Fuel and Fuel Treatment

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1. Diesel Oil

Diesel oil fulfilling:
British Standard MA 100, Class M2; ASTM Classification of Diesel fuel oil D975, grade No. 4-D, CIMAC grade 1, or similar; may be used.

2. Heavy Oil

Most commercially available fuel oils with a viscosity below 700 cSt. at 50°C (7000 sec. Redwood I at 100°F) can be used.

For guidance on purchase, reference is made to ISO 8217, BS6843 and to CIMAC recommendations regarding requirements for heavy fuel for diesel engines, edition 1990. From these, the maximum accepted grades are RMH 55 and K55. The mentioned ISO and BS standards supersede BS MA 100 in which the limit is M9.

For reference purposes, an extract from relevant standards and specifications is shown in Plate 70501.

The data in the above fuel standards and specifications refer to fuel as delivered to the ship, i.e. before on-board cleaning.

In order to ensure effective and sufficient cleaning of the fuel oil – i.e. removal of water and solid contaminants – the fuel oil specific gravity at 15°C (60°F) should be below 0.991.

Higher densities can be allowed if special treatment systems are installed.
See Section 705-03.

Current analysis information is not sufficient for estimating the combustion properties of the oil.

This means that service results depend on oil properties which cannot be known beforehand. This especially applies to the tendency of the oil to form deposits in combustion chambers, gas passages and turbines. It may therefore be necessary to rule out some oils that cause difficulties.

If the ship has been out of service for a long time without circulation of fuel oil in the tanks (service and settling), the fuel must be circulated before start of the engine.

Before starting the pump(s) for circulation, the tanks are to be drained for possible water settled during the stop.

The risk of concentration of dirt and water in the fuel to the main and auxiliary engines caused by long time settling is consequently considerably reduced. For treatment of fuel oil, *see further on in this Chapter.*

3. Fuel Sampling

3.1 Sampling

To be able to check whether the specification indicated and/or the stipulated delivery conditions have been complied with, we recommend that a minimum of one sample of each bunker fuel lot be retained. In order to ensure that the sample is representative for the oil bunkered, a sample should be drawn from the transfer pipe at the start, in the middle, and at the end of the bunkering period.

3.2 Analysis of Samples

The samples received from the bunkering company are frequently not identical with the heavy fuel oil actually bunkered. It is also appropriate to verify the heavy fuel oil properties stated in the bunker documents, such as density, viscosity, and pour point. If these values deviate from those of the heavy fuel oil bunkered, there is a risk that the heavy fuel oil separator and the preheating temperature are not set correctly for the given injection viscosity.

3.3 Sampling Equipment

Several suppliers of sampling and fuel test equipment are available on the market, but for more detailed and accurate analyses, a fuel analysing institute should be contacted.

4. Guiding Fuel Oil Specification

Based on our general service experience we have, as a supplement to the above-mentioned standards, drawn up the guiding fuel oil specification shown in the Table below.

Fuel oils limited by this specification have, to the extent of the commercial availability, been used with satisfactory results on MAN B&W two-stroke low speed diesel engines, as well as MAN B&W auxiliary engines.

Guiding specification (maximum values)		
Density at 15°C	kg/m^3	991 *
Kinematic viscosity at 100°C	cSt	55
Kinematic viscosity at 50°C	cSt	700
Flash point	°C	≥60
Pour point	°C	30
Carbon residue	%(m/m)	22
Ash	%(m/m)	0.15
Total sediment after ageing	%(m/m)	0.10
Water	%(v/v)	1.0
Sulphur	%(m/m)	5.0
Vanadium	mg/kg	600
Aluminium + Silicon	mg/kg	80
Equal to ISO 8217/CIMAC – H55		

* 1010 provided automatic modern clarifiers are installed.

The data refers to the fuel as supplied, i.e. before any on-board cleaning.

If fuel oils with analysis data exceeding the above figures are to be used, especially with regard to viscosity and specific gravity, the engine builder should be contacted for advice regarding possible fuel oil system changes.

On account of the relatively low commercial availability of the above-mentioned residuals, only limited service experience has been accumulated on fuels with data exceeding the following:

Viscosity	450 cSt / 50°C
Conradson Carbon	18%
Sulphur	4%
Vanadium	400 mg/kg

Therefore, in the case of fuels with analysis data exceeding these figures, a close watch should be kept on engine performance.

Pressurised Fuel Oil System

1. System Layout

Plates 70502, 70503

The system is normally arranged such that both diesel oil and heavy fuel oil can be used as fuel.

Plate 70502 shows the UNI-Concept common for main and auxiliary engines. It is possible to run the auxiliary engines on heavy fuel oil or diesel oil independent of the main engine.

From the bunker tanks, the oil is pumped to an intermediate tank, from which the centrifuges can deliver it to the respective service tanks ("day-tank").

To obtain the most efficient cleaning, the centrifuges are equipped with preheaters, so that the oil can be preheated to about 95-98°C (regarding the cleaning, *see 'Fuel Treatment' in this Chapter).*

From the particular service tank in operation, the oil is led to one of the two electrically driven supply pumps, which deliver the oil, under a pressure of about 4 bar (possibly through a meter), to the low pressure side of the fuel oil system.

The oil is thereafter drawn to one of two electrically driven circulating pumps, which passes it through the preheater, the viscosity regulator, the filter, and on to the fuel injection pumps.

The filter mesh shall correspond to an absolute fineness of 50 μm (0.050 mm). The absolute fineness corresponds to a nominal fineness of approximately 30 μm at a retaining rate of 90%.

The return oil from the fuel valves and pumps is led back, via the venting pipe, to the suction side of the circulating pump.

In order to maintain a constant pressure in the main line at the inlet to the fuel pumps, the capacity and delivery rate of the circulating pump exceeds the amount of fuel consumed by the engine.

In addition, a spring-loaded overflow valve is fitted, which functions as a by-pass between the fuel oil inlet to the fuel injection pumps and the fuel oil return, thus ensuring a constant pressure in the fuel oil inlet line.

The fuel oil drain pipes are equipped with heat tracing, through which hot jacket cooling water flows. The drain pipe heat tracing must be in operation during running on heavy fuel. *See also Plate 70903.*

To ensure an adequate flow of heated oil through the fuel pumps, housings and fuel valves at all loads (including stopped engine), the fuel valves are equipped with a slide and circulating bore, *see Vol. III, Section 909.*

By means of the "built-in" circulation of preheated fuel oil, the fuel pumps and fuel valves can be maintained at service temperature, also while the engine is stopped.

Consequently, it is not necessary to change to diesel oil when entering harbour, provided that the circulating pump is kept running and preheating of the circulated fuel oil is maintained, *see Section 3.2 in this Chapter.*

If, during long standstill periods, it is necessary to stop the circulating pump or the preheating, the fuel oil system must first be emptied of the heavy oil.

This is carried out by:

- either changing to diesel oil in due time before the engine is stopped, *see Item 4.2.B,* or
- stopping the preheating, and pumping the heavy oil back to the service tank, through the change-over valve mounted at the top of the venting pipe. *See Item 4.2.C.*

2. Fuel Oil Pressure

Carry out adjustment of the fuel oil pressure, during engine standstill, in the following way:

1. Adjust the valves in the system as for normal running, thus permitting fuel oil circulation.

2. Start the supply and circulating pumps, and check that the fuel oil is circulating.

3. Supply Pumps: Adjust the spring-loaded safety valve at supply pump No. 1 to open at the maximum working pressure of the pump.

   The pressure must not be set below 4 bar, due to the required pressure level in the supply line, *see point 4.*

   Make the adjustment gradually, while slowly closing and opening the valve in the discharge line, until the pressure, with closed valve, has the above-mentioned value.

   Carry out the same adjustment with supply pump No. 2.

4. Regulate the fuel oil pressure, by means of the over-flow valve between the supply pump's discharge and suction lines. Adjust so that the pressure in the low pressure part of the fuel system is 4 bar.

5. Circulating Pumps: With the supply pumps running at 4 bar outlet pressure, adjust the spring-loaded by-pass valve at circulating pump No. 1 to open at the maximum working pressure of the circulating pump, about 10 bar.

   Make the adjustment gradually, while slowly closing and opening a valve in the pressure line, until the pressure, with closed valve, has the above-mentioned value.

   Carry out the same adjustment with circulating pump No. 2.

6. Fuel Line: Regulate the fuel oil pressure by means of the spring-loaded overflow valve installed between the main inlet pipe to the fuel injection pumps and the outlet pipe on the engine. Adjust the overflow valve so that the pressure in the main inlet pipe is 7-8 bar, *see also Chapter 701.*

7. With the engine running, the pressure will fall a little.
   Re-adjust to the desired value at MCR.

Fuel Treatment

1. Cleaning

1.1 General

Fuel oils are always contaminated and must therefore, before use, be thoroughly cleaned for solid as well as liquid contaminants.

The solid contaminants are mainly rust, sand and refinery catalysts; the main liquid contaminant is water, - i.e. either fresh or salt water.

These impurities can:

- cause damage to fuel pumps and fuel valves.
- result in increased cylinder liner wear.
- be detrimental to exhaust valve seatings.
- give increased fouling of gasways and turbocharger blades.

1.2 Centrifuging

Effective cleaning can only be ensured by means of centrifuges.

The ability to separate water depends largely on the specific gravity of the fuel oil relative to the water - at the separation temperature. In addition, the fuel oil viscosity (at separation temp.) and flow rate, are also influencing factors.

The ability to separate abrasive particles depends upon the size and specific weight of the smallest impurities that are to be removed; and in particular on the fuel oil viscosity (at separation temp.) and flow rate through the centrifuge.

We recommend the capacity of the installed centrifuges to be at least according to the maker's instructions.

To obtain optimum cleaning, it is of the utmost importance to:

a) operate the centrifuge with as low a fuel oil viscosity as possible.

b) allow the fuel oil to remain in the centrifuge bowl for as long as possible.

Re a)

The optimum (low) viscosity, is obtained by running the centrifuge preheater at the maximum temperature recommended for the fuel concerned.

It is especially important that, in the case of fuels above 1500 Sec. RW/100°F (i.e. 180 cSt/50°C), the highest possible preheating temperature - 95-98°C - should be maintained in the centrifuge preheater. See Plate 70505.

The centrifuge should operate for 24 hours a day except during necessary cleaning.

Re b)

The fuel is kept in the centrifuge as long as possible, by adjusting the flow rate so that it corresponds to the amount of fuel required by the engine, without excessive re-circulation.

The ideal "through-put" should thus correspond to the normal amount of fuel required by the engine, plus the amount of fuel consumed during periods when the centrifuge is stopped for cleaning.

For efficient removal of water by means of a conventional purifier, the correct choice of gravity disc is of special importance. The centrifuge manual states the disc which should be chosen, corresponding to the specific gravity of the fuel in question.

Centrifuge Capacity:
Series or Parallel Operation

It is normal practice to have at least two centrifuges available for fuel cleaning.

Plate 70504 Fig. 1

As regards centrifuge treatment of today's residual fuel qualities, experimental work has shown that, provided the capacity of each centrifuge is sufficient, the best cleaning effect, particularly as regards removal of catalyst fines, is achieved when the centrifuges are operated in *series* – in purifier/ clarifier mode.

Series operation of centrifuges (ensuring a maximum of safety), is therefore a fully acceptable alternative to the previously recommended parallel operation. Each centrifuge must however be able to handle the total amount of fuel required by the engine, without exceeding the flow-rate recommended by the centrifuge maker.

This recommendation is valid for conventional centrifuges. For later types, suitable for treating fuels with densities higher than 991 kg/m^3 at 15°C, it is recommended to follow the maker's specific instructions, *see item 1.3 below.*

Plate 70504 Fig. 2

If the installed centrifuge capacity is on the low side (relative to the specific viscosity of the fuel oil in question), and if more than one centrifuge is available, *parallel operation* may be considered in order to obtain a lower flow rate. However, in view of the above recommendations, serious considerations should be given to the possible advantages of installing new equipment, in accordance with today's fuel qualities and flow recommendations.

As regards the determination/checking of the centrifuging capacity, we generally advise that the recommendations of the centrifuge maker are followed, but the curves shown on Plate 70505 can be used as a guidance.

1.3 High Density Fuels

To cope with the trend towards fuels with density exceeding 991 kg/m^3 at 15°C, the centrifuging technology has been further developed.

Improved clarifiers, with automatic desludging provides adequate separation of water and particles from the fuel, up to a density of 1010 kg/m^3 at 15°C.

The centrifuges should be operated in parallel or in series according to the maker's instructions and recommendations.

1.4 Homogenisers

As a supplement only (to the centrifuges), a homogeniser may be installed in the fuel oil system, to homogenise possible water and sludge still present in the fuel after centrifuging.

1.5 Fine Filter

As a supplement only (to the centrifuges), a fine filter with very fine mesh may be installed, to remove possible contaminants present in the fuel after centrifuging.

A homogeniser should be inserted before a possible fine filter in order to minimise the risk of blocking by agglomeration of asphaltenes.

1.6 Super Decanters

As a supplement only, a super decanter may be installed. This is, in principle, a "horizontal" clarifier. The aim is to remove sludge before normal centrifuging and thus minimize the risk of blocking of the centrifuges.

2. Fuel oil stability

Fuel oils of today are produced on the basis of widely varying crude oils and refinery processes. Practical experience has shown that, due to *incompatibility,* certain fuel types may occasionally tend to be unstable when mixed.
As a consequence, fuel mixing should be avoided to the widest possible extent.

A mixture of incompatible fuels, in the bottom tanks and the settling tanks, may lead to stratification, and also result in rather large amounts of sludge being taken out by the centrifuges, in some cases even causing centrifuge blocking.

Stratification can also take place in the service tank, leading to a fluctuating preheating temperature, when this is controlled by a viscorator.

Service tank stratification can be counteracted by recirculating the contents of the tank through the centrifuge. This will have to be carried out at the expense of the previously mentioned benefits of low centrifuge flow rate.

3. Preheating before Injection

In order to ensure correct atomization, the fuel oil has to be preheated before injection.

The necessary preheating temperature is dependent upon the specific viscosity of the oil in question.

Inadequate preheating (i.e. too high viscosity):

- will influence combustion,
- may cause increased cylinder wear (liners and rings),
- may be detrimental to exhaust valve seatings,
- may result in too high injection pressures, leading to excessive mechanical stresses in the fuel oil system.

In most installations, preheating is carried out by means of steam, and the resultant viscosity is measured by a viscosity regulator (viscorator), which also controls the steam supply.

Depending upon the viscosity/temperature relationship, and the viscosity index of the fuel oil, an outlet temperature of up to 150°C will be necessary. This is illustrated in the diagram on Plate 70506, which indicates the expected preheating temperature as a function of the fuel oil viscosity.

Recommended viscosity meter setting is 10-15 cSt.

However, experience from service has shown that the viscosity of the fuel, before the fuel pump, is not a too strict parameter, for which reason we allow a viscosity of up to 20 cSt after the preheater.

In order to avoid too rapid fouling of the preheater, a temperature of 150°C should not be exceeded.

3.1 Precaution

Caution must be taken to avoid heating the fuel oil pipes by means of the heat tracing when changing from heavy fuel to diesel oil, and during running on diesel oil. Under these circumstances excessive heating of the pipes may reduce the viscosity too much, which will involve the risk of the fuel pumps running hot, thereby increasing the risk of sticking of the fuel pump plunger and damage to the fuel oil sealings. *(See point 4.3).*

3.2 Fuel Preheating when in Port

During engine standstill, the circulation of preheated heavy fuel oil does not require the viscosity to be as low as is recommended for injection. Thus, in order to save energy, the preheating temperature may be lowered some 20°C, giving a viscosity of about 30 cSt.

3.3 Starting after Staying in Port

If the engine has been stopped on heavy fuel, and if the heavy fuel has been circulated at a reduced temperature during standstill, the preheating and viscosity regulation should be made operative about one hour before starting the engine, so as to obtain the required viscosity, *see Item 3 'Preheating before Injection'.*

4. Other Operational Aspects

4.1 Circulating Pump Pressure

The fuel oil pressure measured on the engine (at fuel pump level) should be 7-8 bar, equivalent to a circulating pump pressure of up to 10 bar. This maintains a pressure margin against gasification and cavitation in the fuel system, even at 150°C.

The supply pump may be stopped when the engine is not in operation. *See Plate 70502.*

4.2 Fuel change-over

(See also 'Pressurised fuel oil system' earlier in this Chapter).

The engine is equipped with uncooled, "all-symmetrical", light weight fuel valves – with built-in fuel circulation. This automatic circulation of the preheated fuel (through the high-pressure pipes and the fuel valves) during engine standstill, is the background for our recommending *constant operation on heavy fuel.*

However, change-over to diesel oil can become necessary if, for instance:

- the vessel is expected to have a prolonged inactive period with cold engine, e.g. due to:
  - a major repair of the fuel oil system etc.
  - a docking
  - more than 5 days' stop (incl. laying-up)
- environmental legislation requiring the use of low-sulphur fuels.

Change-over can be performed at any time:

- during engine running, *see Items 4.2.A and 4.2.B.*
- during engine standstill, *see Item 4.2.C.*

In order to prevent:

- fuel pump and injector sticking/scuffing,
- poor combustion,
- fouling of the gasways,

it is very important to carefully follow the temperature / load requirements of the change-over procedures. *See Items 4.2.A, 4.2.B and 4.2.C.*

A. Change-over from Diesel oil to <u>Heavy Fuel during Running</u>

To protect the injection equipment against rapid temperature changes, which may cause sticking/scuffing of the fuel valves and of the fuel pump plungers and suction valves, the change-over is carried out as follows (manually):

First, ensure that the heavy oil in the service tank is at normal temperature level.

Reduce the engine load to 3/4 of normal. Then, by means of the thermostatic valve in the steam system, or by manual control of the viscosity regulator, the diesel oil is heated to *maximum* 60-80°C. Regulate the preheating so as to give a temperature rise of about 2°C per minute.

The diesel oil viscosity should <u>not</u> drop below 2 cSt, as this might cause fuel pump and fuel valve scuffing, with the risk of sticking, due to failing lubrication ability of the diesel oil.

For some light diesel oils (gas oil), this will limit the upper temperature to somewhat below 80°C.

Due to the above-mentioned risk of sticking/scuffing of the fuel injection equipment, the temperature of the heavy fuel oil in the service tank must <u>not</u> be more than 25°C higher than the heated diesel oil in the system (60-80°C) at the time of change-over.

When the temperature requirements have been fulfilled, the change to heavy oil is performed by turning the change-over cock. The temperature rise is then continued at a rate of about 2°C per minute, until reaching the required viscosity, *see Item 3, ' Preheating before Injection'.*

B. Change-over from Heavy Fuel to Diesel Oil during Running

See also Item 3.1, 'Precautions'.

To protect the fuel oil injection equipment against rapid temperature changes, which may cause scuffing with the risk of sticking of the fuel valves and of the fuel pump plungers and suction valves, the change-over to diesel oil is performed as follows (manually):

- Preheat the diesel oil in the service tank to about 50°C, if possible.
- Cut off the steam supply to the fuel oil preheater and heat tracing.
- Reduce the engine load to 3/4 of MCR-load
- Change to diesel oil when the temperature of the heavy oil in the preheater has dropped to about 25°C above the temperature in the diesel oil service tank, however, not below 75°C.

Note: If, after the change-over, the temperature (at the preheater) suddenly drops considerably, the transition must be moderated by supplying a little steam to the preheater, which now contains diesel oil.

C. Change-over from Heavy Fuel to Diesel Oil during Standstill

- Stop the preheating. Regarding temperature levels before change-over, *see Item B, 'Change-over from Heavy Fuel to Diesel Oil during Running'.*
- Change position of the change-over valve at the fuel tanks, so that diesel oil is led to the supply pumps.
- Start the supply pumps and circulating pumps (if they are not already running).
- Change position of the change-over valve at the venting pipe, so that the fuel oil is pumped to the HFO-tank.
- When the heavy fuel oil is replaced by diesel oil, turn the change-over valve at the venting pipe back to its normal position, so that the heavy oil in the venting pipe is now mixed with diesel oil.
- Stop the supply pumps.
- Stop the circulating pumps.

Residual Marine Fuel Standards

Plate 70501-40

<table>
<tr><td colspan="3">Designation</td><td>CIMAC A 10</td><td>CIMAC B 10</td><td>CIMAC C 10</td><td>CIMAC D 15</td><td>CIMAC E 25</td><td>CIMAC F 25</td><td>CIMAC G 35</td><td>CIMAC H 35</td><td>CIMAC K 35</td><td>CIMAC H 45</td><td>CIMAC K 45</td><td>CIMAC H 55</td><td>CIMAC K 55</td></tr>
<tr><td colspan="3">Related to ISO 8217 (87): F -</td><td>RMA 10</td><td>RMB 10</td><td>RMC 10</td><td>RMD 15</td><td>RME 25</td><td>RMF 25</td><td>RMG 35</td><td>RMH 35</td><td>RMK 35</td><td>RMH 45</td><td>RMK 45</td><td>RMH 55</td><td>-</td></tr>
<tr><td>Characteristic</td><td>Dim.</td><td>Limit</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Density at 15°C</td><td>Kg/m^3</td><td>max.</td><td>950</td><td colspan="2">975</td><td>980</td><td colspan="2">991</td><td colspan="2">991</td><td>1010</td><td>991</td><td>1010</td><td>991</td><td>1010</td></tr>
<tr><td rowspan="2">Kinematic viscosity at 100°C</td><td rowspan="2">cSt 2)</td><td>max.</td><td colspan="3">10</td><td>15</td><td colspan="2">25</td><td colspan="3">35</td><td colspan="2">45</td><td colspan="2">55</td></tr>
<tr><td>min. 4)</td><td>6</td><td colspan="2"></td><td></td><td>15</td><td></td><td colspan="3"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Flash point</td><td>°C</td><td>min.</td><td colspan="3">60</td><td>60</td><td colspan="2">60</td><td colspan="3">60</td><td colspan="2">60</td><td colspan="2">60</td></tr>
<tr><td>Pour point</td><td>°C</td><td>max.</td><td colspan="2">0
6 3)</td><td>24</td><td>30</td><td colspan="2">30</td><td colspan="3">30</td><td colspan="2">30</td><td colspan="2">30</td></tr>
<tr><td>Carbon residue</td><td>%(m/m)</td><td>max.</td><td colspan="2">12</td><td>14</td><td>14</td><td>15</td><td>20</td><td>18</td><td colspan="2">22</td><td colspan="2">22</td><td colspan="2">22</td></tr>
<tr><td>Ash</td><td>%(m/m)</td><td>max.</td><td colspan="3">0.10</td><td>0.10</td><td>0.10</td><td>0.15</td><td colspan="3">0.15</td><td colspan="2">0.15</td><td colspan="2">0.15</td></tr>
<tr><td>Total sediment after ageing</td><td>%(m/m)</td><td>max.</td><td colspan="3">0.10</td><td>0.10</td><td colspan="2">0.10</td><td colspan="3">0.10</td><td colspan="2">0.10</td><td colspan="2">0.10</td></tr>
<tr><td>Water</td><td>%(V/V)</td><td>max.</td><td colspan="3">0.50</td><td>0.80</td><td colspan="2">1.0</td><td colspan="3">1.0</td><td colspan="2">1.0</td><td colspan="2">1.0</td></tr>
<tr><td>Sulphur</td><td>%(m/m)</td><td>max.</td><td colspan="3">3.5</td><td>4.0</td><td colspan="2">5.0</td><td colspan="3">5.0</td><td colspan="2">5.0</td><td colspan="2">5.0</td></tr>
<tr><td>Vanadium</td><td>mg/kg</td><td>max.</td><td colspan="2">150</td><td>300</td><td>350</td><td>200</td><td>500</td><td>300</td><td colspan="2">600</td><td colspan="2">600</td><td colspan="2">600</td></tr>
<tr><td>Aluminium and silicon</td><td>mg/kg</td><td>max.</td><td colspan="3">80</td><td>80</td><td colspan="2">80</td><td colspan="3">80</td><td colspan="2">80</td><td colspan="2">80</td></tr>
<tr><td colspan="3">Ignition properties 5)</td><td colspan="13"></td></tr>
</table>

1) Approximate equivalent viscosities (for information only)

Kinematic viscosity (cSt) at	100°C	6	10	15	25	35	45	55
Kinematic viscosity (cSt) at	50°C	22	40	80	180	380	500	700
Sec. Redwood I at	100°F	165	300	600	1500	3500	5000	7000

2) 1 cSt = 1 mm^2/sec

3) Applies to region and season in which fuel is stored and used, (upper value winter quality, bottom value summer quality)

4) Recommended value only. May be lower if density is also lower

5) **Ignition Properties**

Normally applied analytical data for fuel oil contain no direct indication of ignition quality, neither do current specifications and standards. Although not an important parameter for low and medium speed engines with high compression ratios, the ignition quality can to some extent be predicted by calculations based on viscosity and density, using formulas issued by the oil industry (CCAI by Shell or CII by BP). High density in combination with low viscosity may be an indication of poor ignition quality.

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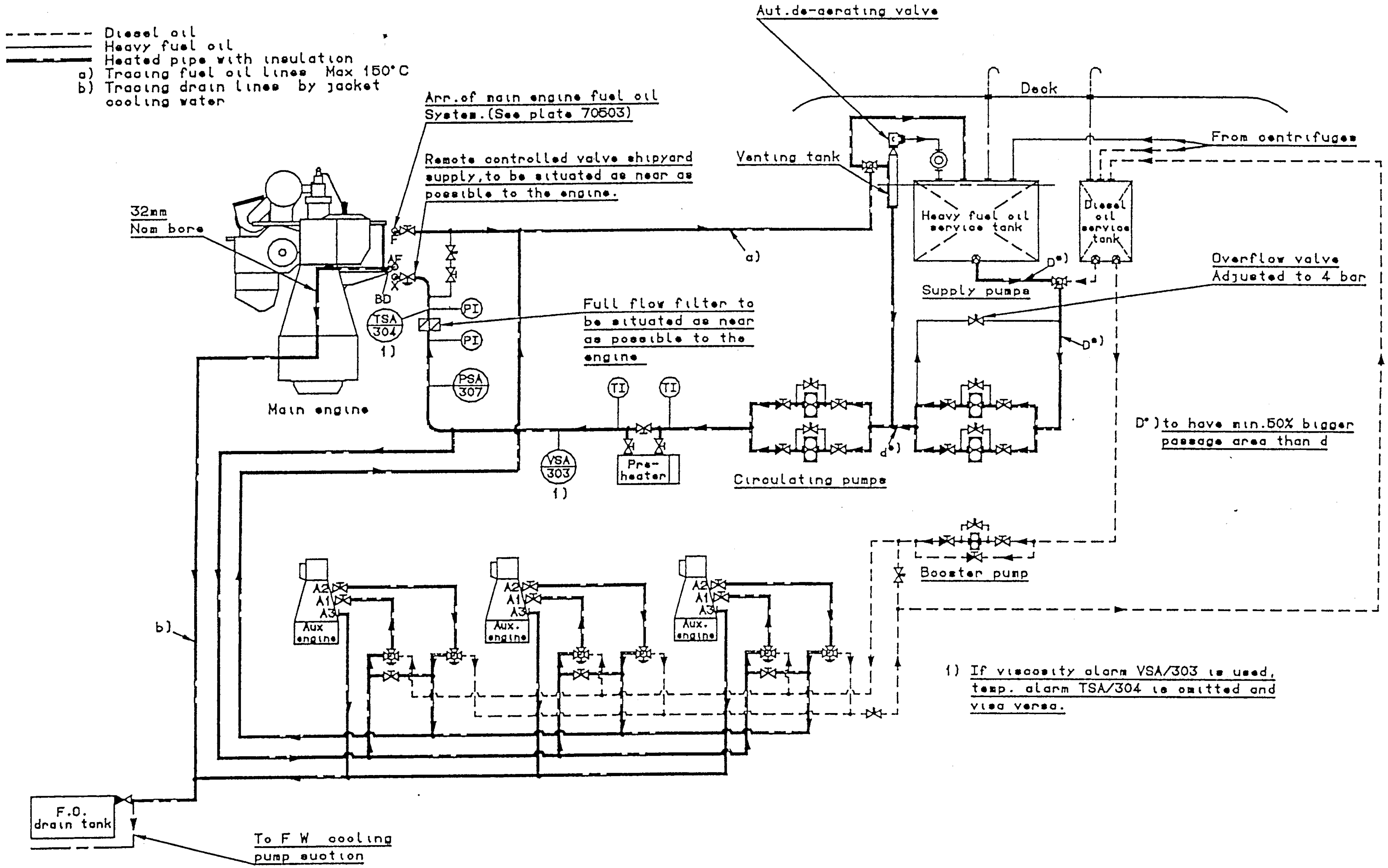
Plate 70502-40 Fuel Oil System



Fuel Oil Pipes on Engine

Plate 70503-40

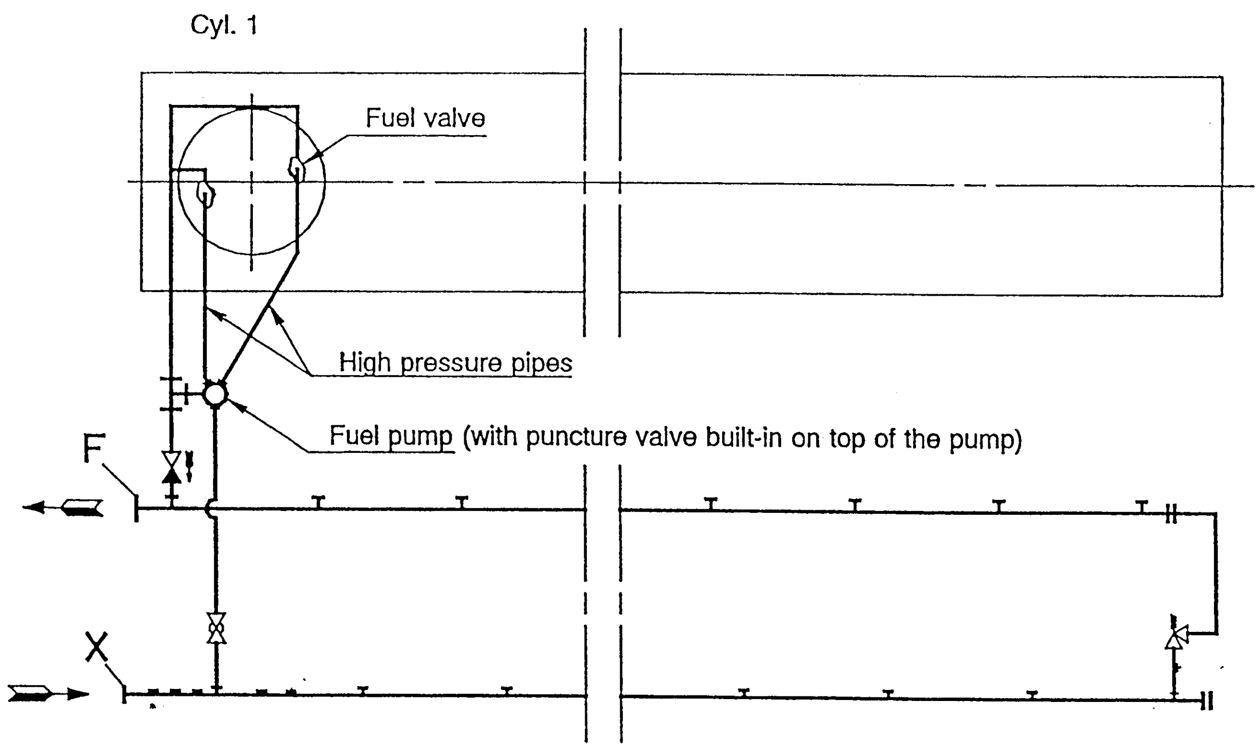


Plate 70504-40 **Fuel Oil Centrifuges**
Modes of Operation

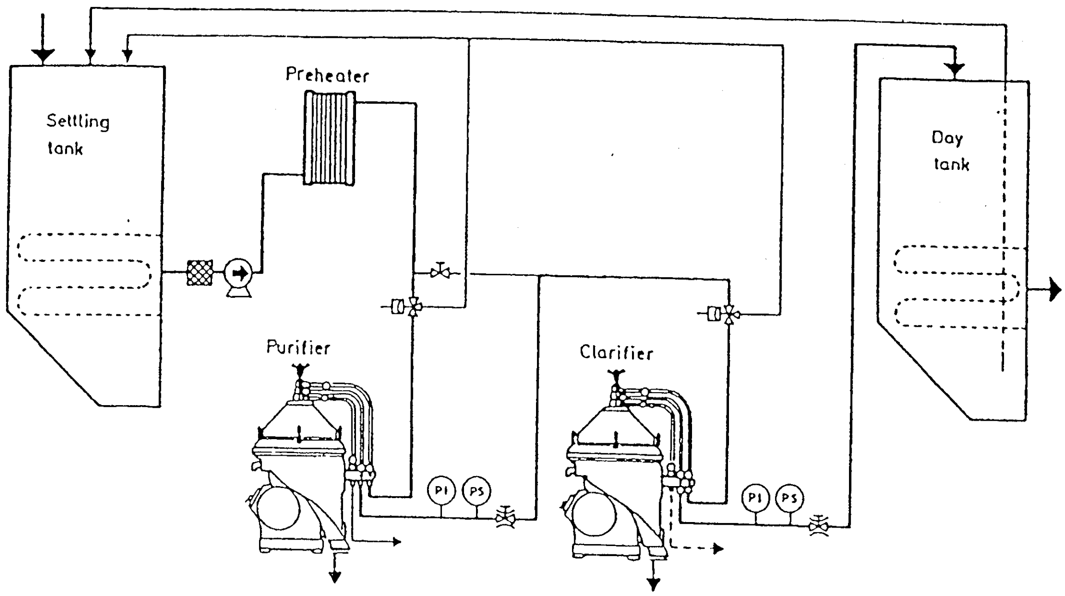


Fig. 1

In Series

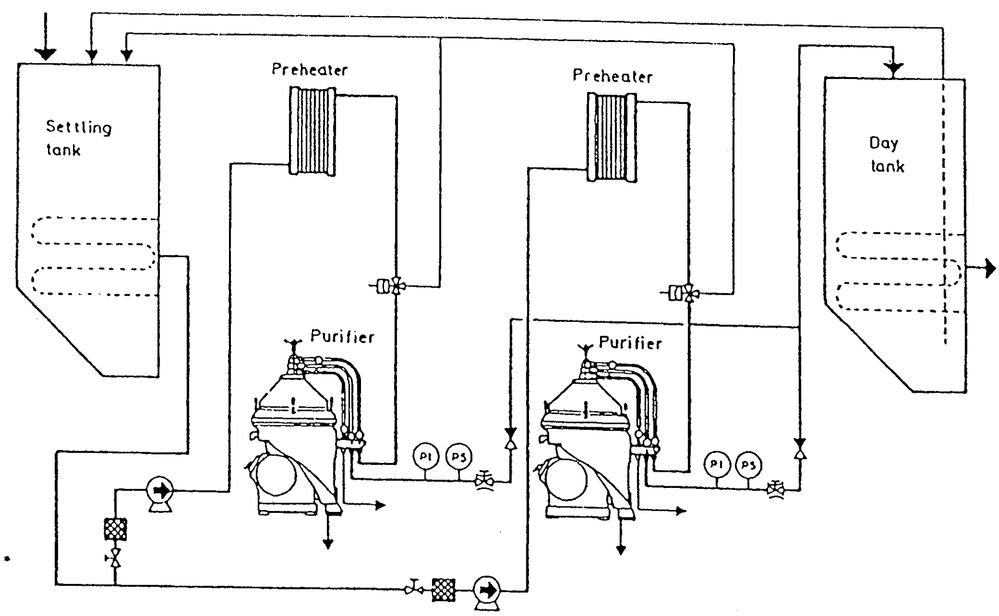


Fig.2

In Parallel

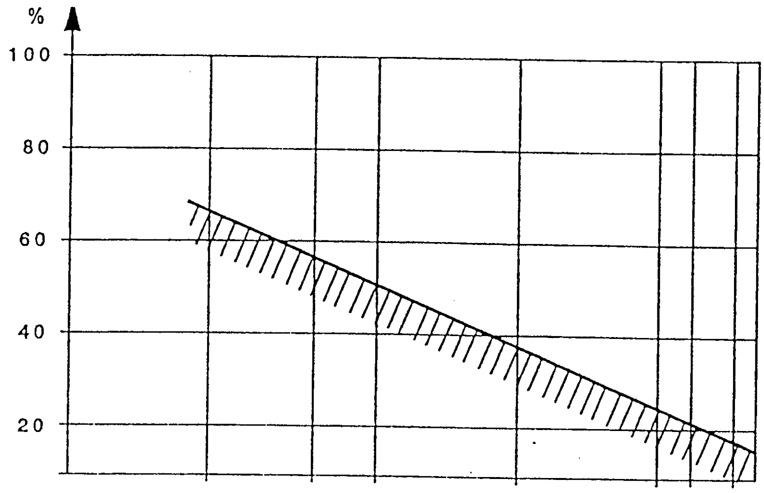
By courtesy of Alfa-Laval

Centrifuge Flow Rate and Separation Temperature (Preheating)

Plate 70505-40

Rate of flow

Related to rated capacity of centrifuge



Separation temperature

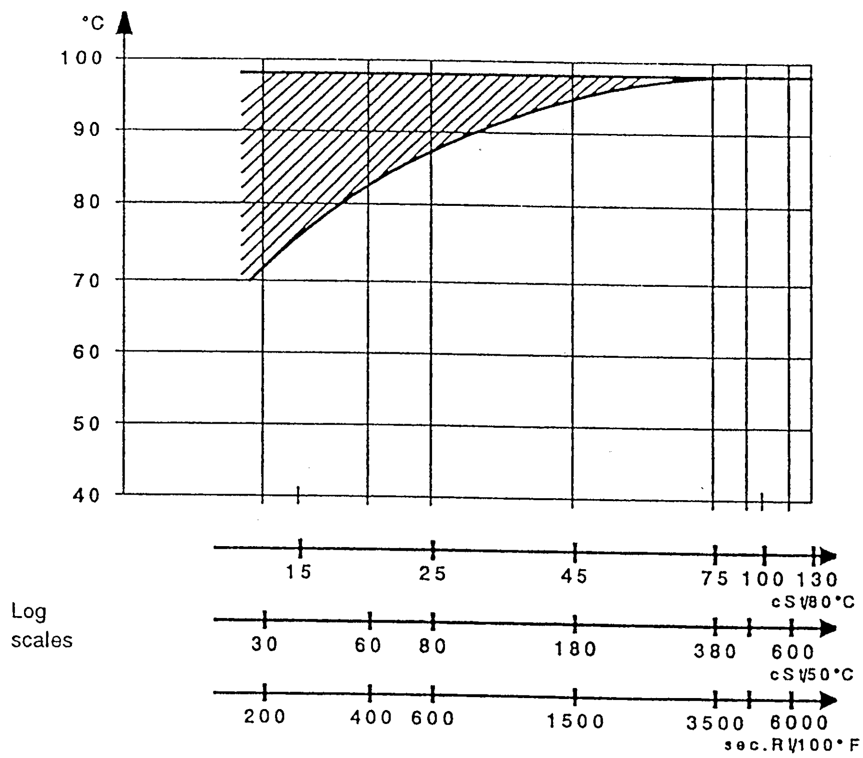
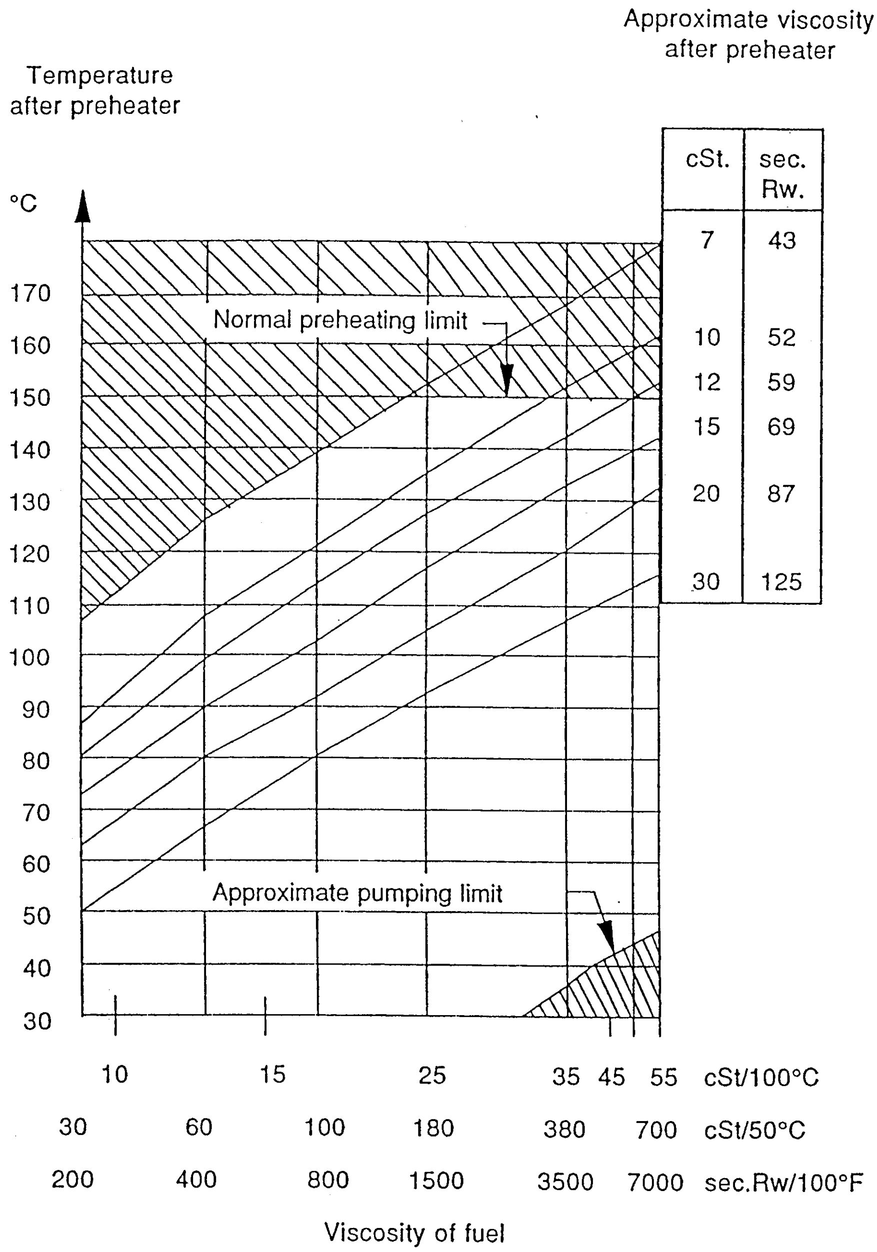


Plate 70506-40 **Preheating of Heavy Fuel Oil**
(Prior to Injection)



This chart is based on information from oil suppliers regarding typical marine fuels with viscosity index 70-80.
Since the viscosity after the preheater is the controlled parameter, the preheating temperature may vary, dependent on the viscosity and viscosity index of the fuel.

Recommended viscosity meter setting is 10-15 cSt.