Low sulphur fuels

Properties and associated challenges

Maritime

MANAGING RISK

DNV

Content

Low sulphur fuels

The present paper intends to inform DNV clients and other interested parties about potential consequences of the introduction of various international and regional regulations, specifically the EU Directive 2005/33/EC and new sections of the California Code of Regulation title 13/17. Both of these regulations set forth limitations on the sulphur content of marine fuels used in specified areas (EU ports and Californian waters)

The paper specifically aim at providing

- a summary of DNV's and various industry stakeholders concerns regarding operations using fuels that comply with the abovementioned regulations
- general recommendations for safe operation

The issues raised in this paper are of a general nature and it is important to note that the paper does not intend to address technical specialities of individual systems or components.

Furthermore, the new regulations may result in a need to modify both new and existing ships with regard to fuel oil systems and/or fuel oil consumers (primarily boilers and diesel engines). Such modifications are subject to approval and survey by the vessel's classification society. This includes requirements to documentation to be submitted for approval, certification of components and materials and survey and testing onboard. These requirements are further described in **Appendix A**.

It is envisaged that not all required modifications will be completed by 1st January 2010 and there may be a need for owners to document that necessary modifications have been planned for and are in progress. Upon request, DNV may issue a statement to this effect, see **Appendix B**.

Whilst DNV's present Rules for main class does not specifically address fuel quality, a voluntary class notation addressing this aspect may be assigned to new and existing ships from beginning of 2010. A description of the voluntary class notation is given in **Appendix C**.

On the background of the possible adverse consequences of changing from the standard fuels the equipment were originally designed for, to low sulphur fuels as described in this paper, DNV reminds Ship Owners/Managers of their obligation, through the ISM Code 1.2.2.2, to systematically analyse hazards involved for each particular ship, and to develop appropriate maintenance (ISM 10) and operational procedures (ISM 7). Should the necessary knowledge/competence not be available in-house, DNV recommends that the owners seek necessary advice by consultants, system designers and/or makers. **Appendix D** outlines advisory services DNV may offer in this respect.

1. Introduction

Shipping is under a continuous development to contribute to more environmental friendly operations as a measure to improve air quality and ultimately public health. Through the latest regulations concerning environmentally harmful emissions, the shipping industry will reduce, amongst other things, the amount of emitted sulphur oxide combinations (SOx).

Of the two methods available to reduce SOx emissions, the after-treatment of exhaust gases or the use of fuels with a low sulphur content, presumably the latter requires the lowest investment and probably leads to the lowest operational cost for the ship owner. However, the use of such fuels is not without its challenges.
The most common of these challenges and their significance for the operation of boilers and diesel engines will be highlighted in this document.

1.1. Fuel standard

Although some emission regulations refer to, in order of increasing viscosity within the categories of fuels: Marine Gas Oil (MGO), Marine Diesel Oil (MDO) and Heavy Fuel Oil (HFO), these are not standardised fuel grades. However, they can be translated respectively into DMA, DMB and RMx category fuels as defined in the most recent ISO standard for fuel quality, ISO 8217: 2005E.
According to ISO 8217, the upper sulphur content limit for these fuel grades is as follows:
Marine Gas Oil (DMA): 1.50% m/m*
Marine Diesel Oil (DMB): 2.00% m/m*
Heavy Fuel Oil (RMx): 3.50-4.50% m/m depending on the categories and the viscosity therein*

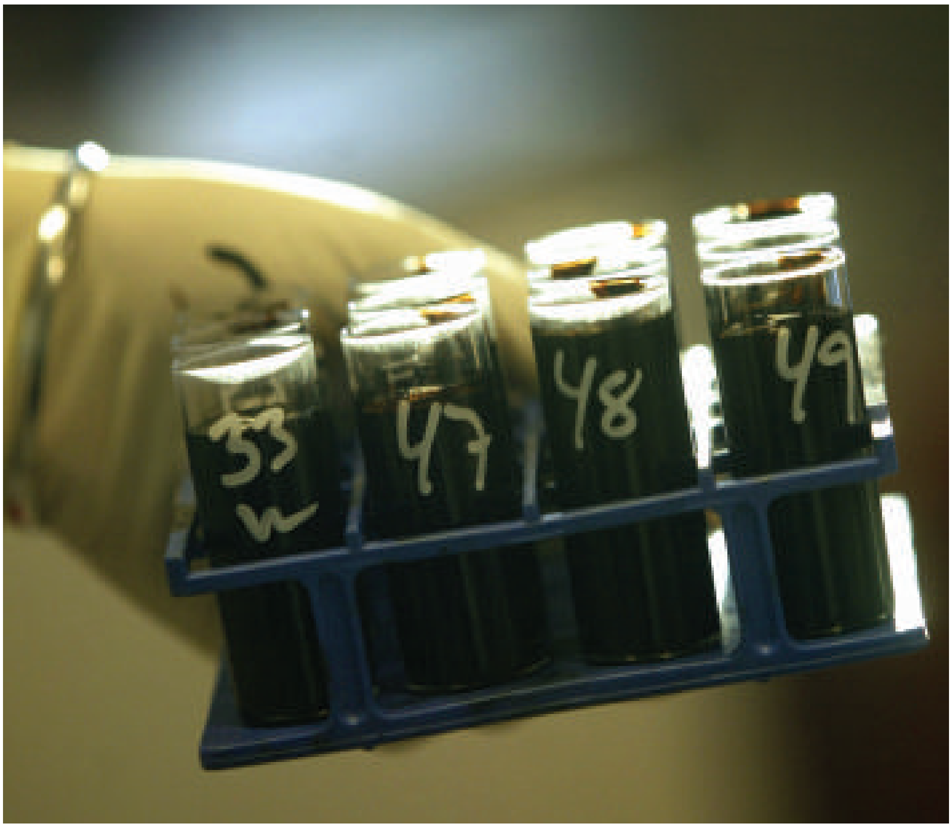
*) m/m : mass to mass percent. A new edition of this standard is now under development and it is expected that there will be a direct reference to the Sulphur limits found in MARPOL Annex VI.

1.2. Low sulphur definition

The sulphur content limit for "low sulphur" fuels allowed in the various areas and for the various grades depends on the regulations in force at the time and location. At the time of writing, for example, the following is known:

- low sulphur of any grade of fuel used in EU community ports, at berth, means sulphur less than 0.1% after 01-01-2010
- low sulphur MDO under Californian regulations means sulphur less than 0.5% (0.1% after 01-01-2012)
- low sulphur MGO under Californian regulations means sulphur less than 1.5% (0.1% after 01-01-2012)
- low sulphur of any grade in IMO-regulated Emission Control Areas (ECAs) means sulphur less than 1.50% prior to 01-07-2010
- low sulphur of any grade in IMO-regulated Emission Control Areas (ECAs) means sulphur less than 1.00% after 01 -07-2010
- low sulphur of any grade in IMO-regulated Emission Control Areas (ECAs) means sulphur less than 0.10% after 01-01-2015

Hence it is important to note that fuel which is within specification, ISO 8217:2005 is not necessarily in compliance with the regulations in force at the vessel's location.



2. Areas of challenge

The EU Directive 2005/33/EC and CARB title 13/17 both limit the level of sulphur in the fuels allowed in the regulated areas. Although the amount of sulphur partly has an effect on the fuel's properties, the main concern relates in fact to other characteristics often found inherent in low sulphur fuels stipulated by the said regulations.

Independent of the actual limit for the sulphur content, the potential challenges caused by fuels which have a sulphur content that is significantly lower than that specified in ISO 8217 are all related to the same issues:

- Low viscosity (MGO)
- Lubricity (MGO/MDO)
- Acidity (MGO/MDO/HFO)
- Flashpoint (MGO/MDO/HFO)
- Ignition and combustion quality (HFO)*
- Increased catalytic fines (HFO)

* May be affected through blending with some "Cutter Stocks"

2.1. Low viscosity

Potential challenges of low viscosity are twofold:
Because of regulations, it will be necessary to operate equipment designed for HFO on MDO or MGO.
Low sulphur MGOs often have a viscosity that is lower than that of MGOs with "normal" sulphur levels, thus increasing the problems and even creating problems for equipment designed to operate on MGO.
Most marine equipment designed for the use of MGO or MDO requires a fuel viscosity no lower than approximately 2.0 cSt (mm2/s) at operating temperature.
Low sulphur MGOs typically have a viscosity in the lower part of the allowable range (1.5 - 6.0 cSt at 40°C) stipulated by ISO 8217. Unless provisions are made for cooling of the fuel oil, the operating temperatures of the fuel will normally be in excess of 40°C. The operator should therefore consider fuel bunker specifications (referring to 40°C) with sufficiently high viscosity in order to compensate for the raise in temperature of the fuel in the system.
Whatever the reason, the use of a fuel grade different from the design grade or use of the design grade but with a lower viscosity, the related problems are:

- increased internal leakage in fuel pumps
- increased flow rates through nozzles, restrictors and injectors

2.2. Lubricity

Another concern directly related to the viscosity is the lubricity.
With decreasing viscosity, the lubricity of a liquid decreases and as a result components that depend on the pumped medium for lubrication, such as plunger pumps, can experience insufficient lubrication.

2.3. Acidity

With the decrease in a fuel's sulphur content, the acidity decreases as well. Many cylinder oils are chosen so that their alkalinity neutralizes the corrosive acids in the fuel. Hence, when the fuel's sulphur content is lowered, the alkalinity of the lubrication oil should be adjusted accordingly or the increased build up of deposits might be the result.

2.4. Flashpoint

Sometimes low sulphur fuels, in all grades, are manufactured by mixing a fuel with a normal sulphur grade with one that has a very low sulphur content, typically light diesel fractions such as automotive diesel, in order to obtain a "normal" low sulphur fuel. These lighter fractions often have a flashpoint which is lower than that of the fuel they are mixed with . The lower limit for DMX grade fuel, is 43°C, as a result, the flashpoint of a mixture will be lower than that of the original fuel. It may even drop below the minimum allowable limit, 60°C, for fuels used on board ships (ref. SOLAS II-2 reg.15).

2.5. Ignition/combustion quality

Because of the way in which some of today's low sulphur HFOs are produced, they are more likely to have poor ignition and/or combustion properties, and this may cause ignition delay and incomplete or late combustion. This in turn can result to starting difficulties, knocking, and likely also an increased fouling of machinery. Such fouling may cause serious engine damage, e.g. collapse of piston rings, blow by, burned down piston crowns, worn/cracked cylinder liners and broken or bent exhaust valves.
The blending in of low sulphur "Cutter Stocks" may also have an adverse effect on the ignition/combustion properties of low viscosity MGO/MDO.

2.6. Increased catalytic fines

Data collected by DNV Petroleum Services show that, with the progress in oil refining technologies, the content of catalytic fines (cat-fines) in fuels has increased during the past two decades. More recent data also show that the introduction of a sulphur limitation of 1.50% for some HFO grades has led to an even greater proportional increase in cat-fines for these types of fuels.
Cat-fines are small, hard and incombustible particles that can be left in the fuel oil after refining. When not removed, these particles, typically Aluminium-Silicon oxides, will lead to e.g. increased cylinder-, piston ring- and groove wear and the seizure of barrel-pumps and fuel valves

3. Operational consequences

With the characteristics that may be inherent in the low sulphur fuels resulting from new and upcoming regulations, numerous challenges related to the operation of diesel engines, boilers and associated fuel supply systems are to be anticipated. Although such fuels have the potential to create significant operational implications and serious safety hazards, solutions do exist for their adequate and safe handling.

3.1. Low viscosity

Fuel oil used on board will normally increase in temperature between the storage tank and machinery component because of pump friction, ambient temperature and the recirculation of unused fuel from the component. This will often lead to a fuel temperature of more than 40°C and hence to a viscosity that is lower than that specified in the Bunker Delivery Note. If this viscosity is lower than that recommended by the manufacturers of the component, this may lead to problems for both boilers, diesel engines and other fuel handling equipment.

3.1.1. Diesel engines

As a result of the (too) low viscosity, internal leakages in fuel supply, booster and fuel injection pumps increases, resulting in reduced fuel supply to the engine. In addition, the atomization of the fuel might not be optimal.
As a consequence, the maximum engine output will be reduced accordingly. This may also translate into a reduced starting performance, especially when reversing the engine.
To avoid the above, it might be necessary to install fuel pumps and injection nozzles better adapted to low viscosity fuels. Alternatively, or simultaneously, the installation of a chiller or cooler unit can be considered in order to maintain sufficient viscosity. Manufacturers can normally advise on the location and dimensions of such units.
A disadvantage of the latter can be the increased thermal stresses introduced when the cooled fuel enters the warm fuel valve or injector. This is especially relevant for preheated standby engines, where typically the cylinder units are preheated but not the fuel system.

3.1.2. Boilers

The low viscosity causes increased internal leaks in the fuel pumps resulting in reduced pressure and delivery capacity. At minimum burner load the MGO flow through the nozzle will be substantially higher than the HFO flow at the same pressure. This may cause “over firing” and thereby increase the risk of flame failures. In most cases, it will be necessary to change the nozzle and/or the air/fuel ratio settings in order to prevent the overfeeding of fuel.
Such modifications may also be necessary in order to obtain proper smoke-free boiler operation.

3.1.3. Miscellaneous

Due to increased internal leakage and the low viscosity, fuel transfer, supply and booster, pumps may encounter suction difficulties.
Separator feed pumps are also prone to suffer from increased internal leakage resulting in a lower flow rate through the separator.

3.2. Lubrication

Reduced lubricity because of low viscosity is mainly relevant for pumps that are dependent on the medium pumped for their lubrication.

3.2.1. Diesel engines

The problems are mainly related to high pressure fuel pumps that depend on the fuel oil for their lubrication. A too low viscosity oil may lead to increased wear or seizure.
Increased wear may also be encountered in any other parts where fuel oil is used to lubricate the component. (e.g. mechanical shock absorbers etc)
Reduced time between overhauls (TBO) of such parts is to be expected.

3.2.2. Boilers

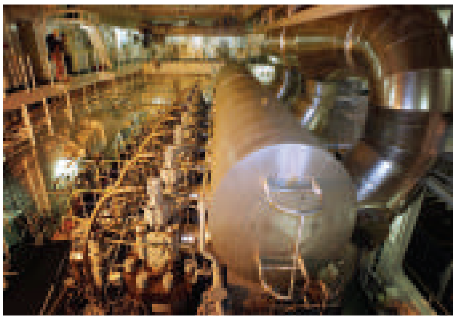
Similarly, boiler fuel pumps may experience increased wear because of the poorer lubrication. The resulting internal leakage will also reduce the pump capacity.

3.3. Acidity

The change in the fuel’s acidity is not a problem for most boilers and is not a big problem as such for diesel engines. Nevertheless, it may have severe consequences when not catered for.

3.3.1. Diesel engines

For most diesel engines, the cylinder lubrication philosophy is based on the principle that the lubrication oil supplied to the cylinder contains sufficient alkaline additives to neutralise the corrosive effect of the acidic sulphur products formed during combustion. When the amount of sulphur in the fuel is reduced, the amount of neutralising additives should be reduced accordingly. Failure to do so may lead to an unwanted build-up of deposits that in turn are detrimental to the lubricating film.
The alkalic (or base) additives can be reduced by either selecting a different lubricant with a lower Base Number (BN) or reducing the amount of lubricant supplied or a combination of both (two-stroke engine). However the amount of oil supplied must remain sufficiently large to maintain a lubricating film on the cylinder liner.
For most engines with a separate cylinder lubrication system, typically two-stroke engines, the change to lubrication oil with a lower BN is a matter of changing the supply of cylinder lubrication oil to the cylinders.
Be aware that wear and tear on the cylinder lubrication units might become more apparent when the supply to the individual cylinders (feedrate) is reduced.



When reducing the feedrate, care should be taken to ensure that all cylinders are indeed being fed sufficient lubrication oil to maintain the lubrication film.
The distribution of the oil in the cylinders may not be optimal at a low feedrate, especially for older cylinder-lubricating systems. The use of electronically controlled cylinder-lubrication systems may be beneficial to both the control of the feedrate and distribution of the oil.
For engines that do not have a separate cylinder lubrication oil system, typically four-stroke engines, the oil's BN is slowly lowered during operation. Therefore the lubrication oil's BN should be assessed in order to decide if the oil filling needs to be partially or fully replaced.

3.4. Flashpoint

Because of the explosion risks connected to the use of highly volatile fuels on board ships, the IMO has banned the use of fuels with a flashpoint lower than 60°C.
As recent figures from DNV Petroleum Services show, an increasing percentage of low sulphur MGO/MDO fuels have a flashpoint lower than 60°C (see 2.4). Such fuels must not be used on board and shall be handled in accordance with instructions from the Flag Administration and Class.
Hence it is important to have the flashpoint confirmed prior to bunkering.
Note that the flashpoint is a required element of the Bunker Delivery Note (BDN).
In the event that a too low flashpoint is confirmed after bunkering, you are advised to contact your class society for guidelines on how to proceed.
It is important to realise that low flashpoints are not limited to MGO/MDO fuels, HFO fuels with a too low flashpoint do occur, albeit less frequently.

3.4.1. Boilers

When low flashpoint fuels are being atomised with the help of steam, there is a chance that the fuel will evaporate before entering the boiler because of the steam temperature.
Condensation of the atomizing steam may also be experienced when the steam get in contact with the cold MGO.
This may lead to poor combustion, an irregular flame or flame extinction.
Such boilers may require modification of the oil burning equipment.
Boiler manufacturers should be able to advice on this matter.

3.5. Ignition and combustion quality

Because of the way in which some low sulphur HFOs are produced (see 2.5), they are more prone to have poor ignition and combustion properties, which may result in late ignition, poor combustion or prolonged combustion.
Due to better refinery techniques and increased blending to sulphur limits, the conventional parameters for predicting ignition quality (CCAI) doesn't always properly reflect ignition quality. Hence it may not be reliable to judge a fuel purely by the Bunker Delivery Note (BDN), nor, depending on the bunker port or supplier, the calculated CCAI. However, a supplementary test method IP 541, Fuel Combustion Analyser, can test the sample for actual ignition (and combustion) properties. It is therefore advisable to have all bunker fuels analysed before use by a reputable laboratory such as DNV Petroleum Services.

3.5.1. Diesel engines

Poor combustion and ignition may lead to increased fouling of the engine. Sometimes the fouling is so excessive that moving parts such as exhaust valves are inhibited by the soot, leading to broken/bent valves. Excessive fouling of the scavenge air receiver combined with late ignition or prolonged combustion may lead to a scavenge air receiver fire. In addition, poor ignition quality may lead to a decrease in starting performance.

3.5.2. Boilers

Poor ignition quality may lead to repeated starting failures or more frequent flame failures. In addition, the poor combustion quality may lead to increased soot formation and consequent fouling of the boiler and exhaust system, with the associated risk of a boiler fire.
It should be noted that some flame monitoring equipment is not suitable for multiple fuel grades, resulting in false alarms and/or boiler shutdowns or in the worst case undetected flame failures. The equipment manufacturer should normally be able to verify that the flame detector used is suitable for the fuel burned.

3.6. Catalytic fines

Although Cat-fines may pose problems for boilers through e.g. abnormal wear of burner nozzles and boiler pumps, the concerns are normally associated with substantial damages to diesel engines.

3.6.1. Diesel engines

When not properly removed during the onboard treatment, cat-fines may cause damage to all moving parts that come into contact with fuel oil, such as high pressure fuel pumps, fuel valves, piston rings/grooves and cylinder liners.
The best way to prevent damage is by refusing or returning any bunker fuel with a too high cat-fine content. However this is not always practicable, so it is very important that the onboard treatment plant, i.e. separators and filters, are functioning properly. The functioning of the treatment plant can be verified by sampling the fuel oil in the system before and after the plant and sending the samples in for analysis by a recognised laboratory.
The best results are achieved by adjusting the treatment plant to the minimum required flow, i.e. so that the oil spends as long time as possible in the separator. In the event of high cat-fines in the system, it is advisable to make contact with the provider of the oil analysis and the separator manufacturer.

4. General recommendations

Most engine and boiler manufacturers have recently published guidelines on how best to operate their equipment using low sulphur fuels. These recommendations are not discussed in detail here, but some general issues are listed below.

4.1. Piping system modifications

It might be advisable to install coolers or chiller units in the fuel supply or return line. The location, type and dimensions of such units should in general be in accordance with the manufacturer's recommendations and applicable rules for fuel and cooling water systems. Modifications to piping systems are subject to approval by class on a case-by-case basis.

4.2. Equipment modifications

4.2.1. Diesel engines

Any modifications should be reported to class prior to the modification being undertaken. The necessary approval and/or inspection of the modifications will be determined on a case-by-case basis.
It is recommended to modify an engine in a manner supported by the original designer/manufacturer.
For engines that are NOx certified, any changes to parts and settings that influence the NOx emissions must be in accordance with the engine's Technical File (TF). If they are not in accordance with the TF, it must be documented that the engine's NOx emissions have not increased beyond the applicable limit.
For engines that are not NOx certified, it must be documented that the NOx emissions have not increased beyond the level measured prior to the modifications.

4.2.2. Boilers

Any modifications should be reported to class prior to the modification being undertaken. The necessary approval and/or inspection of the modifications will be determined on a case-by-case basis.
It is recommended to modify a boiler in a manner supported by the original designer/manufacturer.

4.3. Changeover procedures

For vessels that trade between areas with different sulphur limitations, it is important that a detailed changeover procedure is readily available and that the crew is familiar with this procedure. Insufficient knowledge of the required actions may result in a boiler shutdown or engine standstill. Whilst many operators claim experience with changeover from HFO to MGO during e.g. docking, the changeover between HFO/ LSHFO and low sulphur distillates with viscosity as low as 1.5 cSt at 40° is clearly considered more of a challenge. This relates to

- Changes in viscosities;
  Additional heating of the low viscosity fuel during the changeover with the heated HFO may bring the fuel well below any limitation on viscosity for any of the machinery on board. Various cases have shown that engines have stopped because of erroneous actions during fuel changeover. Furthermore engines that have stopped whilst operating on low viscosity fuels have experienced starting difficulties.
- Temperature gradients in the fuel oil and corresponding changes in thermal expansions or contractions in different parts of the fuel pumps;
  Too large temperature gradients in the fuel oil increase the likelihood of pump seizures. Some manufacturers are advising rates of temperature changes in the order of 2°C per minute. Such limitations will imply changeover processes extending in time
- Incompatibility between the HFO and the low sulphur distillates;
  The risk of incompatibility between HFO and low sulphur distillates is considered higher than that typically associated with mixing of different types of HFO/ LSHFO. An increased awareness of this phenomenon is thus recommended. Operators are advised to consult recognised fuel oil laboratories, such as DNV Petroleum Services, in this issue before proceeding with the fuel mixing

It is highly recommended, especially for vessels that do not perform fuel changeovers on a regular basis, to practice such a changeover as well as manoeuvring trials before entering restricted waters.

For further information, please contact your DNV Customer Service Manager, or your local DNV office.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Appendix A

Class requirements as to the modification of machinery, systems and components for the use of low sulphur and low viscosity marine distillate fuel

General

This guideline describes the documentation required for plan approval and survey of modifications of machinery, systems and components that are likely to be carried out in order to operate on low sulphur and low viscosity marine distillate fuel. As scope of modification will vary from vessel to vessel, the plan approval shall be considered on a "case by case" basis, thus documents submitted shall be vessel specific.

Components and systems are to be arranged with redundancy so that a single failure of any active component or system does not cause loss of any main function. Redundancy can either be arranged as component redundancy or system redundancy.

Document requirement

The following documentation shall be submitted:

General

- Functional description of the new/ modified system(s), including their technical specifications, and interfaces towards other systems.
- Test program describing initial test condition, what and how to test including related acceptance criteria.

Machinery

- Description of modification to existing machinery/components.

Electrical

- Overall single line diagram.
- Schematic diagram of starter motor for essential services.
- Load balance calculation (applicable if new installation >100kW).

Piping

- Schematic drawing of the modified piping system clearly indicating modifications made.

Control & Monitoring

- Description of modification to existing control and safety system.
- Circuit diagrams showing modifications on control and safety system including power arrangement.
- Data sheets with environmental specifications.
- Arrangement of alarm for marine distillate fuel oil high/low temperature or low viscosity.

Inspection and Testing

The installation shall be subject to survey by the Society in accordance with approved plans and documentation. The followings are considered as within scope of survey;

- Verification of the modification for compliance with the approved plans and associated approval letters.
- Verification of material and/or component certificates as applicable.
- Verification of compliance with SOLAS II-2 Reg.15 regarding hot surface insulation and oil fuel lines screening.
- Witnessing of NDT and hydraulic pressure test as applicable.
- Functional test of system and components including associated control, monitoring and alarm systems.

Appendix B

Statement of Class approved retrofit plan

Provided applicable documentation as described in Appendix A is submitted for approval, DNV will upon request from the owner issue a statement of "Class approved retrofit plan". This statement will include a summary of main scope of modifications as described in the submitted documentation.

The statement will also reflect the progress of the approval and the inspection and testing to be carried out by DNV.

Appendix C

Description of the voluntary class notation ECA (SOx)

General

DNV has developed a new voluntary class notation ECA (SOx), which sets a new standard for design of fuel oil systems as well as required modifications for machinery components to enable consumption of low sulphur and low viscosity marine distillate fuel oils (marine gas oil). The class notation can be given to both new and existing ships.

ECA denotes that the vessel is adapted to operate within Emission Control Areas as per Annex VI of MARPOL 73/78. SOx denotes that the vessel is adapted to comply with SOx regulations within Emission Control Areas as per Annex VI of MARPOL 73/78 and can operate safely on marine distillate fuels with very low viscosity (2 cSt) and sulphur content (0.10%) for an unlimited or specified number of operating days.

The new class notation can be applied to vessels where all machinery components (main propulsion plant, power generation plant and steam/thermal oil plant, inert gas plant and incinerator etc.) are arranged to change between residual oil and marine distillate fuels and safely operate on marine distillate fuels over a specified period of time. The Rules are also applicable to vessels that will continuously operate on marine gas oils and also vessels with approved abatement technology.

The Rules will have impact on vessel designs, in particular related to additional marine distillate fuel tank capacity and arrangements, as well as design of certain machinery components and design of fuel oil piping systems. It will also have impact on design of boiler burner arrangements and control systems.

The scope of approval is to verify that the marine distillate fuel capacity is sufficient, that all machinery components are designed to operate safely on marine distillate fuels and that the supporting systems have been arranged to operate safely on marine distillate fuels.

The machinery components and supporting systems are subject to onboard survey and testing after installation or modification. A functional test, using marine distillate fuel, is to be carried out using marine distillate fuels. The function test is to include a verification of the vessels' fuel change-over procedures.

Appendix D

Advisory services

To navigate in the modern landscape of environmental legislation is difficult. New proposals for legislations are being developed all over the world, and in IMO new and upcoming proposals are processed with an increasing speed. Being updated on all that is going on is both time consuming and challenging, and lack of knowledge may lead to costly quality gaps, both organisationally and technically onboard your ships.

New Environmental Requirements

DNV constantly follow international developments on the environment for you and may assist in updating your organisation on legislation developments and corresponding technical developments, both on the ship design and systems/equipment needed for you to be prepared for the future. Further, DNV may assist you in an organisational change management process with the purpose of position your company in the forefront of the development by preparing for a cost effective operation and new growth.

Fuel Management and Testing

As the world leading Fuel management Agency, DNV Petroleum Services (DNVPS) has extensive knowledge on fuel management, fuel quality and fuel treatment. DNVPS has a world-wide organisation with highly qualified engineers and chemists who can assist you in solving your fuel management challenges, including reducing the risks involved with fuel purchase and safe, economical use of the fuel. Fuel management covers a set of services supplementary, in addition to the fuel testing programme followed by most ship operators today. DNVPS run fuel management courses, and tailor made training courses on request, world wide with the latest regulation incorporated as part of the training. As a result of the changing regulations there is a continuous need to update the operational procedures onboard the ships and DNVPS may also assist in this respect. An efficient and professional fuel management has proven, in addition to reducing damages on fuel consumers and machinery components, to reduce your operating costs considerably. .

Design Modification

If you are considering modifying your vessel's fuel system, or other related system, DNV can assist you with a review of the design modifications for the purpose of selecting the appropriate modification solution for your ship and location of trade. By performing this design review together with DNV you will benefit from DNV's extensive experience from the design, installation and operational phase.

Troubleshooting

If incidents occurs resulting in damages on fuel systems and other related system DNV has an extensive experience in trouble shooting, both on design level and onboard the ship. Engineers with extensive experience may help to find root causes and recommend modifications and improvement to reduce future damages with respect to related cost consequences and even off-hire.

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