MARPOL 73/78 Annex VI

Regulations for the Prevention of Air Pollution from Ships

Technical and Operational implications

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MANAGING RISK DNV

Content:

1. Introduction

MARPOL 73/78 Annex VI *Regulations for the prevention of Air Pollution from ships* will enter into force on 19 May 2005, and includes many new aspects related to design of ships, but even more related to operational issues.
The intention with this paper is to highlight some of the most important aspects of MARPOL Annex VI for the guidance of Ship owners and Managers, as well as DNV surveyors.

2. Annex VI in general

The adoption of MARPOL Annex VI has followed some years of debate within organisations. At the same time IMO Technical code on the Control of Emissions of Nitrogen Oxides from Marine Diesel Engines was adopted. MARPOL Annex VI and the Technical Code have retroactive requirements for diesel engines 130 KW and above installed on ships keel-laid on or after 1 January 2000, and Incinerators installed onboard on or after 1 January 2000.

MARPOL Annex VI will apply to all ships, fixed and floating drilling rigs and other platforms from 19 May 2005, but the certification requirements are depending on size of the vessel and time of periodical survey.
Ships of 400 gross tons and above engaged in international voyages involving countries that have ratified the conventions, or ships flying the flag of those countries, are required to have an International Air Pollution Prevention Certificate (IAPP Certificate).
This certificate must be on board at delivery for a ship constructed (keel laid) after 19 May 2005.
For ships constructed before this date, the IAPP certificate must be on board at the first scheduled dry-docking after 19 May 2005, but not later than 19 May 2008.

The IAPP certificate will be issued following an initial survey carried out by the Flag Administration or by a recognised organization (e.g. Det Norske Veritas) on behalf of the Flag Administration, confirming compliance with MARPOL Annex VI. For ships with the flag of an Administration that have not yet ratified Annex VI, a Certificate of Compliance with Annex VI may be issued by DNV.

Annex VI also requires diesel engines (as described above) to carry individual certificates with regard to NOx emissions, named Engine International Air Pollution Prevention (EIAPP) Certificates.

Annex VI requires that every ship of 400 gross tonnage or above and every fixed and floating drilling rig and other platforms shall be subject to the following surveys:

- An initial survey before the ship is put into service or before the IAPP Certificate is issued for the first time.
- Periodical surveys at intervals specified by the Administration, but not exceeding five years.
- A minimum of one intermediate survey during the period of validity of the certificate.

In the case of ships of less than 400 gross tons, the Administration may establish appropriate measures in order to ensure that Annex VI is complied with.

The Administration shall arrange for unscheduled inspections during the period of validity of the certificate. If the Administration establishes mandatory annual surveys, these unscheduled inspections shall not be obligatory, and for this purpose DNV has so far considered that all Administrations will apply a system with mandatory annual surveys.

Annex VI has requirements to the following main issues, which will be highlighted more in detail in this paper.

- Regulation 12 - Emissions from Ozone depleting substances from refrigerating plants and fire fighting equipment.
- Regulation 13 - Nitrogen Oxide (NOx) emissions from diesel engines
- Regulation 14 - Sulphur Oxide (SOx) emissions from ships
- Regulation 15 - Volatile Organic compounds emissions from cargo oil tanks of oil tankers
- Regulation 16 - Emissions from shipboard incinerators.
- Regulation 18 - Fuel Oil quality.

2.1 Application for ships keel-laid before 1 January 2000

Ships constructed (keel-laid) before 1 January 2000 need to comply with operational requirements in MARPOL Annex VI from 19 May 2005. Unless existing engines are subject to major modification, or new engines or incinerators are fitted, the requirements in Regulation 13 and constructive requirements in Regulation 16 do not apply.
Formal certification of the ships applies at the first scheduled dry-docking after 19 May 2005.

3. Regulation 12 – Ozone depleting substances

Annex VI prohibits any deliberate emissions of ozone-depleting substances. Ozone-depleting substances, and equipment containing such substances, shall be delivered to appropriate reception facilities when removed from a ship.
New installations which contain ozone-depleting substances are prohibited on all ships after the entry into force date, except that new installations containing hydrochlorflourocarbons (HCFCs) are permitted until 1 January 2020.
The use of Halon in fire extinguishing systems and equipment is already prohibited for newbuildings. For newbuildings, this requirement in Annex VI will therefore always be complied with.
More restrictive requirements for ozone depleting substances are in place regionally, e.g. in the European Union (EU).

4. Regulation 13 – Nitrogen Oxides (NOx)

4.1 Regulations/Definitions from Annex VI

Regulation 13 of Annex VI concerns NOx-emission from diesel engines and shall apply to:

- *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*
- *each diesel engine with a power output of more than 130 kW which undergoes a major conversion on or after 1 January 2000.*

This regulation does not apply to:

- *Emergency diesel engines, engines installed in life boats or for any equipment intended to be used solely in case of emergency.*

The phrase *"major conversion"*, means a modification of an engine where:

- *the engine is replaced by a new engine built on or after 1 January 2000, or*
- *any substantial modification is made to the engine, as described in the NOx Technical Code 1.3.2 (e.g. changing camshaft, fuel injection system, or any other NOx-related settings or components), or*
- *the maximum continuous rating of the engine is increased by more than 10%*

For this purpose, *Substantial Modification* is defined as follows:

- For engines installed on vessels constructed on or after 1 January 2000, a 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.

- For engines installed on vessels constructed before 1 January 2000, a 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(Ref. NOx Technical file.). These changes include, but are not limited to, changes in its operations or in its technical parameters (e.g. changing camshaft, fuel injection systems, air systems, combustion chamber configuration, or timing calibration of the engine)

According to Annex VI the operation of applicable diesel engines are prohibited except when the emission of nitrogen oxides from the engine is within the following limits:

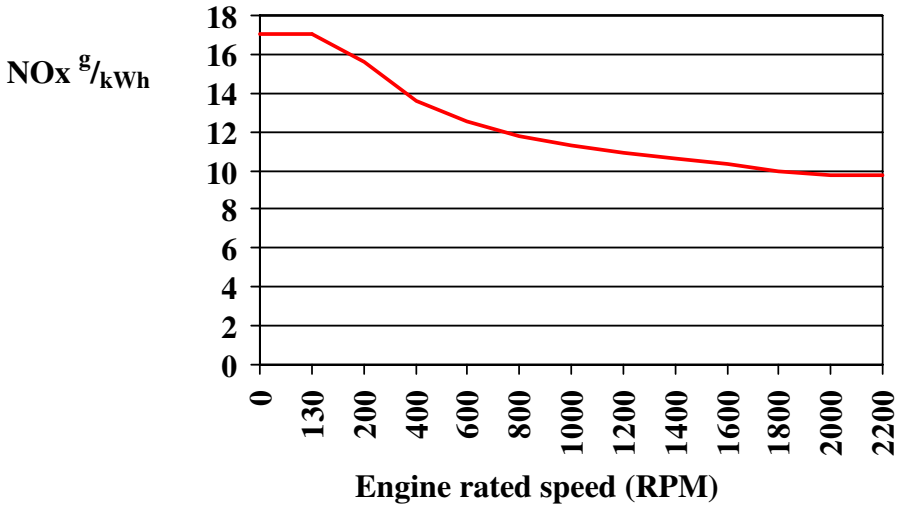
(i) 17,0 $^{g}/_{kWh}$ when n is less than 130 rpm

(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 revolution per minute) and the emission of nitrogen oxides are calculated as total weighted emission of NO_2

The table below illustrates the allowable NOx emissions from diesel engines:



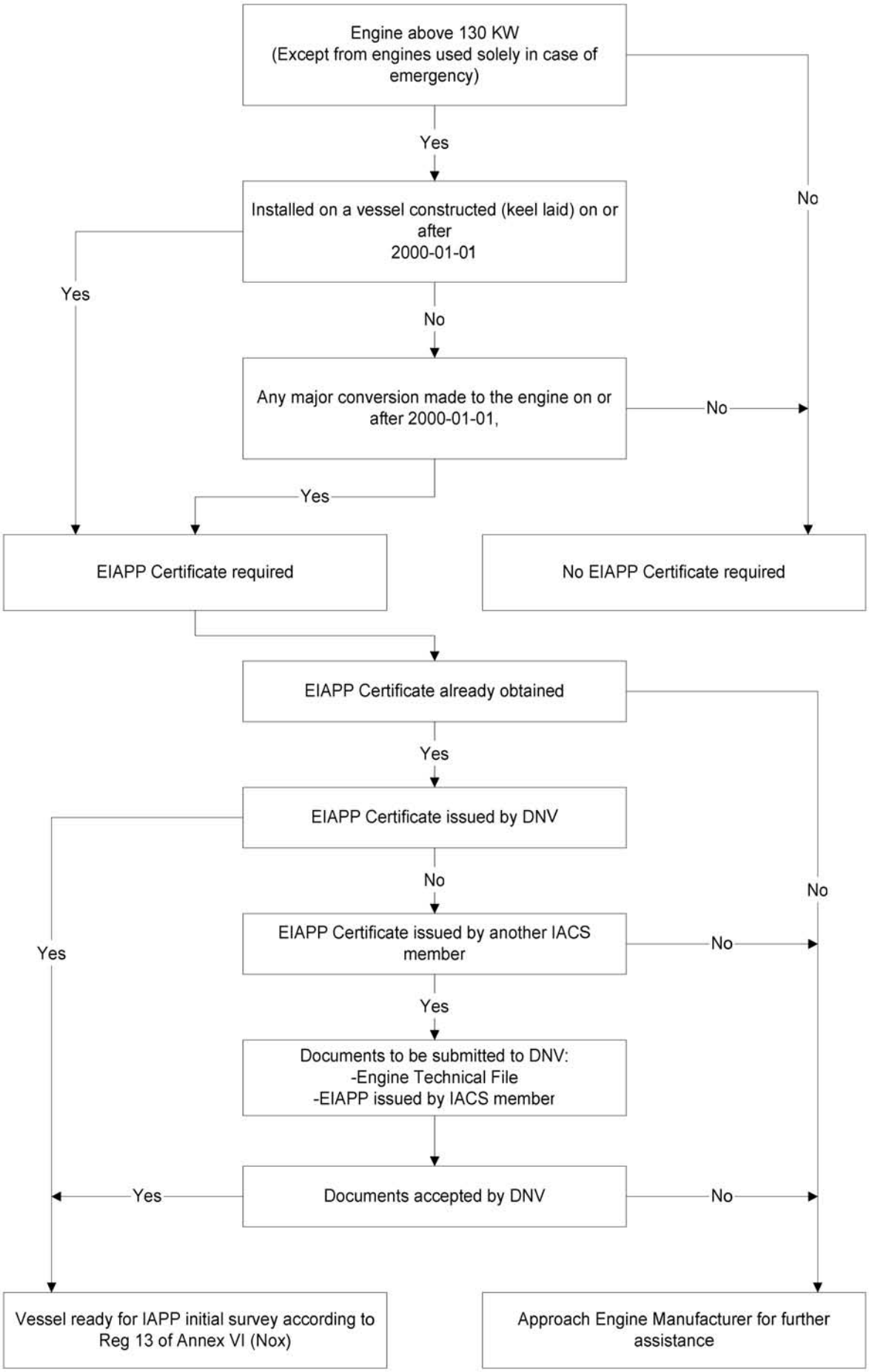
4.2 Certification and onboard verification

The EIAPP (Engine International Air Pollution Prevention) certificate is required for all diesel engines as described above, and will be issued for marine diesel engines after demonstrating compliance with NOx emission limits. The certification process is to be carried out in accordance with the NOx Technical Code issued by IMO.

In order to decide whether your engines need EIAPP certificates or not, we can advise you to consider the following for your vessels and engines:

- Engine power output above 130 kW?
- Is the vessel constructed (keel laid) before or after 1 January 2000?
- Major conversion of the engine on or after 1 January 2000?

As a general guidance, see the flow chart on the next page.


Engine above 130 KW
(Except from engines used solely in case of emergency)
Yes
No
Installed on a vessel constructed (keel laid) on or after
2000-01-01
Yes
No
Any major conversion made to the engine on or after 2000-01-01,
No
Yes
EIAPP Certificate required
No EIAPP Certificate required
EIAPP Certificate already obtained
Yes
No
EIAPP Certificate issued by DNV
Yes
No
EIAPP Certificate issued by another IACS member
No
Yes
Documents to be submitted to DNV:
-Engine Technical File
-EIAPP issued by IACS member
Documents accepted by DNV
Yes
No
Vessel ready for IAPP initial survey according to Reg 13 of Annex VI (Nox)
Approach Engine Manufacturer for further assistance

The flow chart above is meant as a general guidance indicating the necessary steps for you to consider regarding the NOx requirements of Annex VI. Please note that the flow chart is only concerning the NOx requirements to the diesel engines, and this is also what the EIAPP certificate is covering.
If you find that your engines are required to carry an EIAPP certificate, but for some reason they don't have this, our advice is for you to approach the engine manufacturer for further assistance.

The certification process includes an emission test for compliance with the NOx requirements on the manufacturer's test bed, and approval of the Technical File.
All certified engines are delivered with an individual Technical File that contains the engine's specifications for compliance with the NOx regulation, and the applicable onboard verification procedure.

The NOx Technical Code opens for 3 different onboard verification procedures:

- Engine parameter check method
- Simplified measurement method
- Direct measurement and monitoring method

The applicable onboard verification procedure is initially decided by the engine manufacturer, and is usually a specific chapter in the engine's Technical File. The by far most common method is the Engine parameter check method, but the ship owner is free to use the method they prefer. If they wish to change to another method than the one specified in the Technical File, the new onboard verification procedure must be submitted to the Administration (or DNV on behalf of the Administration when authorised) for approval before taken into use.

4.2.1 Engine parameter check method

For the purpose of assessing compliance with Regulation 13 of Annex VI, it is not always necessary to measure the NOx level to know that an engine is likely to comply with the NOx emission limits. It will 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.

The engine's Technical File is identifying its components, settings and operating values that influences the exhaust emissions and these must be checked to ensure compliance during surveys and inspections.
Ship owners or people responsible for vessels equipped with diesel engines required to undergo an engine parameter check method shall ensure that the following documentation is kept onboard and updated as applicable:

- Technical File including the onboard verification procedure.
- Record book of engine parameters for recording all of the changes made relative to an engine's components and settings. Also to include technical documentation in case of modification of any of the engine's designated components.
- EIAPP certificate (Statement of Compliance) for each applicable engine.

The NOx-influencing components and settings depend on the design of the particular engine, and shall be listed in the engine's Technical File. The below list shows typical NOx-influencing parameters:

- Injection timing
- Injection system components (nozzle, injector, fuel pump)
- Injection pressure
- Camshaft components (fuel cam, inlet- and exhaust cam)
- Valve timing
- Combustion chamber (piston, cylinder head, cylinder liner)
- Compression ratio (connecting rod, piston rod, shim, gaskets)
- Turbocharger type and build (internal components)
- Charge air cooler/charge air pre-heater
- Auxiliary blower
- NOx reducing equipment "water injection"
- NOx reducing equipment "emulsified fuel" (fuel/water emulsion)
- NOx reducing equipment "exhaust gas recirculation"
- NOx reducing equipment "selective catalytic reduction"

The actual Technical File of an engine may include less components and/or parameters other than the list above, depending on the particular engine and the specific engine design.

4.2.2 Simplified measurement method

For onboard verification tests during periodical and intermediate surveys, the NOx Technical Code opens for a simplified measurement method. Note that every first engine test for certification shall be performed on the engine maker's test-bed.

The simplified measurement method is to be performed more or less like the parent testing on the test-bed, but simplifications according to the NOx Technical Code 6.3 are accepted.
However, the testing shall be performed in accordance with the applicable test cycle as specified in the engine's Technical File. This involves full load running of the engine for about 20 minutes, and will in most cases require a test trial.

Due to the possible deviations when applying the simplified measurement method, an allowance of 10% of the applicable limit value is accepted for confirmation tests and during periodical and intermediate surveys.

4.2.3 Direct measurement and monitoring method

The ship-owner will have the option of direct measurement of the NOx emissions during the engine operation. Such data can either 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 they can result from continuous monitoring and date storage. Data must be taken within the last 30 days, and must have been acquired using the test procedures given in the NOx Technical Code. These monitoring records are to

be kept onboard for at least three months for verification purposes. We would however recommend maintaining the documents, on board or in shore office, for a longer period of time.
To demonstrate the compliance by the direct measurement method, sufficient data shall be collected to calculate the weighed average NOx emissions in accordance with the NOx Technical Code.

It should be noted that the two methods that involve measuring of the exhaust emissions do not include any kind of identification markings of the NOx-influencing components.

4.3 Spare parts and spare parts policy

One of the main consequences of MARPOL Annex VI is that the onboard verification procedure "Engine parameter check method" requires identification markings on the NOx influencing components. These components are typically those specified in above list.

All the components listed are to be fitted with identification markings according to the Technical File. Please note that these markings may not be the same as the article no's usually found on the engine components.

DNV, on behalf of the Flag Administration, can not accept any other markings than those stated in the Technical File. Manufacturer's producing engines on licensee from an engine designer usually have their own Id Numbers on the engine components. Since these numbers may differ from the designer's Id Numbers, it may be advisable to ask the licensee to also include the designer's Id No's in the Technical Files.
In order to make the purchasing easier, it could be an idea to keep a copy of the Technical Files in the purchasing section.

There may be situations where the engine maker comes up with a new design for one of the NOx-influencing components, with a different Id No from what's stated in the Technical File. The new design should then be approved by the Administration (or DNV on behalf of a Flag Administration when authorised) and the change is to be documented in the *"Record book of engine parameters"*. The same is applicable for all other changes the engine may be approved for during its lifetime.

4.4 Surveys and inspections

Following the regime of the IAPP certificate, the diesel engines will also be subject for the following surveys:

- An initial survey before the ship is put into service or before the IAPP Certificate is issued for the first time.
- Periodical surveys at intervals specified by the Administration, but not exceeding five years,
- A minimum of one intermediate survey during the period of validity of the certificate.

- Annual Surveys (or a Flag Administration may instead implement unscheduled inspections as an alternative to Annual surveys)

If the “Engine Parameter Check Method” is the selected onboard verification procedure, the surveyor will typically want to see:

- EIAPP Certificates for all applicable diesel engines onboard
- Approved Technical Files including “Onboard verification procedure” for all the applicable diesel engines onboard
- Record Book of Engine parameters for all the applicable diesel engines onboard
- One or all of the identified components, settings or operating values specified in the engines’ Technical File

If the “Simplified Measurement Method” is the selected onboard verification procedure, the surveyor will witness the testing in addition to review the following documentation:

- EIAPP Certificates for all applicable diesel engines onboard
- Approved Technical Files including “Onboard verification procedure” for all the applicable diesel engines onboard
- All recommendations from engine manufacturer and approvals from the Administration concerning the “Simplified Measurement Method”
- Test results

If the “Direct Monitoring and Measurement Method” is the selected onboard verification procedure, the surveyor will typically want to see:

- EIAPP Certificates for all applicable diesel engines onboard
- Approved Technical Files including “Onboard verification procedure” for all the applicable diesel engines onboard
- Documentation/Approval of the installed measuring equipment
- Logged measurement results in order to verify that the engines comply with the NOx Technical Code.

Regardless of what onboard verification procedure the Ship-Owner chooses, the IAPP Certificate for the vessel will be issued if all other requirements are found to comply with the applicable requirements.

4.5 Engines with EIAPP certificates issued by another company

There are a number of different companies that are certifying diesel engines with regard to NOx-emissions. DNV, on behalf of the Flag Administration, can only accept certification from companies that are authorised by the applicable flag to perform certification on their behalf. This procedure will be based on a case-by-case approval. The certificates and Technical Files, including all possible upgrades, are to be submitted to DNV for review.

5. Regulation 14 - Sulphur Oxides (SOx)

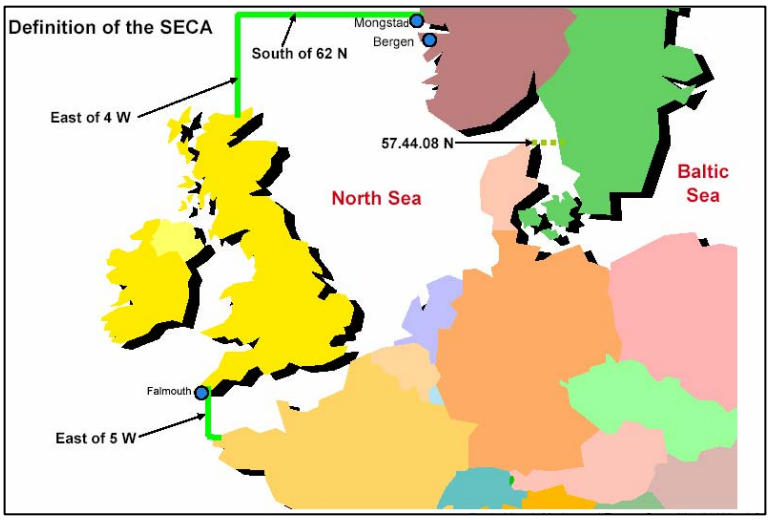
5.1 General

Upon entry into force of Annex VI to MARPOL on the 19 May 2005, the sulphur oxide (SOx) emissions from ships will be controlled by setting a limit of 4.5% on the sulphur content of marine fuel oils.

Further, a limit of 1.5% on the sulphur content of marine fuel oil will apply in designated SOx Emission Control Areas (SECAs). IMO has currently agreed on the designation of two SECA's as per below. The first designated SECA is the Baltic Sea Area which has been agreed that will enter into force on the 19 May 2006.

The second area, the North Sea Area and the English Channel has also been agreed, but due to the amendment process in IMO, it has been indicated that it will not enter into force as a SECA until 19 November 2007. It is expected that further SECA's will be designated in the future and IMO has set forth certain criteria for designating such SECA's. It should however be noted that the amendment process within IMO may take considerable time.

For the sake of good order, it should be noted that the limitations in sulphur content applies to all fuel oils (heavy fuel oils, marine diesel oils and gas oils) and regardless of use on board (i.e. in combustion engines, boilers, gas turbines etc.).



Indication of SECA's

Currently, the average sulphur content in fuel oils is in the region of 2.7%. Results of the comprehensive number of fuel samples tested by DNV Petroleum Services indicate that only 0.2% of the fuel oils tested have a sulphur content exceeding the required 4.5%. However, it also indicates that only 4% of the fuel oils supplied today have a sulphur content of 1.5% or less.

It has been estimated that the low sulphur fuel oil demand in the SECA's will be in the region of 14-20 million tons per year, of which approximately 0.7 million tons per year is available in North West Europe today.

While certain owners with a high environmental profile currently have a sulphur limit of 1.5% in their fuel specifications, the sulphur content of the fuel is generally dependent on the composition of the crude oil from which it is refined. Increasing the output of low sulphur fuel oil can be obtained through the following:

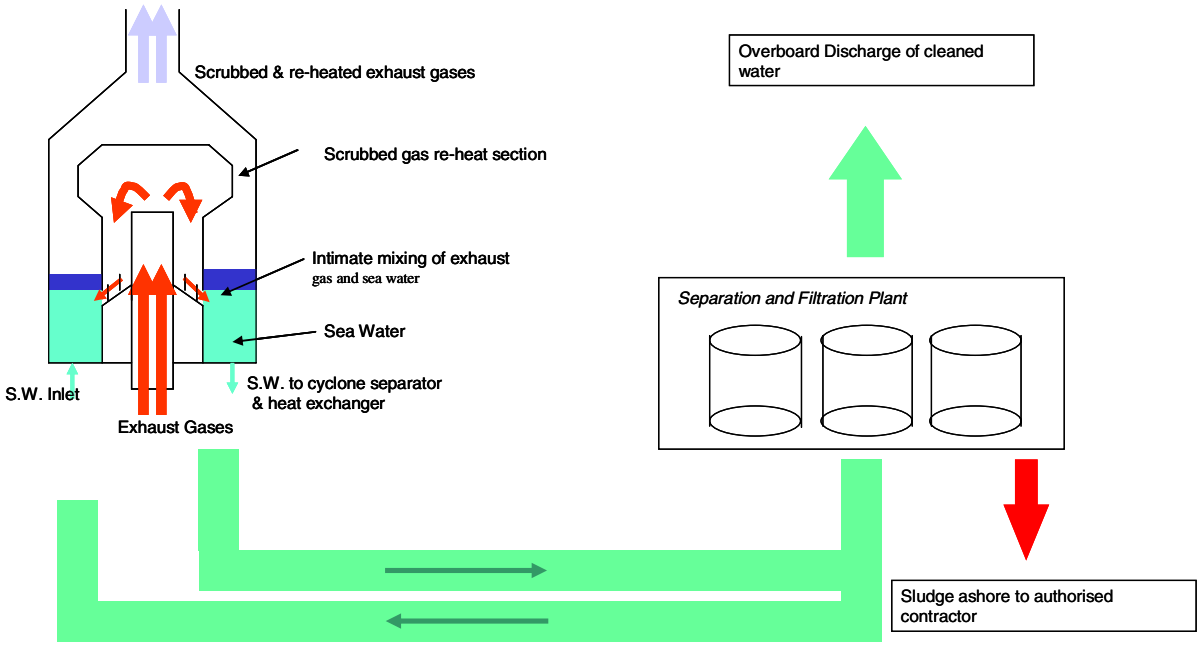
- Refining of naturally occurring low sulphur crude oils.
- Re-direct/blend inland grade fuel to the marine fuel market.
- Re-blending of residual fuel oils down to the required specification.
- Residue de-sulphurisation (Note that large scale investments in residue de-sulphurisation units are not expected to be made until a substantial price difference between high and low sulphur fuels are achieved).

It is generally acknowledged that the above will lead to increased prices for low sulphur fuel oils and a price hike from 25 to 100 USD/ton has been indicated depending on method of production and market availability/demand.

Although it has been indicated that the total world wide availability of low sulphur fuel is adequate with the current SECA's and associated low sulphur limit (1.5%), it is highly uncertain as to whether the availability will be adequate in world wide ports. It should further be noted that currently, low sulphur fuel is in general only available to operators with contract agreements with Oil Majors. Future spot availability is thus dependent on the developments in market demand and price after entry into force of SECA's.

5.1.1 Exhaust Gas Cleaning systems

As an alternative to using marine fuel oil with a 1.5% sulphur content in SECA's, an exhaust gas cleaning system or other equivalent system may be used (abatement technologies). The emission criteria for such systems are 6 g SOx/kWh.



Exhaust gas cleaning system

Development of a type approval standard for such systems is ongoing in IMO. The current available abatement technology is based on seawater scrubbing principles. There is however a few concerns related to these types of scrubber type systems:

- Annex VI states that port states may prohibit discharge of scrubber effluent overboard in ports within SECA's unless it can be documented that the effluent complies with criteria set by that port state. A mitigating measure is installation of filtration/treatment systems.
- It has been indicated that conventional scrubber technology may be struggling to meet the emission criteria at high exhaust gas discharge flows.
- It has been indicated that there is a risk of blue-sheen originating from the scrubber overboard discharge. Although, not necessarily constituting an environmental hazard, the mere risk of such occurrences is to some operators unacceptable.
- There are space considerations in the engine room and more specifically the funnel. Although it has been indicated that the more advanced scrubber types can replace standard silencers, the associated piping systems may represent a challenge. Pressure drop in scrubbers has also been indicated as a limitation, particular in way of main engines uptakes.
- Tanker owners have had mixed experiences with corrosion of inert gas scrubbers and associated piping systems.
- The EU has been reluctant to accept scrubbers. However, in the latest proposed amendments to the EU directive, they have opened for "trials of ship emission abatement technologies". Based on such trials they have indicated that they may accept abatement technology as an equivalent to low sulphur fuel. Note that EU has indicated that it will develop criteria for resulting waste streams in their ports.

Regrettably, the number of development projects related to new scrubber technology appears to be limited. However, some projects currently in the prototype phase show promising results in terms of overcoming the above indicated constraints. It should also be taken into account that exhaust gas cleaning alternatives will reduce the emission of particulate matter (PM). Particulate matter is considered to be the next focal point of IMO and this increases the future relevance of exhaust gas cleaning systems.

Despite the indicated installation costs of 1-2 mill USD, future legislation, and elimination of the problems associated with low sulphur fuel bunker management and operation, may lead to exhaust gas cleaning systems becoming a cost-beneficial alternative worthwhile exploring.

5.2 EU Directive 1999/32/EC with proposed amendments

In connection with MARPOL Annex VI one cannot disregard ongoing low-sulphur developments in the EU.
EU directive 1999/32/EC has been amended a number of times, and in force today is the following:

- Member states to ensure that Marine Distillates used within their territory from July 2000 do not exceed 0,2% Sulphur (0,1 % from January 2008).

  In other words, ships must ensure that if they are using Marine Distillates in EU territory (territorial waters including seas 12 nautical miles from shore and inland waterways), their sulphur content is below 0,2%.
  Marine Distillates in this context include both marine gas oils and marine diesel oils (DMX, DMA, DMB and DMC). As far as DNVPS has been informed this requirement is currently only enforced by Dutch Authorities

Amendment to EU directive 1999/32/EC reached a common position in July 2004, and although the amendment process is in its final stages, implementation date is highly uncertain and further amendments cannot be ruled out. As of July 2004 the following is in the pipeline:

- A 1.5% sulphur limit for fuels used by all ships in the Baltic Sea, North Sea & Channel in accordance with the implementation dates of Annex VI to MARPOL (i.e. starting in 19 May 2006 for the Baltic Sea Area). As of 19 May 2006, EU member states shall ensure that the sulphur content in marine diesel oils (ISO 8217 grades DMB and DMC) supplied within their territory does not exceed 1.5%.
- A 1.5% sulphur limit for fuels used by passenger vessels on regular services between EU ports as of 19 May 2006.
- A 0.1% sulphur limit on fuel used by inland vessels and by seagoing ships at berth in EU ports. The Council agreed this limit delayed until 1 January 2010, to allow single-fuel ships time to adapt their fuel tanks.
- A further two year delay has been proposed given to 16 unifuel (vessels using heavy fuel oil for both main and auxiliary engines) ferries serving the Greek islands.
- As of 1 January 2010, EU member states shall ensure that the sulphur content in marine gas oils (ISO 8217 grades DMX and DMA) supplied within their territory does not exceed 0.1%.
- For ships arriving from outside the EU, the requirement need only be complied with upon leaving the EU port of call.

5.3 Low sulphur heavy fuel

It has been indicated that experience in terms of low sulphur residual (or heavy) fuel oil blending is varying and that quality problems are to be expected. Although there is limited usage of (blended) low sulphur fuel oils, DNV Petroleum Services has already seen indications that the low sulphur processing of fuel oils may lead to additional quality problems such as instability, incompatibility, ignition and combustion difficulties and an increase of catalytic fines levels. Regrettably one has also seen

cases where chemical waste has been introduced in such fuel. In light of the required demand for low sulphur fuel oils, there have also been concerns over the potential increase of sulphur content in high sulphur fuel oils.

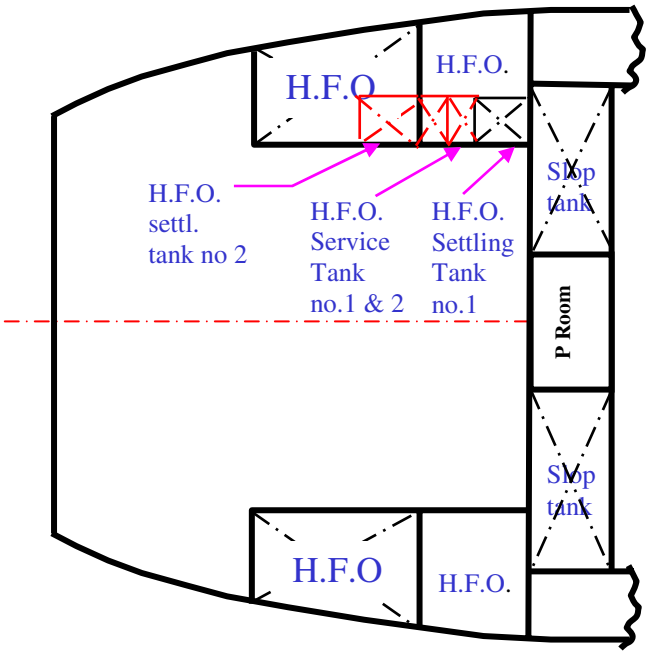
5.3.1 Fuel tank/system configuration

It should be noted that when approaching a SECA the fuel must be changed over to the 1.5% sulphur content fuel and completed before entering the SECA. For ships with standard fuel oil system configurations (one service and settling tank), this will involve filling of settling tanks with low sulphur fuel oil, adequate fuel treatment of same and subsequent filling of service tank, as well as flushing of the fuel service piping systems of high sulphur fuel oil.

The current problems with incompatibility between heavy fuel oils, and between heavy fuel oils and marine diesels are not expected to disappear with increased demands for low sulphur heavy fuel oils (excessive sedimentation/sludging and separator and filter problems). Considering the differences in cost, some owners are installing an additional set of service and settling tanks for low sulphur fuel oils. Additional bunker tanks are considered installed for the same reasons. Such measures would also simplify change-over procedures and bunker management. Inadequate availability of low sulphur heavy fuel oils may force owners to increase the consumption of low sulphur diesel oils within SECA's. Owners will therefore have to assess whether the diesel oil tank capacity needs to be upgraded. Taking into account the current EU requirements to use of ultra low sulphur distillates within its territories, and not to mention the proposal for ultra low sulphur fuel at berth in EU ports, there is also an issue of whether to allocate or convert existing fuel tanks to tanks for marine gas oil.
The differences in cost between low and high sulphur heavy fuel oils as well as between heavy fuel oils and low sulphur diesel oils, has led some owners to consider separating fuel treatment and service piping systems. This is increasingly important with respect to potential requirements to use of ultra low sulphur fuels in EU ports (Auxiliary engines and boilers).

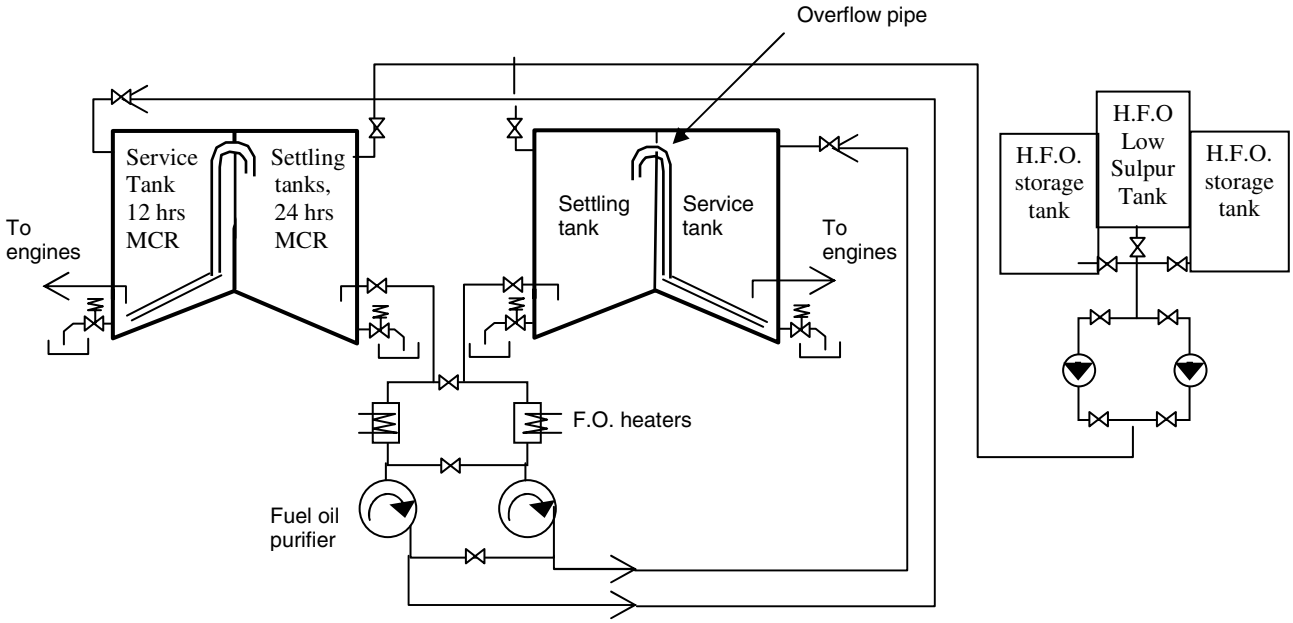
In order to facilitate safe and simple change-over, the installation of separate marine gas oil/diesel oil supply piping with heating capabilities should be considered. (While separate direct diesel oil supply lines are often arranged for auxiliary diesel engines, the same is less frequently encountered for boilers and main engines.)

The below serves as examples of proposed modifications regarding duplicated heavy fuel oil service and settling tanks and piping systems.



Possible arrangement for additional fuel oil tanks.

The below shows the arrangement of fuel oil tank piping arrangement as per the optional DNV class notation FUEL, which enables handling of different fuel qualities.



Handling of different fuels.

5.3.2 Change-over procedures

Change-over between heavy fuel oil grades is standard practice and so is change-over from heavy fuel oil to marine diesel oil in connection with e.g. dry-dockings.

Change-over from heavy fuel oil to marine gas oil is however completely different and clearly not common standard. If gas oil is mixed in while the fuel temperature is still very high, there is a high probability of gassing in the fuel oil service system with subsequent loss of power.
It should be acknowledged that the frequency and timing of such change-over may increase and become far more essential upon entry into force of SECA's and the EU proposed amendments
Additionally, the time, ship's positions at the start and completion of change-over to and from 1.5% fuel oil must be recorded in a logbook (e.g. ER log. book), together with details of the tanks involved and fuel used. It can be anticipated that the same will be applicable with respect to the EU proposal upon entry into force.

5.3.3 Bunker management

In view of the change-over requirements, bunker grade segregation constraints, uncertainty in terms of low-sulphur fuel oil availability and potential quality problems, the flexibility in bunker management may be impaired. In addition to the potential increase in fuel oil cost, it could also result in increased frequency of bunkering. Further, owners/managers and charterers may need to amend their bunker specifications, fuel supply agreements as well as charter parties to take the new requirements into account.

5.3.4 Charts

Due to the introduction of SECA's and associated change-over procedures, it need be ensured that onboard charts are upgraded with respect to SECA borders.

5.3.5 Operating Engines and Boilers on Low Sulphur Fuels.

Operating Engines and Boilers on these fuels, including ultra low sulphur distillates, have many challenges, and some guidance and experience is given in Appendix 1 of this paper.

6. Regulation 15 – Volatile Organic Compounds

Emissions of volatile organic compounds (VOCs) from tankers may by each party to Annex VI be regulated in its ports and terminals. Such requirements shall be given in a list published by IMO. The list shall also specify size of tankers, and which cargoes, that requires vapour emission control system.

All tankers which are subject to vapour emission control in accordance with above list shall be provided with an approved vapour collection system, and shall use such system during the loading of such cargoes.

Existing tankers which are not fitted with vapour collection systems may be accepted for a period of three years after the terminal was included in the above list.

DNV has for many years had class notations VCS 1 and 2 for vapour control systems complying with IMO Guidelines (MSC/Circ.585), and USCG regulations. It may be noted that a vessel complying with VCS- 1 or 2 will comply with regulation 15.

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.

7. Regulation 16 – Shipboard Incineration

Onboard incineration outside an incinerator is prohibited except that sewage sludge and sludge oil from oil separators may be incinerated in auxiliary power plants and boilers when the ship is not in ports, harbours and estuaries.

Incineration of Annex I, II and III cargo residues, of PCB's (Polychlorinated biphenyls), of garbage containing more than traces of heavy metals and of refined petroleum products containing halogen compounds is always prohibited.

Incineration of PVC’s (polyvinyl chlorides) is prohibited except in shipboard incinerators type approved according to resolutions MEPC 59(33) or MEPC 76(40).

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. It must be ensured that the incinerators' flue gas outlet temperature monitoring system is operational.

All incinerators installed on or after 1 January 2000 shall be type approved in accordance with Resolution MEPC 76(40) giving the IMO standard specification for shipboard incinerators. For such incinerators a manufacturer's operating manual is required.

8. Regulation 18 – Fuel Oil Quality

8.1 General

While fuel oil quality is currently primarily a matter between owners/managers (and charterers) and suppliers, it will under Annex VI of MARPOL 73/78 also become a statutory matter.

In addition to requirements limiting the sulphur content of oil fuel, Annex VI contains requirements preventing the incorporation of potentially harmful substances, and in particular waste streams (e.g. chemical waste), into fuel oils.

Regulation 18 specifically requires that fuel oil supplied to ships is to be free from inorganic acids or chemical wastes that could jeopardise the safety of the ship, be harmful to ships' personnel, or which would contribute overall to additional air pollution. The addition of small amounts of additives intended to improve performance is however permitted.

Incidentally, the requirements to fuel oil quality in Regulation 18 are more or less identical to the general requirements of ISO 8217, although no references are made to the same. Accordingly one question raised has been whether a fuel found off-spec compared to ISO 8217 test parameters is in violation of Regulation 18. Consultations with certain port states indicate that this will likely not be the case. Instead it has been indicated that Regulation 18 may be enforced in case a ship is involved in accidents or near-accidents where fuel quality is a suspected contributor.

8.2 Operational issues

It is important to note that elaboration and clarifications relating to Regulation 18 are found in Resolution MEPC. 96(47) “Guidelines for the sampling of fuel for determination of compliance with Annex VI of MARPOL 73/78”. Although this is a guideline, it is expected that the guideline will be used as requirements by port state inspectors. It should be noted that Intertanko has issued a thorough and useful guideline related to Annex VI which elaborates on the issues at hand.

8.2.1 Bunker delivery notes

It is a requirement of Regulation 18 that any fuel oil for combustion purposes delivered to and used onboard shall be recorded by means of a Bunker Delivery Note (BDN). This implies that a bunker delivery note shall be presented for every barge delivery and every grade.

Bunker Delivery Notes are required to contain all specific information as follows:

- Name and IMO number of receiving ship
- Bunkering Port
- Date of commencement of bunkering
- Name, address, and telephone number of marine fuel oil supplier
- Product name
- Quantity (metric tons)
- Density at 15 ^{o}C (kg/m3)
- 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 and 18 (I.e. that the fuel supplied has a sulphur level below 4.5% and that the fuel is free from inorganic acid, does not include any added substance or chemical waste which either jeopardises the safety of ships, adversely affects the performance of the machinery, is harmful to personnel, or contributes overall to additional air pollution).

Further, Resolution MEPC.96(47) recommends that the seal number of the associated MARPOL Annex VI fuel sample is included in the BDN's for cross-reference purposes.

The BDN's are to be kept on board and readily available for inspection at all times. It shall be retained for a period of three years after the fuel oil has been delivered on board.

8.2.2 MARPOL 73/78 Annex VI fuel oil samples

Regulation 18 requires that every BDN is to be accompanied by a representative sample of the fuel oil delivered, taking into account the guidelines in Resolution MEPC.96(47).

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 12 months from the time of delivery. Although MEPC.96(47) specifies that the volume of the sample bottle should be no less than 400 ml, due to potential need for repetitive testing, Intertanko has recommended that the sample volume is not to be less than 750 ml.

For the sake of good order it should be noted that the practical purpose of this sample is to enable port states to verify the sulphur content of the fuel, as well as to verify that the fuel oil quality is in accordance with Regulation 18.

As Annex VI specifies that the Annex VI sample is not to be used for commercial purposes, DNV Petroleum Services recommends that for ship's already participating in a fuel oil quality testing scheme, the Annex VI sample should be the fourth sample (in addition to the sample sent to laboratory for testing, suppliers sample and the retained onboard sample). The reason is that it is considered an advantage to always have an Annex VI sample onboard in case of port state controls.

8.2.3 Sampling procedures

Note that the referred to Resolution MEPC.96(47) specifies in detail that the fuel sample is to be obtained at the receiving ship's inlet bunker manifold and is to be drawn continuously throughout the bunker delivery period. The term continuously drawn is specified to mean a continuous collection of drip sample throughout the delivery of bunker fuel. Sampling methods are further clarified as either; manual valve-setting continuous-drip sampler (equivalent to DNV Petroleum Services' Line

sampler), time-proportional automatic sampler, or flow-proportional automatic sampler.

Further the guidelines specify that sample bottle labels are to contain the following information:

- Location at which, and the method by which, the sample was drawn
- Bunkering date
- Name of bunker tanker/bunker installation
- Name and IMO number of the receiving ship
- Signatures and names of the supplier's representative and the ship's representative
- Details of seal identification
- Bunker grade.

8.2.4 Sample inventory

Resolution MEPC.96(47) also contains recommendations on sample storage location. Specifically the samples are to be kept in a safe storage location, outside the ship's accommodation and where personnel would not be exposed to vapours which may be released from the sample. Further, the retained sample should be stored in a sheltered location where it will not be subject to elevated temperatures, preferably at a cool/ambient temperature, and where it will not be exposed to direct sunlight. On tankers, the cargo sample locker would be considered an adequate storage space. Alternatively, a suitable locker (with opening ensuring adequate air flow) in an adequately ventilated area of the engine room located at a safe distance from ignition sources and hot surfaces may be considered

The above guideline also recommends that an inventory system is developed (e.g. log book) to keep track of the retained samples.

8.2.5 Supplier's responsibility

While most IMO conventions place full responsibility on the ships and ship owners, Regulation 18 places a certain responsibility on the suppliers (fuel oil quality

declaration, BDN and the Annex VI fuel oil sample by continuous drip and at the receiving ships manifold).

Annex VI of MARPOL also contains instruments to encourage port states to ensure that suppliers fulfil their obligations. Port states are therefore required to:

- Maintain a register of local suppliers of fuel oil;
- Require local suppliers to provide the BDN and sample, certified by the fuel oil supplier that the fuel oil meets the requirements of regulations 14 and 18.
- Require local suppliers to retain a copy of the bunker delivery note for at least three years for inspection and verification by the Port State as necessary;
- 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;
- Inform the Flag Administration of any ship receiving fuel oil found to be noncompliant with the requirements of regulations 14 or 18 of this Annex.
- Inform IMO 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.

However, despite the suppliers' responsibilities and the instruments available, previous experience from Port State Controls indicates that it is advisable for owners/managers themselves to ensure compliance. In order to assist ships in ensuring that the operational requirements are met, it should be considered to include clauses related to MARPOL Annex VI compliance in bunker contracts and agreements with suppliers, as well as charter parties.

8.2.6 Third party inspections

It can be expected that upon implementation, class surveyors, port state inspectors and possibly also vetting inspectors will scrutinise onboard documentation and records (e.g. sampling procedures, change-over procedures, ER log books, BDN's, sample inventory log books etc.), as well as the fuel oil sample inventory.

Consultations with port states indicate that analysis of the onboard Annex VI samples will be carried out upon suspicion, e.g. in case of an accident or near accident. However, the EU has proposed a more frequent testing of both onboard retained samples and also tank samples to verify compliance. It should also be noted that

Dutch authorities carry out such testing today to verify compliance with existing low sulphur requirements to marine distillates.

Based on experiences with port state inspectors scrutinising of oil record books related to sludge and oily bilge water inventory and balance, owners and managers could expect that similar practice could be applied with respect to high-sulphur and low-sulphur fuel movements and consumption when operating in SECA's or the EU (bunker quantity is required specified in BDN's). Accordingly, it is advisable that crews are instructed and trained to thoroughly verify that the supplied quantity is in accordance with that specified in the BDN's, or alternatively that independent bunker quantity surveyors are hired for this purpose.

There is some uncertainty as to whether the requirements of Regulation 18 are applicable as of 19 May 2005, or after satisfactory initial survey has been carried out and an IAPP certificate is issued to the ship. However consultations with some port states indicate that they will require compliance as of 19 May 2005. Owners and managers are advised to ensure compliance accordingly.

It need be emphasised that currently, the Annex VI sample is only required to be retained onboard and not tested. However, fuel oil quality testing represents a pro-active approach, both in terms of verifying compliance prior to any port state control, and more importantly as a safeguard against the adverse effects of poor fuel oil quality in combustion machinery. Hopefully, third parties may also consider test reports from a reputable and accredited independent testing laboratory as equivalent to additional testing of onboard samples.
It should also be noted that the procedures and documentation of DNV Petroleum Services fuel oil quality testing scheme will be in full compliance with Annex VI of MARPOL and the associated Resolution MEPC.96(47). Further participation in such a scheme ensures that ships have access to compliant sampling equipment (sample bottles, seals, line samplers and cubitainers). It further gives ship operators access to DNV Petroleum Services bunker alerts and bulletins as well as comprehensive fuel oil quality statistics, all of which will provide ship operators with valuable assistance in their bunker management.

For further information, please contact:

Annex VI in general:
DNV, Cargo Handling, Piping Systems, Marpol and Gas Carriers (MTPNO880@dnv.com)

NOx and engine related inquiries:
DNV, Section for machinery, Ships in Operation (MTPNO867@dnv.com)
DNV, Section for machinery, Newbuilding (MTPNO373@dnv.com)

SOx and fuel related inquiries:
DNV, Cargo Handling, Piping Systems, Marpol and Gas Carriers (MTPNO880@dnv.com)
DNVPS, DNV Petroleum Services (DNVPS.OSLO@dnvps.com)

Appendix 1

Experiences for operating Engines and Boilers on Low Sulphur fuels

1. Lubrication oil considerations

Calcium compounds form the major part of the lube oil additives and has proven efficient in terms of neutralising the sulphur oxides and thus prevent liner corrosion, as well as providing adequate cylinder oil detergency. For many years BN 70-80 cylinder lube oils have been standard and used successfully in two-stroke engines. However, experience has indicated that for long term operation on heavy fuel oils with sulphur level below 1.5%, using such high base number lube oils may lead to overdosing the combustion chamber with deposit generating calcium compounds. Such deposit build-up on piston crowns and piston ring grooves have led to liner scuffing.

It should also be noted that a certain degree of controlled corrosion in liners is desired in order to generate cylinder oil “pockets”. To ensure this, the base number in the lube oil need be matched to the sulphur content of the fuel. If the lube oil completely neutralises the sulphur oxides, such controlled corrosion is not obtained and could result in bore-polish and subsequent liner scuffing.

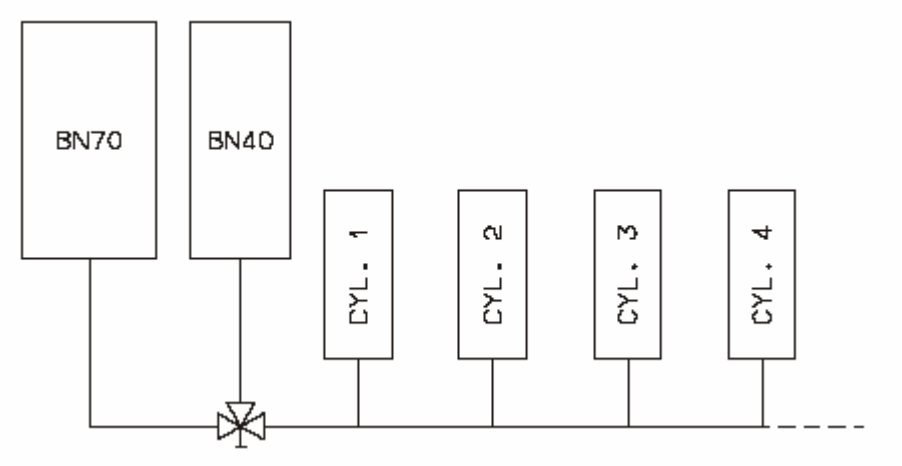
The experiences with and the maximum time for operating on fuel oils with sulphur content of 1-1.5% and high base number (BN) lube oils appears to vary substantially depending on engine make, type, age, load profile, liner temperature, efficiency of water mist catchers, installation of scraper rings, as well as cylinder lube oil feed rate and lubrication system.

Accordingly, it is strongly recommended that the relevant engine manufacturer and lube oil supplier is consulted in connection with operation on low sulphur fuel oil.

Experiences so far, do however indicate that it may be acceptable to operate on BN70 lube oil for an extended period of time (5-15 days) with a fuel sulphur content of 1-1.5%. Experiences further indicate that it may be advisable to reduce the high BN cylinder lube oil feed rate when running on low sulphur fuel oils, provided cylinder lube oil feed rate is not already at a minimum. It is however recommended that liner temperature is monitored and physically the condition of liners, pistons and ring-packs are checked at frequent intervals. It is also recommended to sample and test the scavenge drain oil for monitoring of liner wear.

Calcium has been an important compound with respect to detergency and dispersion of cylinder lube oils. I.e. despite the reduced calcium compound in low BN lube oils, full detergency and dispersion capacity must be maintained. This implies that the competence and experience of the lube oil supplier is a key factor in terms of development of suitable low BN lube oils.

For vessels that will operate on both high- and low sulphur fuel oils, considerations have been made for installing an additional cylinder oil tank.
The below serves as an example of such an arrangement with one tank containing BN 40 lube oil for low sulphur service and one tank for BN 70 for high sulphur fuel oil operation.
For the sake of good order, the concerns related to lube oil BN versus fuel oil sulphur level is primarily applicable for cylinder lubrication oils for two-stroke engines. Engine manufacturers have indicated that for four-stroke engines, equal challenges related to lube oils are not expected.



2. Fuel system/pump considerations

With respect to change-over procedures from heavy fuel oil to low-sulphur marine diesel oil or gas oil, the high pressure fuel pumps were initially highlighted as the area of concern.

The concerns was related to gassing and thermal shock to fuel pumps upon rapid change-over from heated to non-heated fuels, with associated risk of fuel pump damages.

Needless to say, to operate fuel pumps designed for a viscosity in the range 12-18 cSt on distillate fuels having a viscosity below 2 cSt and in violation of makers instructions is of concern.

Firstly there is the potential for increased internal fuel pump leakage which may result in reduced pump pressure, a reduction in delivered oil quantity, delayed injection and impaired fuel atomization.
Secondly there are differences in ignition delays.

To complicate matters further, adjustment of settings, timing and replacement of fuel pumps may be considered as a major conversion with respect to NOx emissions and thus validate re-certification.

Generally, sulphur compounds contribute to the lubricity of fuel oil. Accordingly, substantial reduction in sulphur level will lead to an associated reduction in lubricity. Combined with the low viscosity of e.g. marine gas oils, this represents a potential hazard in terms of fuel pump damages. As a guideline, a viscosity below 2 Centistokes and a sulphur level below 0.05% could lead to fuel pump problems.
A number of engine manufacturers have indicated that the lubricity hazards could be encountered through introduction of lubricity additives in the marine gas oils. Engine manufacturers should be consulted in this respect.

Lastly, it should also be noted that experiences from the automotive industry raises some concerns in terms of gasket material (nitrile rubber) compatibility with marine gas oil or diesel with reduced aromatisation.

3. Boiler Operation

As previously indicated the low sulphur requirements apply also to main and auxiliary boilers. Although operation on low-sulphur fuel oil is not assumed to represent a problem, the operation on **ultra low sulphur distillates** could (ref. EU amendment proposal).

Marine boiler burner installations have generally been designed for normal operation on heavy fuel oils, and not very low viscosity fuel oils such as marine gas oils. (The associated “pilot burners” required for main burner ignition exempted).

The main concerns related to boiler operation on low viscosity marine gas oil and diesel oils are as follows:

- Very likely damages to fuel pumps due to reduced viscosity and reduced lubrication ability of low sulphur marine gas oils and diesels (typically below 4-5 cSt). For pumps running continuously when the boiler is in stand by mode, one could consider modifying the control system to stop pumps when running on low viscosity marine gas oils and diesel oils.

- Potential problems with gassing of marine gas oil and diesel oil within a heated boiler fuel oil service piping system during change-over. To avoid this, the heaters need be bypassed and fuel pipe tracing shut-off. The alternative is to convert the piping system to enable simplified and safe change-over (direct feed).

- Potential increased smoking and local heating of boilers designed for high density/viscosity heavy fuel oil, when operating on low density/viscosity marine gas oil. This may require replacement of nozzles (pressure jet or atomizing steam burners) and/or modifications to enable adjustment of fuel pump pressures for different fuel viscosities.

- Potential problems related to flame backlash and subsequent ignition of marine gas oil and deposit build up within cup in rotary cup burners. This is considered probable for rotary cup burners without a protective heat shield and may require installation of heat shield with associated re-balancing of the rotary cup.

- Potential problems with gassing when applying steam in conjunction with marine gas oil in atomizing steam burners. This may require modifications to enable air atomizing or use of external mix type lances.

- Although the marine gas oils are expected to evaporate rapidly in the combustion space, increased frequency of ignition failures may validate the implementation of automatic post-purging sequences (currently not a requirement by all class societies). Further, it may be advisable to modify the control system to avoid activation of main burner if the ignition flame is absent.

- The higher calorific value for marine gas oils compared to heavy fuel oils should not have significant impact, but an adjustment of the air/fuel ratio may be required to avoid increased smoking.

- Regarding possible consequences and solutions to enable increased frequency and duration of boiler operation on marine gas oils it is recommended that the boiler manufacturer is consulted.

Appendix 2

Owners' Annex VI Checklist

The following table is a proposed checklist for Owners preparing for the implementation of Annex VI of MARPOL 73/78 and the initial survey to obtain the required International Air Pollution Prevention (IAPP) Certificate.

Item	Comment	Tasks
Regulation 6 When do I need to carry out Initial Survey?	First Scheduled Dry-docking after **19 May 2005**, but not later than 2008-05-19	1. Get an overview of scheduled dockings for complete fleet, (400 GRT or above) 2. Planning of Initial Surveys
Regulation 12 Ozone Depleting Substances (ODS)	- Halons - CFCs - HCFCs	1. Prepare lists of ODSs for all ships 2. Prepare instructions for handling ODSs
Regulation 13 NOx Certification	- Engines greater than 130kW on ships keel laid on or after 1 January 2000; and - Engines greater than 130kW which undergoes a major conversion, including replacements by new engines, on or after 1 January 2000	1. Get an overview of engines requiring NOx Certification 2. Check that these engines are certified and have the necessary documentation; EIAPP Certificate and Technical File (See also flow-sheet at page 5 of main document)
Regulation 14 Sulphur Oxides SOx	Max. Sulphur 4.5 %	Prepare instructions
Regulation 14 SECAs	Max. Sulphur 1.5 %	1. Can all engines and boilers operate on low sulphur fuel? 2. Plan bunker strategies 3. Calculate Fuel

		Changeover Time for all ships. Prepare operational and log instructions.
Regulation 15 VOC	Tankers only, operating at VOC designated ports	Certified VOC return system?
Regulation 16 Shipboard Incineration	Restrictions on Incineration	Prepare instructions
Regulation 16 Type approved incinerator	Incinerators installed on or after 1 January 2000 to be type approved according to resolution MEPC.76(40)	1. Get an overview of incinerators requiring type approval. 2. Check that Certificate and operation manual is available
Regulation 18 Fuel Quality	Requirements for fuel quality, documentation and sample storage	1. Prepare routines for filing of Bunker Delivery Notes 2. Prepare instructions for taking samples 3. Prepare facilities for sample storage.

Appendix 3

Ratification status, MARPOL 73/78, Annex VI

The following Flag States have ratified Annex VI (2005-02-02):

Azerbaijan
Bahamas
Bangladesh
Barbados
Bulgaria
Cyprus
Denmark
Germany
Greece
Liberia
Marshall Islands
Norway
Panama
Samoa
Singapore
Spain
Sweden
United Kingdom
Vanuatu

The updated list showing state of ratification can be found on IMO's web pages (www.imo.org/home.asp) under 'conventions' and 'status of conventions by country'.

For further information, please contact:

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(MTPNO880@dnv.com)
DNVPS, DNV Petroleum Services
(DNVPS.OSLO@dnvps.com)

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