pollution from ships.

2. …, the Party shall take such steps as to ensure that the ship shall not sail until the situation has been brought to order in accordance with the requirements of this Annex.

3. ….
Regulation 11 – Detection of Violations and Enforcement

1. Parties shall co-operate in the detection of violations and the enforcement of the provisions of this Annex ….

2. A ship to which this Annex applies may, in any port or offshore terminal of a Party, be subject to inspection by officers appointed or authorized by that Party ….

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.

4. Upon receiving such evidence, the Administration so informed shall investigate the matter ….. 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.

And other aspects ….
5. MARPOL Annex VI
Chapter 3
– Requirements for Control of Emission from Ships –
Regulation 12

Ozone-Depleting Substances (ODS)
What is the ozone layer and ozone hole?

- **Ozone depletion** describes a steady decline of total volume of ozone in Earth’s stratosphere (the ozone layer).

- A much larger spring-time decrease in stratospheric ozone over poles are observed in recent decades (ozone hole).

- The primary cause of ozone depletion is the presence of chlorine-containing gases.

- In the presence of ultra-violet (UV) light, these gases dissociate, releasing chlorine atoms, which then go on to catalyse ozone destruction.
Consequences of ozone depletion?

• Since the ozone layer absorbs UV light from the sun, ozone layer depletion is expected to increase surface UV light levels, which could lead to increase in skin cancer.

• Decreases in atmospheric ozone are well-tied to CFCs (Industrial name Freons).

• Montreal Protocol aims to reduce the level of ODS in atmosphere.

• Refrigeration systems traditionally has been using CFCs as their working fluids.
ODS in ships: Refrigerated vessels

- Carry fresh food (vegetable, fruit, frozen meats and fresh fish, etc.)
- Load and transport cargos separately
- Transportation temperature is different

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Example Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Super Low Temp.</td>
<td>(-30°C ~ -60°C) Tuna etc.</td>
</tr>
<tr>
<td>Low Temp.</td>
<td>(-30°C and more) Beef, Chicken, Pork, Primary processing food etc.</td>
</tr>
<tr>
<td>Chilled</td>
<td>(0°C ~ -4°C) Orange, Apple, Pineapple, Spinach, Cauliflower, Onion, etc.</td>
</tr>
<tr>
<td>0°C and more</td>
<td>(0°C ~ +15°C) Lemon, Potato, etc.</td>
</tr>
<tr>
<td></td>
<td>(+12°C ~ +14°C) Banana etc.</td>
</tr>
</tbody>
</table>
MARPOL Annex VI – Chapter 3 – Reg.12 (ODS)

Refrigerated Machine Room • Refrigeration Plant

Cooler Room
ODS related regulations

- Montreal Protocol
  - Considers the production phase-out of ODS – 99% effective
- IMO, MARPOL Annex VI (regulation 12)
  - Covers control of ODS for international shipping
- EC Regulation No. 2037/2000
  - Covers ODS, their use and also emission control (recovery)
  - Updated and recast as EC Regulation No. 1005/2009
- Kyoto Protocol
  - Applicable to HFCs and PFCs
- Flag/Port State requirements
Regulation 12 – Ozone-depleting substances

- Does not apply to permanently sealed equipment where there are no refrigerant charging connections or potentially removable components containing ODS
- Any deliberate emissions of ODS shall be prohibited
- Installations that contain ODS shall be prohibited (other than hydrochlorofluorocarbons):
  - on ships constructed from 19 May 2005
- Installations that contain hydrochlorofluorocarbons shall be prohibited:
  - on ships constructed from 1 January 2020
Regulation 2 – Definitions

- **Ozone-depleting substances** means controlled substances defined paragraph (4) of article 1 of the Montreal Protocol on Substances that Depleting the Ozone Layer, 1978, listed in Annex A, B, C or E to the said Protocol in force at the time of application or interpretation of MARPOL Annex VI

- Ozone-depleting substances that may be found on board ship include, but are not limited to:
  - Halon 1211
  - CFC-11
  - CFC-114
  - Halon 1301
  - CFC-12
  - CFC-115
  - Halon 2402
  - CFC-113
### Regulation 12 – Ozone-depleting substances

- Maintain a list of equipment containing ODS
  (Supplement to International Air Pollution Prevention Certificate)

#### 2 Control of emissions from ships

#### 2.1 Ozone depleting substances (regulation 12)

2.1.1 The following fire-extinguishing systems, other systems and equipment containing ozone depleting substances, other than hydro-chlorofluorocarbons, installed before 19 May 2005 may continue in service:

<table>
<thead>
<tr>
<th>System or equipment</th>
<th>Location on board</th>
<th>Substance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.1.2 The following systems containing hydro-chlorofluorocarbons (HCFCs) installed before 1 January 2020 may continue in service:

<table>
<thead>
<tr>
<th>System or equipment</th>
<th>Location on board</th>
<th>Substance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Regulation 12 – Ozone-depleting substances

- Maintain an *Ozone-depleting substances record book*
  - Recharge, repair, maintenance or supply of ODS
  - Discharge of ODS (deliberate / non-deliberate) to atmosphere / land based reception facilities

Source: ClassNK
Regulation 12 – Ozone-depleting substances

- ODS and equipment containing ODS shall be delivered to appropriate reception facilities (Regulation 17) when removed from ships

Regulation 17 – Reception facilities

- Each Party undertakes to ensure the provision of facilities adequate to meet the need of ships using its ports, terminals or repair ports for the reception of ODS and equipment containing ODS when removed from ships

  - Information on reception facilities is available through the IMO Global Integrated Shipping Information System (GISIS)

http://gisis.imo.org/Public/
Regulation 12 – Ozone-depleting substances

Expected impacts?

• Reduction in deliberate releases and additional use of equipment to prevent such releases.

• Phase out of CFC and HCFC refrigerants.

• Move to alternative refrigerant types:
  • Natural substances – carbon dioxide, ammonia, propane and cyclo-pentane
  • Possible safety considerations, toxicity, flammability

• Promotion of alternative refrigeration technologies: e.g. Pumping heat electrically using Peltier effect (thermoelectric type).
Operational issues

- IMO considers and prepares technical information, as appropriate:
  - MSC-MEPC.1/Circ.3 “Decreasing availability of halons for marine use” (June 2008)
  - MEPC 64/INF.10 Lloyds Register report “Study on the treatment of ODS used to service ships” (July 2012)
  
  http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Documents/MEPC%2064-INF-10.pdf
Regulation 13

**Nitrogen oxides (NOx)**
What is NOx

• NOx refer to oxides of nitrogen including NO\textsubscript{2} and NO.

• NOx is formed in the process of combustion of fuels where O\textsubscript{2} and N\textsubscript{2} are meeting at high temperature.

• The higher the temperature, the more NOx is formed.

• In engines, the higher the temperature, the more efficient the engine is; thus more NOx produced.

• Marine engines are most efficient engines and also produce highest NOx compared to other types of engines and combustion systems.

• NOx from other sources (e.g. boilers) are relatively small.
Impact of NOx

- NOx is a reactive gas, at the presence of sunlight.

- Causes health problem; in particular on respiratory system.

- NOx together with VOC and other reacting gases in the atmosphere, could lead to smog (smoky fog) phenomenon.

- Additionally, NOx contributes to global warming and acid rain.

Photochemical smog is the chemical reaction of sunlight, nitrogen oxides and VOC in the atmosphere, which leaves airborne particles and ground-level ozone.
Methods of engine's NOx reduction

- There are a number of NOx reduction methods for engines

Lean burn, low temperature combustion.

- Water in fuel emulsions
- Humid Air Manifold or water injection
- Miller cycle: Valve timing
- Low NOx combustion

LNG

Other

NOx Reduction Options

EGR

SCR

Lower combustion temperature due to gas recirculation (mainly CO₂)

• Use of a reduction agents
• Uses a catalyst
• Converts NOx back to N₂
### Regulation 13 – Nitrogen oxides (NOx) - Application

#### Applies to

<table>
<thead>
<tr>
<th>Marine diesel engines</th>
<th>with a power output more than 130 kW</th>
<th>installed on a ship constructed on or after 1&lt;sup&gt;st&lt;/sup&gt; January 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine diesel engines</td>
<td>with a power output more than 130 kW</td>
<td>which undergo a major conversion on or after 1&lt;sup&gt;st&lt;/sup&gt; January 2000</td>
</tr>
</tbody>
</table>

#### Not applicable to

- Emergency marine diesel engines
- Marine diesel engines installed on lifeboats
- Any device or equipment intended to be used solely in case of emergency
- Engines on ships only engaged in domestic voyages can be made subject to alternative NOx control measure or exempted if pre-19 May 2005
**Regulation 13 – Nitrogen oxides (NOx) – Emission limits**

Tier I - Ships constructed 1 Jan 2000 to 31 Dec 2010*
Tier II - Ships constructed 1 Jan 2011 to 31 Dec 2015
Tier III - Ships constructed 1 Jan 2016 onwards when operating within NOx ECA

*NOx limit in original Annex VI

<table>
<thead>
<tr>
<th>Tier</th>
<th>n &lt; 130 rpm</th>
<th>130 ≤ n &lt; 2000 rpm</th>
<th>n ≥ 2000 rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>17.0 g/kWh</td>
<td>45.0*n^{(-0.2)} g/kWh</td>
<td>9.8 g/kWh</td>
</tr>
<tr>
<td>II</td>
<td>14.4 g/kWh</td>
<td>44.0*n^{(-0.2)} g/kWh</td>
<td>7.7 g/kWh</td>
</tr>
<tr>
<td>III</td>
<td>3.4 g/kWh</td>
<td>9.0*n^{(-0.2)} g/kWh</td>
<td>2.0 g/kWh</td>
</tr>
</tbody>
</table>

n = rated engine speed – crankshaft rpm
Regulation 13 – Nitrogen oxides (NOx) – Emission limits

**Tier I**
- Constructed on or after 1 Jan. 2000

**Tier II**
- Constructed on or after 1 Jan. 2011

**Tier III***
- Constructed on or after 1 Jan. 2016
- Applied in ECAs
- Tier II applied outside of ECAs

* For a ship operating within North American ECA and US Caribbean Sea Area ECA
Regulation 13 – NOx – Emission Control Areas (ECAs)

North American ECA

U.S. Caribbean ECA

Source: ClassNK
Regulation 13 – Nitrogen oxides (NOx) – Tier III in ECA

• Tier III – For ships built after January 1, 2016 when operating in North America ECA and U.S. Caribbean ECA

• Applicable ships for future ECA-NOx:
  • “for ships constructed on or after the date of adoption of such an ECA-NOx, or a later date as specified in the adoption decision …”

• For meeting stringent Tier III NOx emission limits, NOx reduction devices are expected to be used.

• If engines certified only to Tier II, can use NOx reduction device in ECA.

• Selective Catalytic Reduction (SCR) system is one such device.
Regulation 13 – NOx – Approved Method for pre-2000 engines

- Ships constructed - 1 Jan 1990 to 31 Dec 1999:

  Required to fit an “approved method” to enable the engine to meet Tier I limits.

  IMO to be notified of approved method

  The approved method to be installed at first renewal survey 12 months after IMO notified the “method” is approved.
Regulation 13 – NOx – Approved Method for pre-2000 engines

- Applicable to the following engines:
  - Power output 5,000 kW
  - Per cylinder displacement 90 litres
  - Installed on ships 1 Jan 1990, and < 1 January 2000

- Emission Standards – Tier I by using
  - “Approved Method” (AM) when certified & IMO notified; or
  - Engines certified as Tier I

- Related guidelines:
  - 2014 Guidelines on the approved method process (resolution MEPC.243(66))
  - 2014 Guidelines in respect of the information to be submitted by an Administration to the organization covering the certification of an approved method as required under regulation 13.7.1 of MARPOL Annex VI (resolution MEPC.242(66))
### Regulation 13 – NOx – Approved Method for pre-2000 engines

**MEPC.1/Circ.764**
- **Date of Notification:** 11 Aug 2011
- **Maker & Model:** MAN B&W 570MC
- **MCR per cylinder:** 2,250 to 2,810 (kW/cyl)
- **Rated speed:** 81 to 91 rpm
- **Approved Method No.:** 29484-11 HH

**MEPC.1/Circ.765**
- **Date of Notification:** 11 Aug 2011
- **Maker & Model:** MAN B&W 550MC
- **MCR per cylinder:** 1,160 to 1,430 (kW/cyl)
- **Rated speed:** 114 to 127 rpm
- **Approved Method No.:** 28470-11 HH
Regulation 13 – NOx – Approved Method for pre-2000 engines

• MEPC.1/Circ.743
  Date of Notification: 4 Feb 2011
  Maker: Wartsila
  Model: RTA52, RTA52U, RTA58T, RTA62, RTA62U, RTA72, RTA72U, RTA84C, RTA84CU, RTA84M, RTA84T-B, RTA96C
  Description of AM: NOx-optimized injection timing
  Approved Method No.: 20347-10 HH

• List of ships with the above engines installed is provided in this circular
Regulation 13 – NOx – Engine certification

• Test bed exhaust emission measurement.

• NOx Technical File
  • Information on components, settings, operating values & adjustments to maintain NOx emissions within allowable limits.

• Issue of Engine International Air Pollution Prevention (EIAPP) certificate or statement of compliance
  • Issued for applicable engines
  • Valid for the engines life (unless major conversion)
Figure 1 – Pre-certification survey at the manufacturer’s facility
Figure 2 – Initial survey on board a ship

NTC 2008
Appendix II
Flowcharts for survey and certification of marine diesel engines
Figure 3 – Renewal, annual or intermediate survey on board a ship
Regulation 13 – NO\textsubscript{x} – Onboard NO\textsubscript{x} Verification Methods

• **Engine Parameter check method**
  
  Check engine components, settings and operating values against NO\textsubscript{x} Technical File.

• **Simplified Measurement method**
  
  Confirmation test of NO\textsubscript{x} emissions to be within the limits of respective emissions measured on the test bed.

• **Direct Measurement and Monitoring method**
  
  Direct measurement of the exhaust flow by flow nozzle or equivalent metering system; difficulties in terms of direct gaseous flow measurement; potential errors.

So far, only “engine parameter check method” is used
Regulation 13 – NOx – Equivalents and alternative methods of compliance

• Exhaust after treatment systems e.g. SCR - Selective Catalytic Reduction.

• MEPC.198(62) is applicable to engines with SCR for complying to Reg. 13 with detailed guidance on testing, survey, pre-certification, and approval of engine/SCR

• Other equivalent method approved by the Administration for NOx emission reduction e.g. exhaust gas recirculation (EGR).

• “Approved methods” for pre-2000 engines.
Regulation 14

Sulphur oxides (SOx) and Particulate Matter
How SOx is produced and what is its impact?

- SOx is normally SO$_2$ and to some extent SO$_3$.
- SOx is produced from oxidation of fuel sulphur.
- S + O$_2$ $\rightarrow$ SO$_2$ + 1/2O$_2$ $\rightarrow$ SO$_3$
- SOx causes: (1) Acid rain (2) Sea and soil acidification and (3) Human health issue
- PM (Particulate Mater) is produced due to non-complete combustion of fuel.
- Level of PM is dependent on fuel sulphur level.
- Reduction of fuel sulphur will reduce SOx but also PM.
Regulation 14 – Sulphur oxides (SO\textsubscript{x}) and particular matter

Fuel oil sulphur %

- 4.50%
- 3.50%
- 1.50%
- 1.00%
- 0.50%
- 0.10%

Time

01/01/2012
01/07/2010
01/01/2015
01/01/2020
01/01/2025

Non-ECA

ECA

Review completion by 2018

ECA

MARPOL Annex VI – Chapter 3 – Reg.14 (SO\textsubscript{x})
IMO Designated Emission Control Areas (ECAs)

North Sea and Baltic Sea ECAs

North American ECA
(Effect from 01/08/2012)

U.S. Caribbean ECA
(Effect from 01/01/2014)

Source: ClassNK
Appendix III – Criteria and procedures for designation of Emission Control Areas (ECAs)

1. Objective
   - NO\textsubscript{X}, SO\textsubscript{X} and particular matter, or all three types of emissions

2. Process for the designation of ECAs
   - A proposal to designate ECA should be submitted to IMO (by Parties)

3. Criteria for designation of an ECA
   - The proposal shall include: a clear delineation, the type emission(s), impacts of ship emissions, etc.

4. Procedures for the assessment and adoption of ECAs
   - IMO shall consider each proposal and an ECA shall be designated by means of an amendments to MARPOL Annex VI

5. Operation of ECAs
Review provision (Regulation 14.8)

A review of the standard set forth in regulation 14.3 (0.50% Sulphur limit) shall be completed by 2018 to determine the availability of fuel oil to comply with the fuel oil standard set forth in that regulation and shall take into account the following elements:

1. the global market supply and demand for fuel oil to comply with regulation 14.3 that exist at the time that the review is conducted;
2. an analysis of the trends in fuel oil markets; and
3. any other relevant issue.

IMO Marine Environment Protection Committee (MEPC) approved Terms of Reference for the assessment of fuel oil availability review (May 2015).
Fuel oil Availability Review – Assessment for 2020 sulphur limit

- MEPC 68 decided to set up a Steering Group to conduct a wide ranging study on the subject.

- An international tender will choose relevant consultants to do this study.

- The study, inter alia, will include the following aspects
  
  - Geographical fuel availability
  - Both refinery and shipping industry should be represented
  - **Demand modelling:** To estimate the volume of compliant fuel oil required in 2020
  
  - **Supply modelling:** Mainly refinery sales and capacities for all major refinery units and for the regions to be modelled.

- Study will be presented to MEPC 70 (Autumn 2016).
ECA Operation – Compliance and fuel change over procedures

• Dominant option: use of 2 separate fuels on-board, i.e. LS and HS fuel oils.

• For this compliance option (Reg. 14.6):
  • Ships entering or leaving an ECA shall carry a written procedure (e.g. fuel change-over plan).
  • The plan should show how the fuel oil change-over is to be done ensuring not any HS fuel is left in the system upon entry into ECA.
  • The volume of LS fuel oils in each tank as well as the date, time, and position of the ship when entering or leaving shall be recorded in such log-book as prescribed by the Administration.

• Other options: LNG as fuel, SOx scrubbers, other alternative fuels
Regulation 15

Volatile Organic Compounds (VOC)
What is VOC and its impact?

• Volatile Organic Compounds (VOCs) are the lighter parts of crude oil or their products that vapourise during the ship loading process.

• VOCs are chemicals that are primarily dangerous to human health. They also cause harm to the environment.

• VOCs are typically not very toxic, but instead have long-term health effects.

• VOCs in shipping:
  • Mainly from oil tankers.
  • Normally polluting the port of loading.
  • VOC could be discharged as part of tank purging process as well.
Regulation 15 – VOC

• Regulation enables ports and terminals to implement VOC controls

• Controls on volatile emissions from tanker cargo tanks during loading/unloading of oil cargoes

• Vapour Emissions Control System (VECS) to be compliant with MSC/Circ. 585 guidelines

• Crude oil tankers to have an approved VOC manual (does not apply to gas carriers - Reg. 15.7)
Schematic of a typical Vapour Emission Control System (VECS)

- MAST RISER
- P/V VALVE
- VAPOUR MANIFOLD
- CARGO MANIFOLD
- LEVEL GAUGE
- VAPOUR
- OIL
- TANK LEVEL ALARMS
- HIGH & LOW PRESSURE ALARMS
Regulation 15 – VOC

• For Parties applying Regulation 15 in port(s) and terminal(s):
  • Shall submit notification to IMO 6 months before effective date (Reg.15.2)
  • Shall take into account IMO safety standards for VECS (MSC/Circ.585) (Reg.15.5)
• IMO shall circulate list of ports and terminals (Reg.15.4)
• Tankers need to install a VECS approved by Administration (Reg.15.5)
• Ports/terminals with approved VECS can accept tankers without VECS for up to 3 years after effective date (Reg.15.5)
• Tankers need to develop and implement a VOC Management Plan approved by the Administration (Reg.15.6)
  • Procedures for minimizing VOC emissions during loading, sea passage & discharge, responsible person identified, language, additional VOC during washing
• Regulation applies to gas carriers for retention of non-methane VOCs (Reg.15.7) but gas carriers not required to develop and implement a VOC management plan.
Regulation 16
Shipboard Incineration

Source: MIURA industries
Regulation 16 – Shipboard Incineration

Incineration of Annex-I, II & III cargo residues onboard is prohibited

Incineration of PCBs (Polychlorinated biphenyls) is prohibited

Incineration of PVCs (Poly Vinyl Chlorides) is prohibited in pre Annex-VI incinerators

For Annex-VI compliance, the combustion chamber temperature should reach 600 deg C within 5 minutes of start-up

All Incinerators should have a combustion flue gas outlet temperature monitoring system

Incineration outside (in drums, etc) prohibited

All Incinerators installed after 01 Jan 2000 shall be Type Approved, as per IMO Specification for shipboard incinerators.
Regulation 16 – Shipboard Incineration

• To allow approval by Administration, incinerators should be designed to comply with:
  • Resolution MEPC.244(66) on “2014 Standard Specification for Shipboard Incinerators”; or
  • Resolution MEPC 76(40) on “Standard Specification for Shipboard Incinerators”

• These Guidelines include topics:
  ✓ Scope
  ✓ Definitions
  ✓ Materials and manufacture
  ✓ Operating requirements
  ✓ Operating controls
  ✓ Other requirements
  ✓ Tests
  ✓ Certification
Regulation 16 – Shipboard Incineration

- Prohibits incineration of (Reg.16.2):
  - MARPOL Annex I, II & III cargoes, Polychlorinated biphenyls (PCB), garbage containing heavy metals, refined petroleum products containing halogens, sewage and sludge oil not generated on board, exhaust gas cleaning system residues

- Permits incineration of:
  - PVC – plastics (where type approved to do so) (Reg.16.3)
  - Sewage sludge and sludge oil permitted in boilers but not when in ports, harbours and estuaries (Reg.16.)

- Incinerators installed before 24 May 2005 on domestic shipping can be excluded by the Administration (Reg. 16.6.2)

- Operating manual, training, and temperature control (Reg. 16.7 – 16.9)
Regulation 17

Reception Facilities
Regulation 17 – Reception facilities

1. Each Party undertakes to ensure the provision of facilities adequate to meet the:
   .1. needs of ships using its repair ports for the reception of ODS and equipment ....;
   .2. needs of ships using its ports, terminals or repair ports for the reception of exhaust gas cleaning residues from an EGCS ...
   .3. needs in ship-breaking facilities for the reception of ODS and equipment ..........

2. If a particular port or terminal of a Party is remotely located from, or lacking in, the industrial infrastructure necessary to manage the above ...., then the Party shall inform the Organization of any such port or terminal...

3. Each Party shall notify the Organization ..... of all cases where the facilities provided under this regulation are unavailable or alleged to be inadequate.
Regulation 17 – Reception facilities

- Parties are obliged to provide facilities without causing delay for:
  - Reception of ODS in ship repair yards (Reg.17.1.1)
  - Reception of Exhaust Gas Cleaning System residues (Reg.17.1.2).
  - Reception of ODS in ship breaking facilities (Reg.17.1.3)

- If unable to provide reception facilities then Party shall inform IMO (Reg.17.2 & 17.3)
Regulation 17 – Reception facilities – Relevant Guidelines

- Resolution MEPC.199(62) adopted 15 July 2011
  - 2011 Guidelines for reception facilities under MARPOL Annex VI
    - Ozone Depleting Substance, EGCS residues

- MEPC.1/Circ.671, A Guide to Good Practice for Port Reception Facility Providers and Users.

- MEPC.1/Circ.644, Advance Notification Form (ANF);

- MEPC.1/Circ.645 Waste Delivery Receipt (WDR).
Regulation 17 – Reception facilities – implications

- Affecting Port & Terminal Operators, Ship Repair Yards, Ship Recycling Facilities

- When Reception Facilities are not available, Masters should ensure sufficient storage for ODS and ECGS residues

- If EGCS is installed, owners should consider onboard storage space requirements.

- Information on reception facilities is available through the IMO GISIS
<table>
<thead>
<tr>
<th>Port</th>
<th>Piraeus, Greece (GRPIR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste category:</td>
<td>Ozone-depleting substances (Annex VI)</td>
</tr>
</tbody>
</table>

**Facility details**

<table>
<thead>
<tr>
<th>Service provider:</th>
<th>AAA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of facility</td>
<td>Tr (tank truck/portable tank)</td>
</tr>
</tbody>
</table>

**Discharge restriction/limitations**

<table>
<thead>
<tr>
<th>Minimum quantity (m³):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum quantity (m³):</td>
</tr>
<tr>
<td>Maximum discharge rate (m³/h):</td>
</tr>
<tr>
<td>Other:</td>
</tr>
</tbody>
</table>

**Availability of the reception facility:** 24 hours a day, 7 days per week

**Minimum prior notice required (hours):** 24

**Charging system:** Cost charged in addition to other services

**Additional information:**
Regulation 18

Fuel Oil Availability and Quality
Regulation 18 – Fuel Oil Availability

• Parties to promote availability of compliant fuel oils and inform IMO (Reg.18.1)

• Ship found not to be in compliance (Reg.18.2.1)
  • Record of actions taken to achieve compliance
  • Need to demonstrate “best efforts” to obtain compliant fuel

• Ship should not be required to deviate or delay unduly the voyage in order to achieve compliance (Reg.18.2.2).

• Party required to take into account all relevant circumstances to determine action (Reg.18.2.3).

• Ship required to notify Administration and port of destination when unable to purchase compliant fuel (Reg.18.2.4).

• Party to notify the Organisation when ship presents evidence of non-availability (Reg.18.2.5)
Regulation 18 – Fuel Oil Quality

- Required properties of fuel oil identified (Reg.18.3).
- Excludes coal, nuclear and gas fuels from some of the provisions (Reg. 18.4).
- When bunkering fuel oil .... It is required to receive a Bunker Delivery Note (BDN) containing information in Appendix V (Reg. 18.5).
- BDN required to be retained for 3 years and be available for inspection (Reg. 18.6)
- BDN accompanied by representative sample, taken in accordance to MEPC.96(47), which is retained under the ship’s control for 12 months (Reg.18.8.1).
- Verification of bunker sample to be done in accordance with Appendix VI (Reg.18.8.2)
- Inspection and verification by PSC (Reg.18.7.1 & Reg.18.7.2).
Fuel Oil Quality – Further work?

- MEPC 67 set up a Correspondence Group (CG) with the Terms of Reference including:
  - Develop draft guidance for assuring the quality of fuel oil supplied to ships
  - Consider the adequacy of the current legal framework in MARPOL Annex VI
- At MEPC 68, it was further decided for CG to continue on the same topics and report to MEPC 69.

➤ Other issues under consideration:

- Guidelines for sampling and verification of fuel oil used on board ships
- Possible changes to BDN declaration
- List of undesirable substances that may need to be monitored included in guidance
**Regulation 18 – Bunker Delivery Note**

- BDN to include the following information:
  - Name and IMO number of receiving ship
  - Port and Date of commencement of delivery
  - Name, address and telephone number of fuel supplier
  - Product name and Quantity
  - Density
  - Sulphur content (actual)
  - Declaration signed by supplier that the fuel oil conforms with Annex VI Regulations.
Regulation 18 – Local suppliers of fuel oil

- Parties are required to:
  - Maintain a *register of local suppliers* of fuel oil (Reg.18.9.1)
  - Require local suppliers of fuel oil to provide a *certified BDN* and sample (Reg.18.9.2), and retain a copy of the BDN for 3 years (Reg.18.9.3)
  - Take action against local suppliers of fuel oil (Reg.18.9.4)
  - Inform the Administration of a ship when the ship is found to be non-compliant (Reg.18.9.5)
  - Inform the IMO of all cases of non-compliant fuel oil being supplied (Reg.18.9.6)
Effects of Regulations 14 and 18

- Possible ship design changes
- Change in ship fuel type over time
- Positive effect on fuel oil quality delivered to ships
- Additional operational requirements for crew
- Legal obligations on fuel suppliers
- Importance of commercial independent testing services
- Additional costs
6. MEPC 68

Other MARPOL Annex VI related matters
MEPC 68 (May 2015)

• Agreed a definition of Black Carbon for international shipping

• Adopted 2015 Guidelines for exhaust gas cleaning systems (resolution MEPC.259(68)) amending 2009 Guidelines as follows:
  • certain aspects of emission testing, regarding measurements of carbon dioxide (CO₂) and sulphur dioxide (SO₂),
  • clarification of the washwater discharge pH limit testing criteria and the inclusion of a calculation-based methodology for verification as an alternative to the use of actual measurements.

• Approved, for adoption at MEPC 69, draft amendments to MARPOL Annex VI regarding record requirements for operational compliance with NOₓ Tier III emission control areas
  • tier and on/off status of marine diesel engines to be recorded in log-book at entry into and exit from an ECA-NOₓ
Black Carbon

- Definition of Black Carbon for international shipping approved at MEPC 68 (May 2015)
- "Black Carbon is a distinct type of carbonaceous material, formed only in flames during combustion of carbon-based fuels. It is distinguishable from other forms of carbon and carbon compounds contained in atmospheric aerosol because it has a unique combination of the following physical properties:
  .1 strongly absorbs visible light with a mass absorption cross section of at least 5 m²g⁻¹ at a wavelength of 550 nm;
  .2 is refractory; that is, retains its basic form at very high temperatures, with vaporization temperature near 4,000 K;
  .3 is insoluble in water, in organic solvents including methanol and acetone, and in other components of atmospheric aerosol; and
  .4 exists as an aggregate of small carbon spherules."
- Measurement methods – protocol needs to be developed
- Possible control measures not considered at this stage
7. On-shore power supply (OPS)
On-shore power supply (OPS)

OPS – What?

- Supply of power from onshore (port) to a ship
- Allow a ship to turn off its engines when in port
- Variety of names:
  - On-shore power supply
  - Alternative Maritime Power (AMP)
  - Cold ironing system
  - Shoreside Electricity

On-shore power supply (OPS)

**OPS – Why?**

- Reduce exhaust emissions in port areas
- Reduce overall GHG emissions
- Provide port State/regional compliant alternative to non-compliant engine(s)

<table>
<thead>
<tr>
<th>Emission factors for auxiliary engines at berth, g/kWh of electricity</th>
<th>NOₓ</th>
<th>SO₂</th>
<th>PM</th>
<th>VOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoreside electricity (compared with 2.7% S Residual Oil (RO))</td>
<td>-97%</td>
<td>-96%</td>
<td>-96%</td>
<td>-94%</td>
</tr>
<tr>
<td>Shoreside electricity (compared with 0.1% S Marine Distillate (MD))</td>
<td>-97%</td>
<td>0%</td>
<td>-89%</td>
<td>-94%</td>
</tr>
</tbody>
</table>

Source: Service contract on Ship Emissions: assignment, abatement and market based instruments, Task 2a shoreside electricity, Entec, 2005
On-shore power supply (OPS)

OPS – Regulatory aspects

- No regulations on OPS
- There have been proposal to add some new regulations to MARPOL Annex VI.
  - IMO Marine Environment Protection Committee in 2012 (MEPC 64) considered standardization of OPS and agreed that mandatory requirements for OPS should not be developed at this stage.
- The International Association of Ports and Harbours (IAPH) provided information on the establishment of an On-shore Power Supply (OPS) website (http://www.ops.wpci.nl/) to provide practical information about OPS for seagoing vessels and shore installations.
On-shore power supply (OPS)

MEPC.1/Circ.794 (October 2012)

International Standards

  Utility connections in port – Part 1: High Voltage Shore Connection (HVSC) Systems – General requirements

- IEC/PAS 60092-510:2009
  Electrical installations in ships – Special features – High Voltage Shore Connection Systems (HVSC-Systems)
On-shore power supply (OPS)

MEPC.1/Circ.794 (October 2012)

➤ Industry guidance

➤ High Voltage Shore Connection (ABS)
   http://www.eagle.org/eagleExternalPortalWEB/ShowProperty/BEA%20Repository/Rules&Guides/
   Current/182_HighVoltage/Guide

➤ High-Voltage Shore Connection System (BV)

➤ Guidelines for High-Voltage Shore Connection System (ClassNK)

➤ Rules for Classification of Ships – Electrical Shore Connections (Part 6, Chapter 29) (DNV)

➤ Rules and Regulations for the Classification of Ships, Other Ship Types and Systems - On-shore Power Supplies (Part 7, Chapter 14) (LR)
## On-shore power supply (OPS)

### MEPC.1/Circ.794 (October 2012)

- **List of ports providing OPS**

<table>
<thead>
<tr>
<th>Port</th>
<th>Country</th>
<th>High Voltage</th>
<th>Low Voltage</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antwerp</td>
<td>Belgium</td>
<td>6.6 kV</td>
<td>50 Hz/60 Hz</td>
<td></td>
</tr>
<tr>
<td>Goteborg</td>
<td>Sweden</td>
<td>6.6 kV/10 kV</td>
<td>400 V</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Helsingborg</td>
<td>Sweden</td>
<td>400 V/440 V</td>
<td>50 HzV</td>
<td></td>
</tr>
<tr>
<td>Stockholm</td>
<td>Sweden</td>
<td>400 V/690 V</td>
<td>50 Hz</td>
<td></td>
</tr>
<tr>
<td>Piteå</td>
<td>Sweden</td>
<td>6 kV</td>
<td>50 Hz</td>
<td></td>
</tr>
<tr>
<td>Kemi</td>
<td>Finland</td>
<td>6.6 kV</td>
<td>50 Hz</td>
<td></td>
</tr>
<tr>
<td>Oulu</td>
<td>Finland</td>
<td>6.6 kV</td>
<td>50 Hz</td>
<td></td>
</tr>
<tr>
<td>Kotka</td>
<td>Finland</td>
<td>6.6 kV</td>
<td>50 Hz</td>
<td></td>
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<tr>
<td>Lübeck</td>
<td>Germany</td>
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<td>50 Hz</td>
<td></td>
</tr>
<tr>
<td>Zeebrugge</td>
<td>Belgium</td>
<td>6.6 kV</td>
<td>50 Hz</td>
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<thead>
<tr>
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<th>Country</th>
<th>High Voltage</th>
<th>Low Voltage</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>U.S.A</td>
<td>6.6 kV/11 kV</td>
<td>480 V</td>
<td>60 Hz</td>
</tr>
<tr>
<td>Long Beach</td>
<td>U.S.A</td>
<td>6.6 kV</td>
<td>480 V</td>
<td>60 Hz</td>
</tr>
<tr>
<td>San Francisco</td>
<td>U.S.A</td>
<td>6.6 kV/11 kV</td>
<td>60 Hz</td>
<td></td>
</tr>
<tr>
<td>San Diego</td>
<td>U.S.A</td>
<td>6.6 kV/11 kV</td>
<td>60 Hz</td>
<td></td>
</tr>
<tr>
<td>Seattle</td>
<td>U.S.A</td>
<td>6.6 kV/11 kV</td>
<td>60 Hz</td>
<td></td>
</tr>
<tr>
<td>Juneau</td>
<td>U.S.A</td>
<td>6.6 kV/11 kV</td>
<td>60 Hz</td>
<td></td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>U.S.A</td>
<td>6.6 kV/11 kV</td>
<td>440 V</td>
<td>60 Hz</td>
</tr>
<tr>
<td>Vancouver</td>
<td>Canada</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oslo</td>
<td>Norway</td>
<td>6.6 kV</td>
<td>440 V</td>
<td>60 Hz</td>
</tr>
<tr>
<td>Rotterdam</td>
<td>Netherlands</td>
<td>6.6 kV</td>
<td>50 Hz</td>
<td></td>
</tr>
</tbody>
</table>
Other relevant IMO Resolutions
### Other relevant IMO Resolutions

- **MEPC.181(59)** – 2009 GUIDELINES FOR PORT STATE CONTROL UNDER THE REVISED MARPOL ANNEX VI
- **MEPC.182(59)** – 2009 GUIDELINES FOR THE SAMPLING OF FUEL OIL FOR DETERMINATION OF COMPLIANCE WITH THE REVISED MARPOL ANNEX VI
- **MEPC.185(59)** – GUIDELINES FOR THE DEVELOPMENT OF A VOC MANAGEMENT PLAN
- **MEPC.244(66)** - 2014 STANDARD SPECIFICATION FOR SHIPBOARD INCINERATORS
- **MEPC.192(61)** – 2010 GUIDELINES FOR MONITORING THE WORLDWIDE AVERAGE SULPHUR CONTENT OF FUEL OILS SUPPLIED FOR USE ON BOARD SHIPS
- **MEPC.180(59)** – AMENDMENTS TO THE SURVEY GUIDELINES UNDER THE HARMONIZED SYSTEM OF SURVEY AND CERTIFICATION FOR THE REVISED MARPOL ANNEX VI
- **MEPC.190(60)** – NORTH AMERICAN EMISSION CONTROL AREA
Thank you for your attention

ANY QUESTIONS?

For more information please see:

www.imo.org