

# MARPOL 73/78 ANNEX VI - NO<sub>x</sub> and SO<sub>x</sub> Controls

The International Maritime Organization, IMO, exists to develop a range of Conventions, Codes and Guidelines which member countries then incorporate into their domestic legislation. The fundamental principle underpinning this activity is the understanding that a uniform approach on a world-wide basis to such matters as maritime safety and environmental protection is essential to the smooth functioning of international shipping. Pollution controls are primarily effected through the workings of the MARPOL Convention and its associated Annexes, as developed by the IMO Maritime Environmental Protection Committee, MEPC.

MARPOL Annex VI, 'Regulations for the Prevention of Air Pollution from Ships', is included within the 1997 MARPOL Protocol which was adopted by the 1997 MARPOL Conference. The Annex will enter into force 19 May 2005 having now met the ratification requirement - a minimum of 15 states which control a combined merchant gross tonnage of not less than 50% of the world total. The Annex will apply to all ships of the Flag States which have ratified the 1997 MARPOL Protocol. These countries are listed on the IMO website ([www.imo.org](http://www.imo.org)). Additionally, the Annex VI requirements will also apply to ships of non-signatory States while operating in waters under the jurisdiction of Parties to the 1997 Protocol, as highlighted by the recent Singapore Administration's Shipping Circular No.20 - 2004. In the case of those Flag States which ratify the 1997 MARPOL Protocol after the entry into force date, the Annex requirements will take effect 3 months from the date of their signing.

In terms of exhaust emissions, the Annex VI controls will apply to the oxides of nitrogen (NO<sub>x</sub>) - Regulation 13 - and the oxides of sulphur (SO<sub>x</sub>) - Regulation 14. Furthermore, there are requirements, partly related to the SO<sub>x</sub> controls, which will cover certain aspects related to fuel oil quality and supply arrangements - Regulation 18. In addition, but outside the scope of this paper, the Annex also covers such aspects as the prohibition of new systems using certain ozone depleting substances (ODS), for example, halons and freons as used for firefighting and refrigeration, the design and operation of onboard incinerators and the design requirements for tanker vapour emission control systems.

Fixed and floating platforms, including drilling rigs and similar structures, are considered as ships for the purpose of this Annex, except in respect of those emissions to the atmosphere resulting directly from operations solely related to their drilling, production or processing functions. These controls are in addition to any imposed by the government which has jurisdiction over the waters in which they operate.

The basis of these Annex VI controls is, as with the other MARPOL Annexes, statutory. Compliance is therefore to be demonstrated to the Administration of the ship's Flag State. Therefore, it is totally separate matter to the ship's classification. However, where so authorised, the ship's classification society may undertake all or part of these statutory functions, but as a Recognised Organisation (RO) on behalf of the Flag State. For example, most of the diesel engine certification undertaken to date has been by the classification societies acting as Recognised Organisations.

Due to the particular nature of the implementation of the NO<sub>x</sub> and SO<sub>x</sub> controls, consideration of these is divided into two sections; prior to and after the Annex entry into force date.

## **Annex VI, Prior to Entry into Force Date**

Prior to the entry into force date, the various provisions of Annex VI cannot be enforced, except where a Flag State decides to enact those requirements on the ships under its control. However, in the case of the NO<sub>x</sub> controls, this initial 'voluntary' compliance over the intervening period will be an essential precursor to eventual mandatory compliance (in view of the extreme difficulty in obtaining post installation certification) and therefore, this must be seen as a highly qualified 'voluntary' compliance. A failure to take these steps now could render a ship uncertifiable in the future. In terms of the SO<sub>x</sub> controls, these too will not be enforceable over this period. Nevertheless, for those ships which will intend to operate on residual fuel oils on a world-wide basis, there are essential preparatory steps which will need to be taken in order to retain operational flexibility thereafter.

## NO<sub>x</sub> Controls

The NO<sub>x</sub> controls as given within the Annex will apply to diesel engines (boilers and gas turbines are not covered) over 130 kW which are not used solely for emergency purposes and which are:

- (a) installed on ships built (i.e. keel laid) on or after 1 January 2000, or
- (b) subject to 'major conversions', as defined, on or after 1 January 2000. For the purpose of this regulation a 'major conversion' is where an engine:
  - is replaced by a new engine built on or after 1 January 2000
  - output of an engine is increased by more than 10%
  - is 'substantially modified', as defined

The 'major conversion' clause is extremely significant, since it potentially extends the scope of these controls to engines which would otherwise be exempt, i.e. those installed on ships built prior to 1 January 2000. In the case of engines installed on ships built before 1 January 2000, 'substantially modified' means any operational or technical modifications which are made after that date which could increase NO<sub>x</sub> emissions, as defined. Such modifications may include changes to fuel injection timing, fuel injection equipment, the charge / scavenge air systems or combustion chamber profile. The onus would be on the shipowner to demonstrate to the responsible Administration that any changes to such operational or technical features did not result in an unacceptable increase in emissions.

The NO<sub>x</sub> emission limits are related to engine rated crankshaft speed:

Engine Speed (n) rpm	NO <sub>x</sub> Emission Limit g/kWh
Less than 130	17.0
130 - 1999	$45 \times n^{-0.2}$ (i.e. 720 rpm - 12.1)
2000 and above	9.8

An engine's duty cycle weighed emission values (since it could be rated for more than one cycle) are given at reference conditions (covering such aspects as fuel type, inlet air temperature and humidity and primary coolant temperature). Consequently, these controls focus on engine design rather than 'end of stack' emission rates.

There are four duty cycles for marine engines:

- E2 Main propulsion, constant speed (including engines driving variable pitch propellers)
- E3 Main propulsion or auxiliaries operating on the propeller law speed curve
- D2 Auxiliary engines, constant speed
- C1 Auxiliary engines not covered by D2 or E3

In this it is important to recognise that, in terms of NO<sub>x</sub> certification, an engine is specifically approved only for those duty cycles and rating (power and speed) which are given in its certification.

Underpinning the whole of these NO<sub>x</sub> emission controls is the NO<sub>x</sub> Technical Code which, as a mandatory document, defines the procedures and means by which an engine is to be certified and compliance demonstrated over its service life.

Over this interim period between 1 January 2000 and the entry into force date, the essential points in respect of those engines which will fall within the scope of Annex VI are:

- Engines, either installed on new buildings or supplied new, are to be in compliance with the NO<sub>x</sub> Technical Code - as indicated by a Statement of Compliance or similar, normally issued by, or on

behalf of, the Flag State of the ship on which they are installed. It will usually be the responsibility of the engine builder to have obtained the appropriate certification at the completion of manufacture.

- For all engines, where changes to duty, ratings, restrictions, components or settings which could affect NO<sub>x</sub> emissions are undertaken, the necessary steps are taken to demonstrate either:

that those changes do not affect the status of the subject engine relative to the Annex requirements and any existing NO<sub>x</sub> certification; or

that the engine as modified is, and will thereafter be, demonstrably compliant with the relevant emission limit and is so certified. These changes would need to be approved by, or on behalf of, the Flag State of the ship on which the engine is installed. In the case of previously certified engines those changes could only be approved by the entity which issued the original Statement of Compliance with the NO<sub>x</sub> Technical Code.

- An original copy of the Technical File as approved by, or on behalf of, the Flag State of the ship on which the engine is installed is to be supplied with the engine. This document is to be retained onboard and is not to be subject to unauthorised amendments. The Technical File is the key document in demonstrating compliance; consequently, it is to be kept with the engine throughout its service life. The Technical File, which is engine specific, defines the engine in terms of rating, application, performance, limitations and NO<sub>x</sub> critical components and settings, the emission test report relevant to that engine and the means by which that engine is to be subsequently surveyed in order to demonstrate compliance. Three survey options, the Onboard NO<sub>x</sub> Verification Procedures, are given in the NO<sub>x</sub> Technical Code:
  - (a) Parameter Check
  - (b) Simplified Measurement
  - (c) Direct NO<sub>x</sub> Monitoring (not applicable for the Initial Survey – see below)

The outlines of the first two of these options are defined in the NO<sub>x</sub> Technical Code. The Guidelines for the Direct Monitoring Method were developed later and were finalised at MEPC 49 in July 2003 as Resolution MEPC.103(49). To date all engines have been certified on the basis of the Parameter Check method. The basis of this is that emissions are only measured in respect of the Parent Engine (as defined), all related Member Engines are then verified as compliant on the basis of their rating, duty, NO<sub>x</sub> critical components and settings and / or performance.

- Engines are installed in accordance with the application and restrictions as given within the Technical File. This covers such matters as rated power, speed and duty cycle. The design requirement is that the engine is to be compliant when operating with 25°C sea water temperature. Therefore, where engines have intermediate, for example fresh water, cooled charge, or scavenge, air coolers, it will be necessary to ensure that they are installed with an adequate cooling capacity to achieve charge / scavenge air temperatures no higher than the reference charge air temperatures ('Tsc ref') as given in the Technical File corresponding to operation with a sea water temperature of 25°C.
- Although the Statement of Compliance with the NO<sub>x</sub> Technical Code for an engine demonstrates that it was in a compliant condition as manufactured, shipowners may require that a survey be undertaken following installation onboard to confirm that the status of the engine has not been compromised. While such engine surveys would be voluntary, they are strongly recommended in order to ensure that it will subsequently be possible to complete the mandatory Initial Survey, see next section, when required.
- Over the period up to the Annex VI entry into force date, those engines to which this regulation applies will either need to be maintained in a (voluntary) compliant condition (including the ongoing completion of the Engine Record Book, for those intending to demonstrate compliance by means of the Parameter Check method, in which all changes to NO<sub>x</sub> critical components or settings are to be

recorded) or capable of being put back into such a condition when compliance becomes mandatory. These points in particular must be considered where a change of Flag or ownership is contemplated.

Over this period, shipowners should also consider whether:

- the implications in respect to the supply of spare parts are acceptable?
- the Onboard NO<sub>x</sub> Verification Procedure as given within the Technical File is compatible with their operating requirements?
- will the given survey regime require specialist services or personnel?
- can the engine survey, when required following the entry into force, be undertaken along with other statutory and classification surveys?
- the organisation which approved the Technical File is that which the owner would want to be responsible for approving any necessary future amendments, additions or deletions to the Technical File? Preferably, this should be the ship's classification society.

While the engine builder will have developed the Engine Group / Engine Family and hence the Technical File supplied with the engine as manufactured, the Code fully allows for other parties, such as the shipowner, with or without the cooperation of the engine builder, to also develop new Engine Groups - which would of course need to be approved. Additionally, shipowners may seek to have alternative options added to existing Technical Files in order to give greater operating flexibility. Again, those amendments would need to be approved by the engine certifier. It would be seen that such alterations would primarily affect the Onboard NO<sub>x</sub> Verification procedures, either to adopt a form of the Parameter Check Method which was not tied to the original equipment supplier or the utilisation of the Direct Monitoring option.

## SO<sub>x</sub> Controls

In order to limit SO<sub>x</sub> emissions, Annex VI will introduce a maximum limit of 4.5 % m/m sulphur for all marine fuel oils, irrespective of fuel grade or the type of combustion machinery in which they are to be used. MEPC has operated a sulphur monitoring programme, in conjunction with the classification society fuel oil testing organisations (ABS, DnV & LR), since 1999. To date, this has covered nearly 300,000 residual fuel oil deliveries. Of these the number with sulphur contents in excess of 4.5 % m/m has been negligible, the overall average sulphur value being 2.6 / 2.7 % m/m. The findings of this programme are shown in Figure 1.

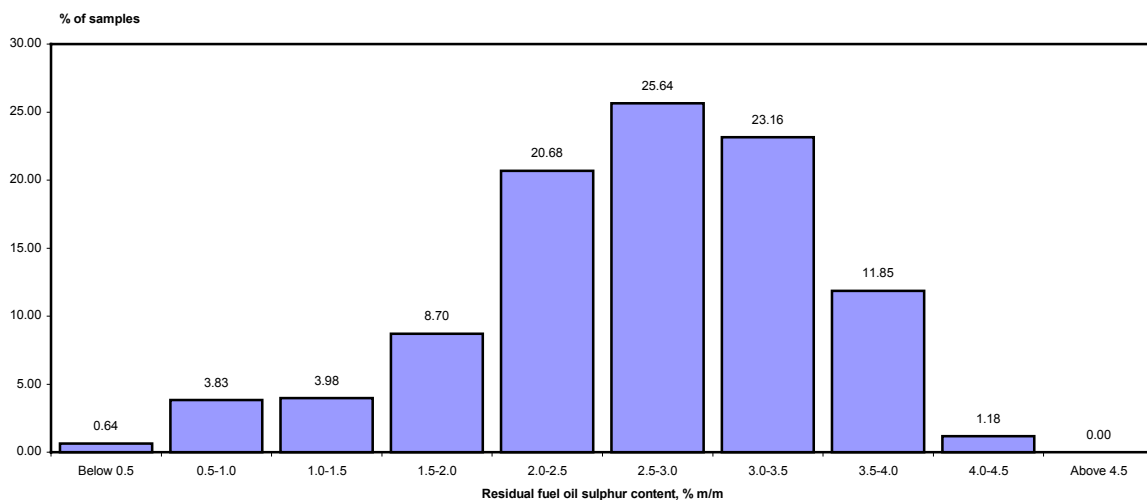


Figure 1 Summary of MEPC Sulphur Monitoring Programme, 1999-2003

Consequently, while this 4.5 % m/m limit does not represent any significant restriction on current fuel supplies, a yet lower limit will apply within designated SO<sub>x</sub> Emission Control Areas (SECA) which inevitably will have a much wider effect.

The Baltic Sea (as defined in MARPOL Annex I) was the first SECA. At MEPC 44 in March 2000, it was further agreed that the North Sea (as defined in MARPOL Annex V) had met the necessary criteria to be declared a SECA after the entry into force of the Annex. Furthermore, there may be other areas (i.e. areas to the west of the British Isles, west of continental Europe, US coastal waters or the Mediterranean, in total or in part) which may be expected to be proposed as SECAs.

Within a SECA, the requirement will be either a maximum limit of 1.5 % m/m sulphur content in respect of all fuel oils as bunkered or the use of an exhaust gas cleaning system, or equivalent, which results in an overall emission value of 6.0 g SO<sub>x</sub> / kWh or less. In practice, it is expected that the majority of ships will seek to comply with the SECA requirements by means of the primary control option of limiting fuel oil sulphur content. Whether this will be achieved by the use of low sulphur residual fuel oils or gas oils (which inherently have sulphur contents below the limit value) will depend on such factors as ship's projected operating profile, bunker tank and transfer systems and the price differentials between the various grades. In any case, the MEPC Guidelines for the approval of exhaust gas cleaning systems have yet to be developed.

There will of course be those ships which will never enter, or alternatively never leave, a SECA. For those ships, the future situation will be relatively straight forward; the respective fuel oil sulphur content limit will apply without exception. The complication arises for ships which use residual fuel oil and operate, or may operate, for only a portion of their time within a SECA, since outside the SECA, such ships will utilise fuel oils of sulphur content typically around 2.0 – 3.5 % m/m. In these instances, it will be necessary to ensure that those ships will have both the necessary segregated bunker capacity and the means to change over to the lower sulphur content fuel prior to entry into a SECA.

Obviously, the effect of this change over requirement is going to differ from ship to ship, but certainly, it can be seen that some ships will require substantial segregated low sulphur fuel oil bunker capacity. In those instances, shipowners will need to consider their options prior to the entry into force of these requirements and take the necessary steps at forthcoming dockings or other opportunities to arrange for the necessary sub-division or addition and segregation of bunker, settling and service tanks and associated piping systems. Ships using residual fuel oil which intend to enter a SECA, but which do not have the capability for two segregated fuel oil grades, will therefore need to operate continuously on the lower sulphur fuel oil with a detrimental effect on fuel costs.

Additionally, where ships are to operate on fuel oils of substantially different sulphur contents, i.e. within and without SECAs, the possible need to change over the engine lubricants will need to be considered. Apart from requiring a further subdivision of the lubricant storage capacity, duplicate service tank systems may also be required.

## **Annex VI, After Entry into Force Date**

From the entry into force date, compliance in terms of both the equipment and operational requirements of Annex VI will be mandatory for all ships engaged on international voyages and to which the Annex applies. In the case of ships of 400 gross tonnage (GT) and above, compliance will be indicated for those ships by the issue of an International Air Pollution Prevention Certificate (IAPPC) following an Initial Survey by, or on behalf of, the responsible Flag State. For ships under this tonnage limit, it is for the individual Administrations to set up schemes appropriate to such vessels to ensure compliance. For ships of those Flags which are not signatories to the Annex but which intend to operate in waters controlled by signatories they will require Statements of Compliance with Annex VI issued by, or on behalf of, their Flag Administration.

For ships completed after the entry into force date, the IAPPC will need to be issued prior to entering into service. However, for ships in service at the entry into force date, the IAPPC Initial Survey is to be undertaken no later than the first scheduled drydocking thereafter, although in all cases, it must be satisfactorily completed within three years of the entry into force date.

Thereafter, a system of annual (or intermediate and unscheduled) surveys will apply with a periodic (renewal) survey every five years. These statutory surveys will be undertaken by, or on behalf of, the relevant Flag State and are to be harmonised with the other MARPOL Annex surveys. Additionally, there will be Port State inspections, which may be either random or targeted in terms of the particular ships checked.

Apart from the specific Annex VI machinery and arrangement requirements, shipowners will also need to ensure that the various operational requirements of the Annex are implemented and verifiable. Consequently, those ISM procedures covering the maintenance of refrigeration and firefighting systems using ODS, incineration and bunkering will also need to have been updated, as necessary, in addition to those required to cover the various aspects of the NO<sub>x</sub> and SO<sub>x</sub> controls.

For ships which will be subject to Annex VI, it is for the shipowner to ensure that the necessary valid certification exists and that compliance can be demonstrated at the various scheduled and unscheduled survey stages. While certain aspects of the certification procedure may normally be undertaken by other parties, i.e. the engine builder in the case of the certification of new engines at the manufacturing stage, ultimately that responsibility will rest solely with the shipowner. Any lack of certification, or failure to be able to demonstrate the necessary compliance, will effectively bar a ship from international trade.

### NO<sub>x</sub> Controls

The NO<sub>x</sub> controls within Regulation 13 form the major part of Annex VI in terms of complexity, implications for the shipowner and survey. The IAPPC survey scheme with regard to NO<sub>x</sub> compliance verification is shown in Figure 2.

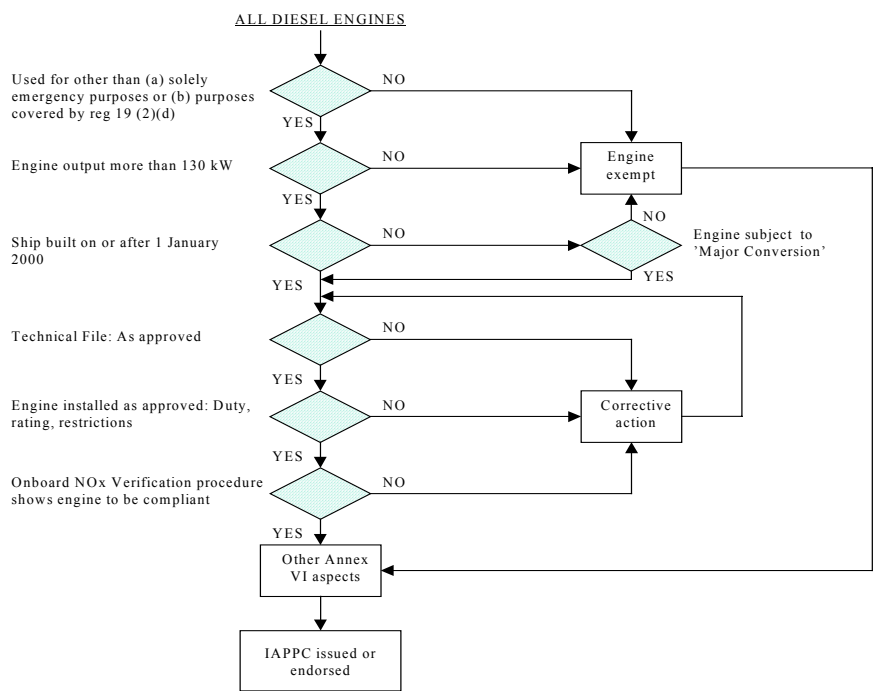


Figure 2 NO<sub>x</sub> Emission Survey Flowsheet.

Any diesel engine falling within the scope of these requirements will need:

- Valid engine certification. Following the entry into force date, Administrations, or organisations acting on their behalf, will issue Engine International Air Pollution Prevention Certificates (EIAPPC) to signify the initial compliance of an engine. For engines already issued with Statements of Compliance with the NO<sub>x</sub> Technical Code, it would be for the responsible Administration to decide whether or not it would require those Statements to be changed to EIAPPCs – a purely administrative task, no re-survey of the engine would be required. Statements of Compliance with the NO<sub>x</sub> Technical Code would however continue to be issued in respect of engines to be installed on ships the Flag State of which is not an Annex VI signatory.
- Technical File, as approved by, or on behalf of, the ship's Flag State, including any associated approved Technical File 'Change Sheets' reflecting modifications (amendments, additions or deletions). As in the previous section, it will be necessary that this document is retained onboard, in good order and not subject to any unauthorised changes, with the engine to which it relates. Where amendments, additions or deletions are necessary, these will need to be duly approved by, or on behalf of, the relevant Flag State – effectively by the organisation which approved that document in the first instance.
- Installed in accordance with the duty, rating and restrictions (including charge air / scavenge air cooling arrangements) as given in the Technical File.
- In the case where the Onboard NO<sub>x</sub> Verification procedure is to be based on the Parameter Check method, the Engine Record Book (ERB) will need to be accurately maintained. This document, as required by the NO<sub>x</sub> Technical Code, is to provide a chronological record of any changes to NO<sub>x</sub> critical components or settings, including adjustments, part replacements and implementation of approved modifications. As with the Technical File, this record is to be retained with the engine to which it refers and must be available, and complete, at the time of scheduled or unscheduled (i.e. Port State) surveys. However, unlike the Technical File, the ERB will be completed by the ship's staff.
- To be in a demonstrably (i.e. surveyable) compliant condition.

Consequently, any engines installed between 1 January 2000 and the entry into force date, which were modified from their initial NO<sub>x</sub> compliant condition or to which spare parts have been fitted, which do not enable the Onboard NO<sub>x</sub> Verification procedure, as given in the Technical File, to be applied, will need to be re-instated to their 'as approved' condition.

With the need to actually implement the Onboard NO<sub>x</sub> Verification procedures as given within the Technical Files, it is to be expected that there will be a greater tendency for shipowners to take action to ensure that such procedures can be applied without undue delay, or specialist services, while retaining the flexibility of component supply to which the industry has been accustomed. Shipowners may also seek to influence the engine builders as to the nature of the verification procedures contained within the Technical Files as supplied, or may take a more direct form in proposing to the responsible Administration alternative survey schemes.

### **SO<sub>x</sub> Controls**

All fuel oils for use onboard will need to be ordered, and verified from the bunker receipt on delivery, as having a maximum sulphur content of 4.5 % m/m. The exception to this is where ships are to operate within a SECA with compliance through primary, rather than secondary controls. In those instances, the fuel oils to be used within a SECA are to be ordered, and verified, to have a maximum sulphur content of 1.5 % m/m.

Where a ship enters a SECA it will be necessary that all fuel oil service systems in use are fully changed over and flushed of all fuel oils exceeding 1.5 % m/m sulphur prior to that entry into the SECA. Consequently, it will be necessary to have onboard, prior to entering such a sea area, an adequate quantity

of 1.5 % m/m maximum sulphur fuel oil. However, this requirement will not be applied to vessels operating in a SECA during the first year after the Annex VI entry into force date or, where such areas are declared after that date, the first year after their designation.

Obviously, the accurate completion of the mandatory (MARPOL Annex I) Oil Record Book will be an essential element in keeping track of the different fuel oil grades (in terms of sulphur content) onboard. Additionally, under the Annex VI requirements, it will be necessary to record the date, time and position when this change over was completed into log-books as prescribed by the relevant Administration, which may well be the Oil Record Book in most cases. Although departure from a SECA is not specifically mentioned within the regulation, these requirements should be considered to be equally applicable on exit from a SECA. Consequently, the date, time and position at which that change over process back to a higher sulphur fuel oil (4.5% m/m maximum) was commenced, of course after exiting a SECA, will therefore also need to be recorded. At both entry and exit from a SECA, it is also required that the quantities of low sulphur fuels in each tank (storage, settling or service) be recorded.

### **Fuel Oil Quality**

In the context of Annex VI 'fuel oil' refers to any grade of petroleum derived fuel (gas oil, diesel oil or residual fuel oils (IFO/HFOs) together with any other alternative source liquid fuel used onboard. Although entitled fuel oil quality, the relevant requirements only cover some of the commercial aspects which often affect supply. These requirements are essentially operational in nature. From the entry into force date, it will be necessary to ensure that:

- Marine fuel oils are only supplied by companies registered with the appropriate authority of the country in which they operate.
- Bunker receipts are only accepted from the supplier if they are fully in accordance with the required scope (given in Annex VI Appendix V), particularly the statement as to the actual sulphur content. Additionally, the bunker receipt must include the required composition clause in order to indicate that the fuel is free of certain deleterious materials.
- For ships of 400 GT and above, the bunker receipt is to be kept onboard for a minimum period of 3 years from the date of delivery. Individual Administrations may extend this requirement to ships below that tonnage limit.
- For those ships which are required to keep their bunker receipts onboard, as above, a retained sample of all fuel oils as supplied is to be drawn by the supplier, in accordance with defined Guidelines, MEPC.96(47), at the ship's receiving manifold, sealed and signed on behalf of the supplier and the Master or ship's officer in charge of the bunkering operation. In this context the 'supplier' is the legal entity which physically delivered the fuel oil to the ship.

This retained sample is to be kept under the ship's control until the subject fuel oil has been substantially consumed, but in any case, for at least 12 months from the date of delivery.

From the above, it is evident that, at change of owner or management, it will be vital for the incoming organisation to ensure the availability of the documentation (i.e. Technical File, Engine Record Book and bunker receipts), together with the representative fuel oil samples required to demonstrate compliance as necessary.

## **CONCLUDING REMARKS**

With increasing public and regulatory concern over air pollution matters, the marine industry must accept that exhaust emission controls will be applied. Such controls will be both direct, covering such aspects as



engine design, or indirect as in the case of fuel oil sulphur limits. The resulting controls will have potentially major influences on the marine diesel engine industry and the fuel suppliers, but will also require close attention by shipowners to ensuring that the necessary individual operating procedures are in place and effectively implemented, both onboard and in the office. With this increased level of scrutiny, it must be recognised that some of the traditional flexibility or freedom over certain operational aspects will be curtailed.

Compliance with these mandatory emission controls will not be optional for ship owners and operators; it will be an essential prerequisite to trading. However, this ability to comply will be heavily influenced by actions taken, or not taken, both now and in the future. Shipowners in particular must be aware of these implications and act accordingly. A failure so to do will not be readily corrected at a later date.