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Guidelines for operation on distillate fuels

As per EU Directive 2005/33/EC, coming into force as of 1 January 2010, shipowners when operating in EU member states, will be required to use marine fuel with a maximum sulphur content of 0.1% at berth, at anchor and when operating on inland waterways.

Three areas of concern can be detected in connection with this new directive coming into force:

- Increased exposure as regards personal injuries
- Increased exposure as regards damage to property
- Increased exposure in relation to the need for handling an additional quality of bunkers (MGO)

Given a limited supply of spares and qualified personnel, it may be assumed that a significant part of the relevant sailing fleet will not be fully converted and technically compatible with this new requirement as per 1 January 2010.

In the meantime there are, however, things to bear in mind in order to prevent the occurrence of personal injuries as well as damage to property.

In most cases the owners will only be able to comply with this new stringent requirement by operating engines and boilers on marine gas oil (MGO).

In general, marine engines and boilers are designed for continuous operation on heavy fuel oils and marine diesel oils, **but not on marine gas oil**.

Changes between fuel types/qualities in service must be made in a controlled manner in order to avoid operational disturbances such as, but not limited to:

Engines:

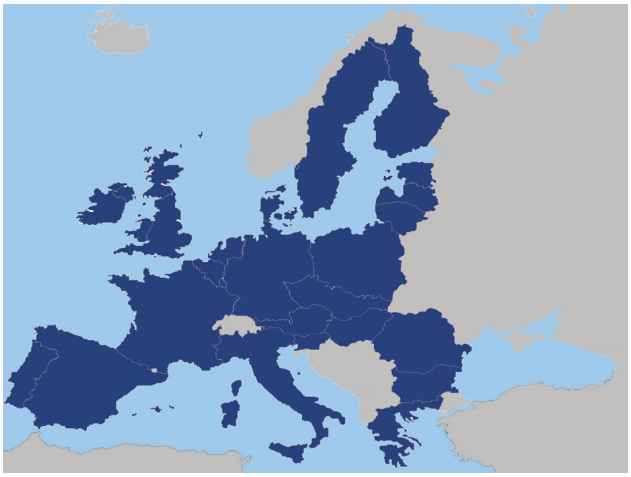
- Formation of sludge
- Internal leakage in fuel pumps
- Reduced power output
- Starting difficulties
- Seepage of fuel from pipe flanges

Boilers:

- Formation of sludge
- Seepage of fuel from pipe flanges
- Loss of flame and/or no ignition due to overfeeding of MGO
- Pulsating combustion
- MGO burner flame will be harder to detect

For advice on modifications to engines and boilers, we recommend contacting the suppliers. Owners are reminded that all modifications to engines and boilers, and associated fuel supply and control systems, must be approved by the Classification Society in order to ensure that Class is maintained.

MAN Service letter SL09-515/CXR and **Aalborg solution No.12, January 2009**, are enclosed for your reference.



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AALBORG INDUSTRIES

Aalborg Solutions

No. 12 · January 2009

Changing from HFO to MDO or MGO

MARPOL Annex VI "Regulations for the Prevention of Air Pollution from Ships" stipulate that Heavy Fuel Oil (HFO) combustion is not permitted during port stay and in specific areas at sea. The switch-over to lighter types like Marine Diesel Oil (MDO) or Marine Gas Oil (MGO) requires monitoring and some modifications to the burner and fuel systems, as outlined by Aalborg Industries in this brief.

1.0 Legislation and compliance

Since May 2005, specific environmentally friendly MARPOL regulations have been in force that stipulate that emissions from main and auxiliary machinery are kept within specific limits. They require, for instance, reduction of sulphur oxide combinations (SO_x), carbon dioxide (CO_2) and nitrogen oxide combinations (NO_x).

The subsequent EU Marine Fuel Sulphur Directive defines Sulphur Emissions Control Areas (SECAs) slightly different from those agreed by the International Maritime Organization (IMO) under MARPOL Annex VI.

The mentioned legislation has substantial impact on existing or future installations of Aalborg Industries' boilers, burners and fuel systems.

This brief covers the cautions and considerations, which should be addressed in connection with switch-overs between the traditional HFO or specified fuels and the lighter grades of fuel such as MDO and MGO.

1.1 Oil selection

The regulations limit the traditional use of Heavy Fuel Oil (HFO) for all operating conditions to the extent that combustion of HFO is no longer permissible during port stay and in specific areas at sea.
It has become necessary to switch to lighter, "better" fuel oil types like low sulphur fuels. Low sulphur fuels are unfortunately not always readily available in all ports, which can again lead to use of yet other fuel types like MDO or MGO that can achieve the stipulated emission results and comply with legislation.

1.2 Auxiliary boilers and burners

Most burner systems have so far been designed to burn HFO as the main fuel, but MDO can usually substitute HFO, and most plants will have no problems with temporary change-over to MDO operation.

1.3 Burner and fuel systems

In general, all auxiliary boiler plants are equipped with a burner and an associated fuel system. This often means that the fuel system has been designed for a particular type of burner installation. The components in the fuel systems are generally quite common and will therefore in the following be dealt with in general terms whereas the various burner types react differently upon fuel changes/switch-overs, and will consequently be dealt with separately.

2.0 Fuel properties

If special fuel such as low-sulphur fuel oil is not available in a port, the obvious choice of fuel would be a good quality Marine Diesel Oil (MDO) or Marine Gas Oil (MGO).

These two fuels differ in their properties, however, and should be handled differently as described in the following.

2.1 Heat value
The heat value of lighter fuel oils is typically a little higher than the heat value of HFO.

The additional heat input to the boiler is, however, considered to have an insignificant influence on the boiler itself. In some cases, it may nevertheless be necessary to re-adjust the air/fuel ratio if the pre-set air amount is beyond the limit and grey smoke is generated.

2.2 Viscosity
Lighter oils commonly have lower viscosity and need not be pre-heated.
When operating on fuel oil types of low viscosity, it must be ascertained that the fuel pumps are indeed able to operate with the low viscosity (see 2.5 Lubricating properties). It should also be considered that the viscosity mentioned in the specification is indicated with a reference temperature and that the actual operation temperature might be higher causing the viscosity to drop further.
Heat tracing should be shut off as should oil preheaters that have not been bypassed.

2.3 Density
Typically the density of lighter fuels is lower than of HFO (and MDO), which may have the result that the amount of (lighter) fuel to the burner will differ from the amount original pre-set and thus for instance cause ignition problems or increased smoke emission.

This can happen because most marine installations have the oil amount pre-adjusted based on a calculation of the main fuel, and on a manual volume calculation/adjustment that takes its density into account.

2.4 Flash point
The flash point for some lighter fuels is occasionally lower than the requirements from the classification societies, which should be considered when storing in the traditional fuel tanks onboard.

2.5 Lubricating properties
Lighter fuel oils traditionally also have lower lubricating properties. The hydrodynamic lubrication can, by using the well-known Sommerfeld number, be described as a function of the viscosity,
So = f (v) x k, for a certain pump.

This means that when the viscosity is reduced, the lubricating properties are reduced, which is an important aspect to consider too, with relation to fuel pumps (see 3.2 Fuel pumps).

3.0 Fuel system
Most of the components in the fuel system will not be affected by operation on a lighter fuel oil, but some considerations have to be made.

3.1 Fuel tank
Consider the new fuel's flash point (see 2.4 Flash point)

3.2 Fuel pumps
It must be ascertained that the fuel pump can actually operate with the new fuel under the given operating conditions.

As most fuel pumps are either screw pumps or gear pumps, it is important to check if the pumps are able to operate with the lower viscosity of the new fuel (see 2.2 Viscosity and 2.5 Lubricating properties), as there is a risk of increased wear and tear as well as breakdown if the pump is unsuited for the viscosity.

Fuel pumps running continuously during periods when the boiler/burner is in standby position may heat up, causing the temperature of the fuel to increase and thereby the viscosity to decrease. In this case, the control of the pumps should be considered, too.
In case the pump control system is not preset to do it already, it may be preferable to adjust the control system in such a way that the pumps are always shut off when not required.

3.3 Fuel preheaters

Light fuels rarely need to be preheated, and if heating is unnecessary, the fuel preheaters should be bypassed during operation on light fuel to avoid the risk of the oil being overheated.

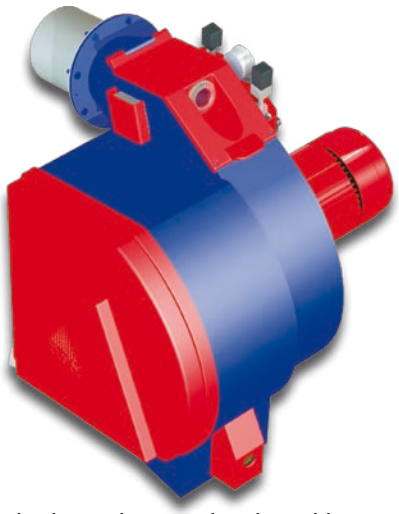
3.4 Fuel pipe tracing

If the fuel does not need preheating, the fuel pipes do not need to be heated, and consequently the tracing of the fuel pipes should be shut off.

If preheating is necessary, check if the tracing is sufficient. Be careful that the tracing does not heat the fuel more than necessary.

3.5 Change-over between fuels

When changing over/switching between fuels, make sure that fuel in the return/recirculation pipes is returned to the correct fuel tank.



The latest burner developed by Aalborg Industries: The KBP™ pressurized burner for our MISSION™ TCi boilers.

Make sure that the new fuel is not preheated in an unintended way.

4.0 Burners

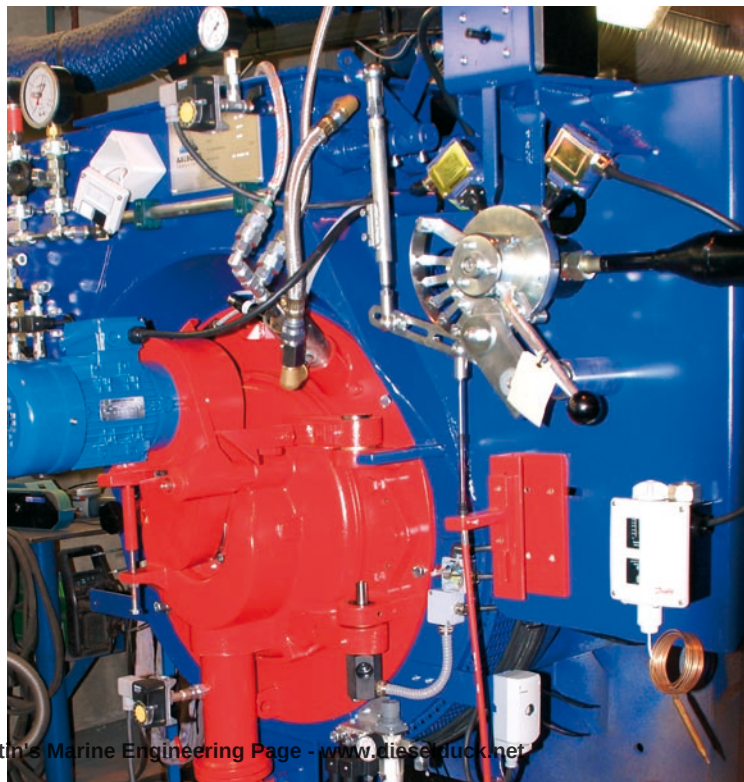
The fuel change-over affects the three common burner types normally supplied for marine boiler installations in various ways.
We recommend a post-purge of the furnace whenever MGO has been used.
It should be observed that the lower viscosity for fuel pumps in systems supplied by Aalborg Industries is normally 4.5 cSt. This means that if a fuel with a lower viscosity is used, the fuel pumps must be changed or modified.

4.1 Pressure jet burner

Pressure jet burners are typically used on smaller boiler types and run on MDO, MGO and HFO.
Installations delivered by Aalborg Industries will typically be able to operate on both MGO/MDO and HFO.
A lower viscosity may also cause an increase in the fuel input through the nozzle, and the risk of increasing smoke emission arises.

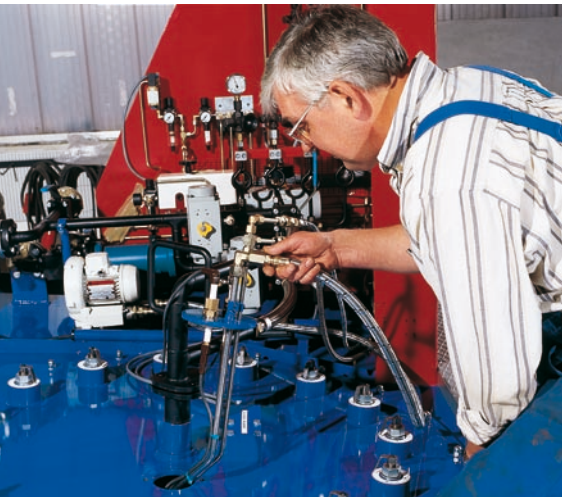
4.2 Rotary cup burner

Rotary burners are used on all boiler types and run on MDO, MGO and HFO.
Installations delivered by Aalborg Industries will typically be able to operate on both MGO/MGO and HFO.
For smaller burners there should be no problem with operation on a lighter fuel; however, the fuel amount (pressure) should be checked/adjusted in order to obtain a reasonably smoke-free combustion.
For larger burners, there is a risk of coke deposit creation in the burner cup, if the installation is not fitted with a suitable heat shield. This happens because the heat radiation into the rotary cup generates a too high temperature of the fuel in the rotary cup causing the fuel to start coking. We therefore recommend having the rotary cup installation checked and if necessary modified.
Due to easier evaporation of lighter fuels, we recommend adjusting the control system so the main burner does not accidentally ignite in case of a missing ignition source/flame, just as it must be avoided that fuel is vaporised unnecessarily.



Oil-fired rotary cup burner type KB™

4.3 Steam atomizing burner
Steam atomizing burners are typically used on medium and larger boiler types and run on MDO, MGO and HFO.
Installations made by Aalborg Industries will generally be able to operate on both MGO/MDO and HFO.
As the viscosity of the fuel burned in the steam atomizing burner is commonly in the range 15–30 cSt, the lower viscosity of a lighter fuel may cause over-firing if the pressure alone controls the oil amount to the burner.



KBSD™ steam atomizing burner for MISSION™ OL boilers.

For continuous operation with lighter fuels, we recommend using either compressed air as the atomizing medium, or changing the lance to a type that does not heat the fuel in the same way as the traditional lance.

Due to easier evaporation of lighter fuels, we recommend adjusting the control system so that the main burner does not accidentally ignite in case of a missing ignition flame/source, just as unnecessarily vaporized fuel should be avoided.

5.0 Modifications to the existing boiler/burner system
When having to operate a boiler/burner system on a lighter fuel than originally intended for the plant, the complete boiler/burner installation should be examined by authorized personnel, as this is not just a matter of complying with legislation but equally so a serious safety matter.

5.1 Steam atomized burner lance
There are two options for the atomization (compressed air and steam) and burner lance design, and Aalborg Industries would recommend changing the existing lance to a modified type where internal volume has been reduced to an absolute minimum and specially designed to operate with MDO/MGO and with steam as atomizing medium. The lance is constructed so the steam piping is insulated from the fuel piping in the burner lance thus avoiding preheating.

5.2 Post purge sequence
The control system needs to be modified to allow for post-purge sequence.

5.3 Flame supervision
On burner plants, usually only one flame scanner is installed (main flame supervision) from the outset. We would recommend having two flame scanners for the main flame supervision and in addition one separate flame scanner to detect the operation of the ignition burner.

5.4 Fuel oil pumps
The usual fuel oil pump installation is designed for a minimum oil viscosity of approx. 4.5 cSt at 50°C. It is therefore recommended to install one additional fuel oil pump to match the chosen fuel viscosity.

5.5 Authorized staff & OEM parts
Modifications to the boiler/burner system should be executed by skilled and authorized combustion experts only. Aalborg Industries offers an inspections and a variety of upgrading options, if required. Modification parts should come from the original equipment manufacturer or an authorized supplier in order to maintain a high degree of operation availability, reliability and safety.
Upon completion of modifications, a test and test report should be carried out by authorized staff.

Aalborg Solutions is published by Aalborg Industries Global After Sales organization and deals with operation of steam and heating equipment. Ideas and suggestions for topics are most welcome.
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Action code: WHEN CONVENIENT

Guidelines on Operation on Distillate Fuels

Low-viscosity fuels

SL09-515/CXR
September 2009

Concerns

Owners and operators of MAN B&W two-stroke diesel engines.

Summary

Guidelines on low-viscosity fuel.
MAN Diesel recommends fuels with a viscosity of 2 cSt at engine inlet.

Dear Sirs

With the introduction of new and tighter fuel sulphur content regulations by the EU and the California Air Resources Board, MAN B&W two-stroke engines will increasingly operate on distillate fuels, i.e. marine gas oil (MGO) and marine diesel oil (MDO) in such areas where required.

MAN B&W two-stroke engines are optimised to operate on heavy fuel. However, MGO/MDO fuels can be used when appropriate considerations are made to the following to ensure a safe and reliable performance, i.e.:

- the viscosity and lubricity of the fuel
- keeping a high fuel pump pressure
- the use of a cooler or chiller in an external fuel supply system
- other considerations, references for more information.

This service letter gives guidelines and recommendations on how to ensure a safe and reliable operation on low-viscosity distillate fuels.

For any questions or inquiries regarding the recommendations in this service letter, please contact our Operation Department at the e-mail address: *leo@mandiesel.com*

Yours faithfully

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Introduction

The lowest viscosity suitable for two-stroke diesel engines is 2 cSt at engine inlet. However, this viscosity limit cannot necessarily be used as a fuel specification for purchasing the fuel, as the viscosity in a purchase specification is tied to a reference temperature. This is due to the fact that the external fuel systems have an individual effect on the heating of the fuel and, thereby, the viscosity of the fuel when it reaches the engine inlet.

The external fuel oil systems on board today have been designed to keep a high temperature for HFO operation. This can make it difficult to keep the fuel system temperature as low as possible, and thereby as high a viscosity as possible, when changing to DO and GO operation. The crew must therefore make an individual test.

Many other factors influence viscosity and its influence on the engine, such as engine condition and maintenance, fuel pump wear, engine adjustment, actual fuel temperature in the fuel system, human factors, etc. Although achievable, it is difficult to optimise all of these factors at the same time. This complicates operation on viscosities in the lowest end of the viscosity range.

To build in some margin for safe and reliable operation, MAN Diesel recommends operators to test the engine's and external systems' sensitivity to low viscosity. Furthermore, the necessity for installation of a cooler or cooler & chiller should be evaluated before purchasing fuels with the minimum level of viscosity necessary.

In principle, fuels according to the specified grades DMX/DMA can be purchased, if the engine and external system are designed to keep a minimum viscosity of 2 cSt at engine inlet. If 3 cSt can be obtained, this is preferred to ensure a higher safety margin.

ISO 8217

According to ISO 8217, distillate grades DMX/DMA can be sold with a viscosity down to 1.4/1.5 cSt at 40°C. This will especially be the case if the DMX/DMA provided origins from automotive gas oil. The 1.4/1.5 cSt can only be applied if the distillate is cooled/chilled down correspondingly to reach the 2 cSt minimum viscosity at engine inlet.

Influence of lubricity and viscosity

Lubricity

The refinery processes intended to remove, e.g., sulphur from the oil result not only in low viscosity, but also impacts the lubricity enhancing components of the fuel. Too little lubricity may result in fuel pump seizures.

Although most refiners add lubricity-enhancing additives to distillates, MAN Diesel recommends testing the lubricity before using fuels with less than 0.05% sulphur. Independent fuel laboratories can test lubricity according to ISO12156-1 (High-Frequency Reciprocating Rig, HFRR). The HFRR wear scar limit is max 460 μm.

Viscosity

A low viscosity fuel oil challenge the function of the pump in three ways: 1. Breakdown of hydrodynamic oil film (resulting in seizures), 2. Insufficient injection pressure (resulting in difficulties during start and low-load operation), and 3. Insufficient fuel index margin resulting in limitation in acceleration.

Due to the design of conventional pumps versus the pressure booster, ME/ME-C/ME-B engines are more tolerant towards a low viscosity compared with the MC/MC-C engines. Many factors influence the viscosity tolerance during start and low-load operation:

- Engine condition and maintenance
- Fuel pump wear
- Engine adjustment
- Actual fuel temperature in the fuel system
- Human factors, etc.

Although achievable, it is difficult to optimise all of these factors at the same time. This complicates operation on viscosities in the lowest end of the viscosity range. To build in some margin for safe and reliable operation, and availability of high-viscosity distillate fuels, it is expected that installation of coolers or cooler & chiller will be necessary for many operators.

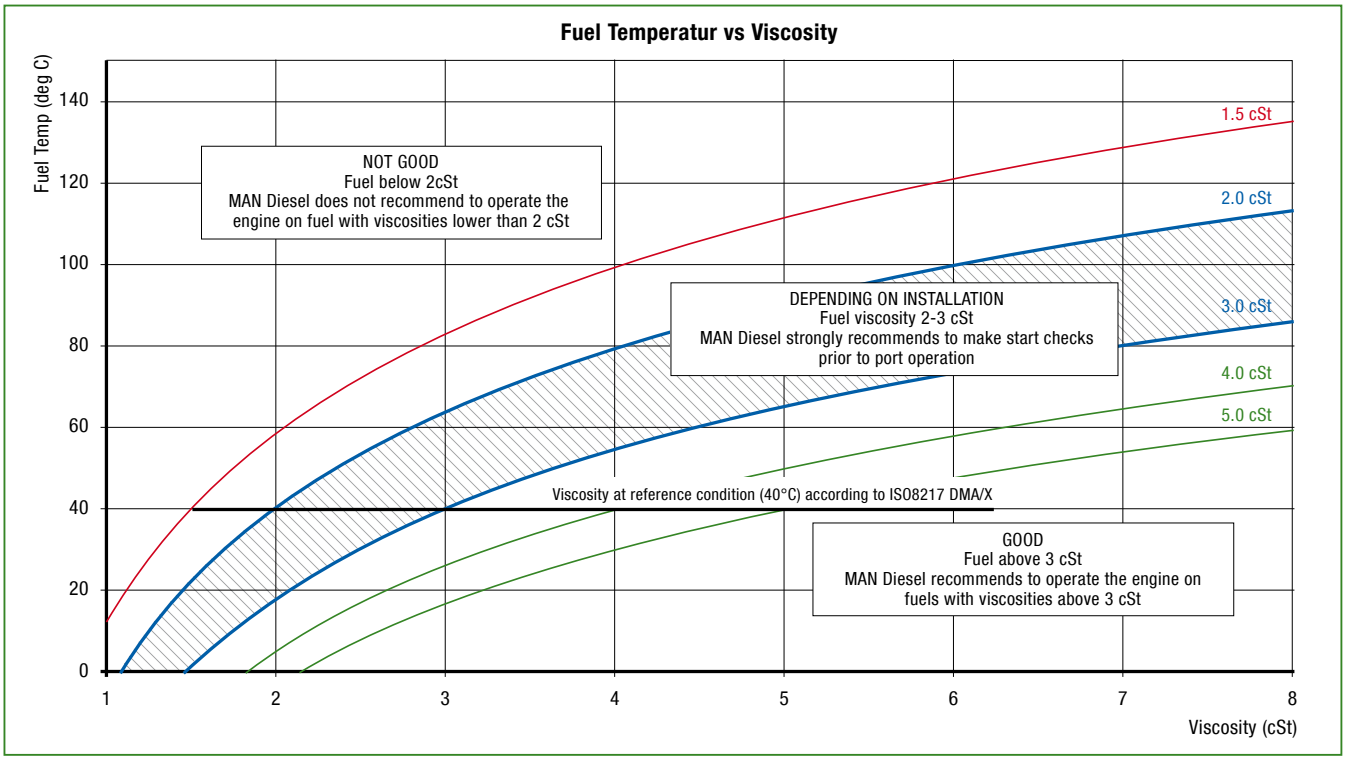
Fuel oil pump pressure

Worn fuel pumps increase the risk of starting difficulties, as the fuel oil pump pressure needed for injection cannot be achieved. An indication of fuel pump wear can be achieved by reading the actual fuel pump index for comparison with the test bed measurements. As a rough guideline, we consider the pump worn out when the index increase is 10 or more. Such fuel pumps should be replaced for better engine performance.

It is always advisable to make start checks at regular intervals. However, as distillates of required minimum viscosity may not be available in all ports, it is an imperative necessity to perform start checks prior to entering high-risk areas (e.g. ports and other congested areas). By such action, the individual low viscosity limit can be found for each engine. It is recommended to perform such a check twice a year, in the following way:

- In an area for safe operation, change fuel to an available distillate.
- At different operating conditions, e.g. start, idle, astern and steady low rpm, gradually change the temperature of the fuel at engine inlet, corresponding to respectively 2, 2.5 and 3 cSt, see Fig. 1 for the typical viscosity and temperature relationship.
- Test start ahead/astern from the control room. If the engine does not start at the first attempt, cancel and repeat the start attempt. If the start ahead/astern functions properly with cancelled limiter, this solution can be used temporarily until either new fuel pumps are installed or a higher viscosity fuel becomes available.

An outcome of the test might be that the specific engine requires a viscosity that cannot be kept due to the influence from the many factors. If the fuel pumps are worn, they must be replaced and the start check repeated.



The horizontal axis shows the bunkered fuel viscosity in cSt, which should be informed in the bunker analysis report. If the temperature of the MGO is below the lower red curve at engine inlet, the viscosity is above 3 cSt.

The black thick line shows the viscosity at reference condition (40°C) according to ISO8217, marine distillates.

Example: MGO with viscosity of 4 cSt at 40°C must have a temperature below 55°C at engine inlet to ensure a viscosity above 3 cSt.

Example: MGO with a viscosity of 5 cSt at 40°C is entering the engine at 50°C. The green curves show that the fuel enters the engine at approximately 4.0 cSt.

Example: MGO with a viscosity of 2 cSt at 40°C needs cooling to 18°C to reach 3 cSt.

Fig. 1: Fuel temperature vs viscosity

Installation of cooler or cooler & chiller

To be able to maintain the required viscosity at the engine inlet, it is necessary to install a cooler in the system. Fig. 2 shows the recommended location to install a cooler.

For the lowest viscosity distillates, a cooler may not be enough to cool the fuel sufficiently due to the cooling water available onboard. In such a case, it is recommended to install a so-called 'chiller'. The chiller principle is shown in Fig. 3.

External pumps

Not only will the engine fuel pumps be influenced by the fuel viscosity. Also most pumps in the external system (supply pumps, circulating pumps, transfer pumps and feed pumps for the centrifuge) need viscosities above 2 cSt to function properly. We recommend contacting the actual pump maker for advice.

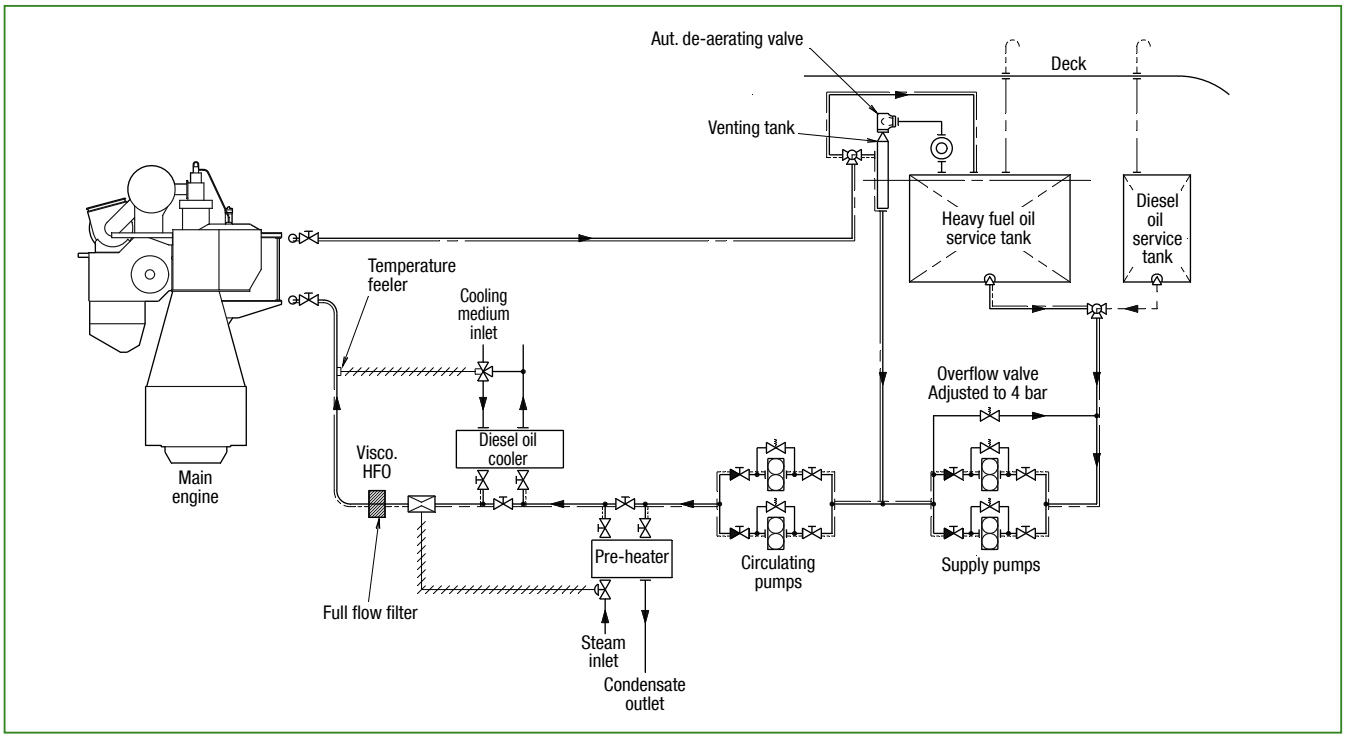


Fig. 2: Fuel system (cooler installed after the circulating pumps)

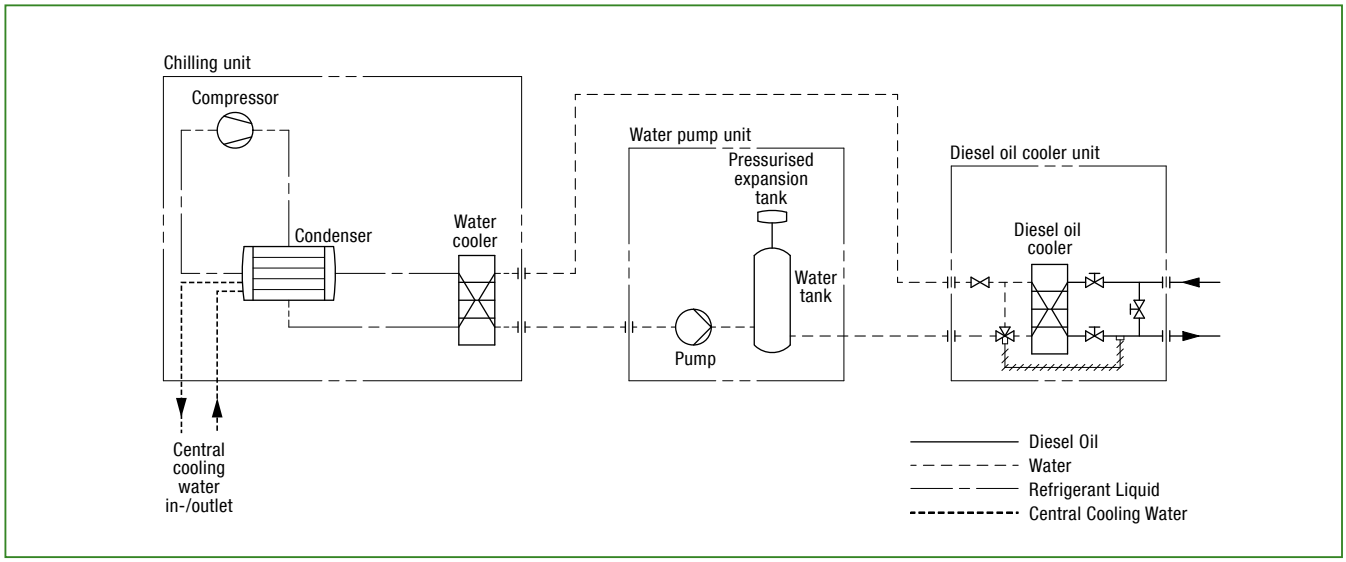


Fig. 3: Chiller principle

Other considerations when operating on distillates

The following items are described in more detail in a separate MAN Diesel paper “Operating on distillate fuels”:

- external pumps
- pour point restrictions (distillates should not be cooled below pour point)
- change-over between HFO and MGO/MDO (to ensure optimal conditions for the fuel pumps)
  Also described in the instruction book, Operation
- DIESEL*switch* for automatic change-over between HFO and MGO/MDO
- correlation between fuel sulphur level and cylinder condition (choice of cylinder lube oil).

Contact PrimeServ for more information on installation of coolers/chillers and DIESEL*switch* (e-mail: *Primeserv-cph@mandiesel.com*).

For operational assistance, please contact our Operation Department at e-mail: *leo@mandiesel.com*.