

Service Bulletin

RT-82

29.06.2009

**Technical Information to all Owners / Operators
of Wärtsilä RTA and RT-flex Engines**

Distillate Fuel Use

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1 Introduction

Wärtsilä Switzerland allows for its engines to be operated on all fuels supplied under the ISO 8217 specification.

Current and foreseen marine fuel legislation is limited to prescribing the maximum sulphur content or to reduce the sulphur in the exhaust gas with alternative methods equivalently.

The availability of fuels with various sulphur levels is not yet fully clear. However, as the demand for sulphur content in the fuel is reduced below 0.5%, the possibility of distillate fuel increases. In many respects, distillate fuel differs from heavy fuel. In general it must be said that both the quality is more strictly specified and improved combustion characteristics are observed for this fuel type compared to heavy fuels.

According to ISO 8217, distillate fuels are categorised as DMX, DMA (also called MGO) and DMB (often called MDO). DMX is emergency fuel with a lower flashpoint, coming with additional storage precautions. Due to the low flash point, this fuel would not normally be used in marine diesel engines. DMA and DMB are most common distillate fuels and also have guaranteed good combustion characteristics due to the specified cetane index, whereas DMC-fuel contains up to 15% HFO and has no cetane index prescribed.

2 Minimum fuel viscosity

The current recommendation for fuel viscosity at the fuel injector is 13 to 17cSt when operating on HFO.

This viscosity level cannot be met with MDO and MGO unless the fuel is cooled. Experience has however shown that viscosities for grades DMA and DMB distillate fuels, as detailed in the ISO 8217 specification, have no adverse affect on the operation of the fuel system components. A nominal lower viscosity level of 2cSt at the fuel pump is recommended. To achieve this level a cooler may be required depending on the actual maximum fuel temperature reached. It could be with low ambient engine room temperatures and heat losses thorough radiation from the relevant fuel tank that this will not be required. The actual viscosity will depend on the fuel bunkered, please contact Wärtsilä for additional information if required.

Low viscosity values raise two main points of concern:

Principally an alteration in the fuel pump timing due to increased leakage between the plunger helix and spill port. This is not a concern on Wärtsilä 2-stroke engines as the pump timing is controlled by valves.

The second concern is the lubrication function of the fuel oil between the barrel and plunger. Providing the fuel meets the specification laid out above, no additional measures are required. As the plunger has no helix, the sealing is over a greater length and the clearances between the barrel and plunger optimised.

3 Distillate fuel use

3.1 RTA engines

Wärtsilä 2-stroke engines are capable of burning all fuels previously mentioned in this Bulletin.

When burning distillate fuels or fuels with very low viscosities, increased leakage may occur through the fuel pump barrels and plungers and suction and spill valve push rods. The rate of leakage may differ depending on the clearance between the components resulting from wear. The leakage fuel cannot enter the lubricating oil if all drains are clear as it is collected and drained from the fuel pump intermediate space.

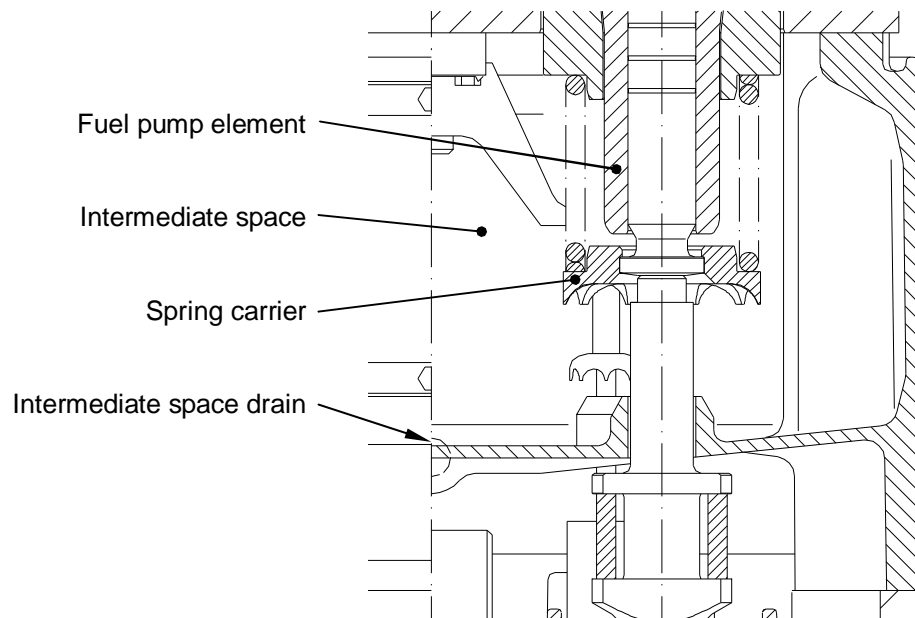


Figure 1: RTA fuel pump detail

This fuel can be reused if it drains to a separate fuel drain tank and not a common waste oil tank. Please confirm the tank layout on each individual installation. Prior to changing fuels please ensure all tanks are empty and the possibility of mixing these fuels is minimised. Please also ensure that the lower plunger spring carrier has no fuel residue which may impair the drainage of this fuel and the all drain bores in the spring carrier umbrella are clear.

With increased fuel leakage through the barrel and plunger, a higher load indicator position may be experienced. This higher load index would correspond with an increased governor terminal shaft position and may on some installations limit the engine load due to the governor torque and / or scavenge air limiters. If an installation is to be run on low viscosity fuels for any length of time this may require adjustments of the governor. Care should however be taken to ensure the maximum crankshaft torque is not exceeded when reverting to the standard fuel.

Further more, fuel grades DMA and DMB have lower densities than HFO, which results in a net reduction in the calorific values by volume. As the fuel pumps are volume controlled, this will lead to a further increase in the load position although there will be an offset due to the varying calorific values.

Please consult Wartsila Switzerland if these measures mentioned above are required and refer to Service Bulletin 2S1 which specifically deals with the interrelation between the engine and propeller.

The cylinder lubrication is load dependent and the feed rate is determined by both the engine speed and load indicator position. With an increased load indicator position, an increase in the cylinder oil feed rate is to be expected. This is not a desired effect and again if the engine is to be run on low viscosity fuels for any length of time, this point should be considered and the feed rate adjusted to compensate for this increase.

As the timing of Wärtsilä RTA 2-stroke engine fuel pumps is valve controlled, no countermeasures are required to adapt the fuel pump timing with regards to increased leakage through the fuel pumps.

When using low viscosity fuel, improved combustion would be experienced. This can result in high peak pressures which may have a negative effect on the reliability of the piston rings and other combustion space components. When using this fuel, measure the peak pressures and retard the timing to compensate for the pressure peaks. On all RTA, RLA/B and some RND-M engines the FQS can be used to retard the timing. On all other older R type engines, the timing has to be retarded by adjusting the fuel pump cams.

The pressure rise differs by both engine type and the rating. The original shop- and / or seatrial data should be used for reference values, although if unavailable please contact Wärtsilä for this information. Refer to the main engine operating manual section 0420/1. This procedure needs to be carried out for each batch of fuel irrespective of the grade and is helpful in optimising the engine performance.

3.2 RT-flex engines

As the fuel injection operating principle of the RT-flex engines differs from the RTA engines, other considerations apply.

When the engine is at standstill the fuel circulation is only through the fuel pumps and not the rail unit. Due to this the fuel cannot be changed over at this point.

The increased oil leakage through the fuel pumps may result in a higher actuator position. This does not have a timing effect and is only to adjust the volume control. The fuel pump has a segregated drain space with o-rings. Ensure the o-rings are in a good condition, these are detailed below. The leakage oil is drained from the engine through drain pipes. It is necessary to ensure these drains are clear, refer to the relevant engine manuals. When the engine is run on gas oil and the fuel change over is complete, allow for any residual heavy fuel oil to be drained. Once complete, ensure the steam or electrical trace heating is switched off. Ensure this is switched on again for HFO use.

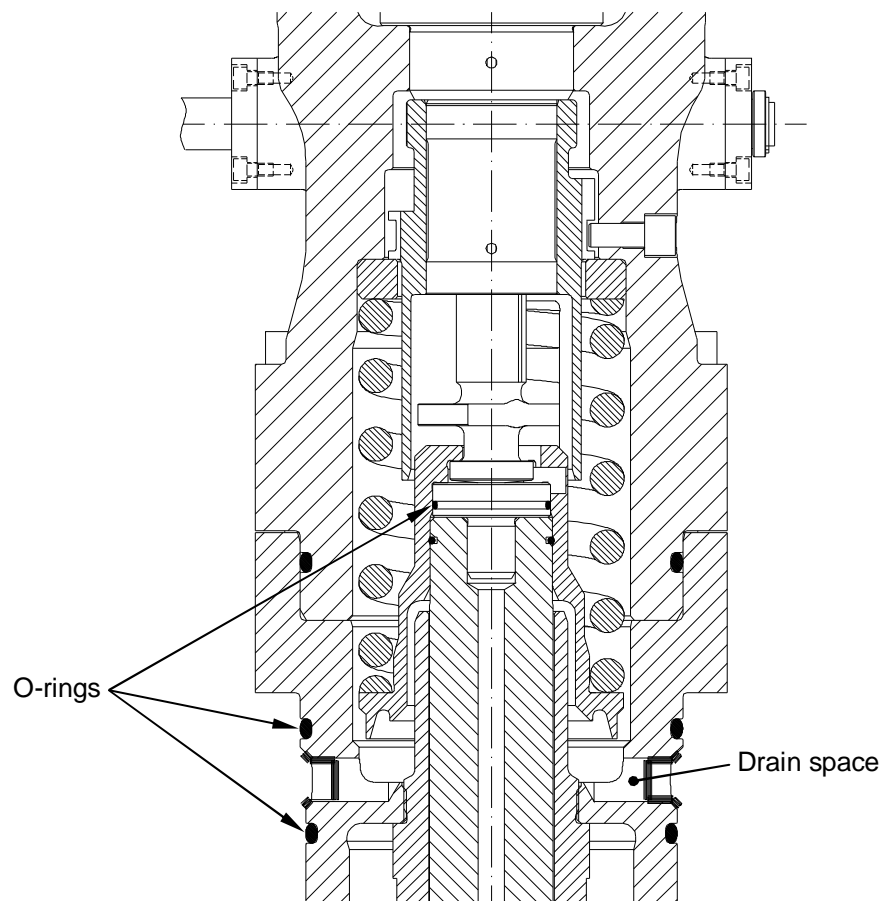


Figure 2: RT-flex fuel pump detail

Increased leakage may occur in the rail unit assembly, including the injection control units (ICU). This fuel oil leakage is through a separate drain system which has flow sensors fitted. Please ensure all drain pipes and

bores are clear and again that the steam or electrical trace heating is switched off for long term low viscosity fuel use.

With the increased leakage through the rail unit the fuel pressure drop may increase when the engine is at standstill. This may lead to a slight increase in the starting air consumption when manoeuvring.

The injection timing is controlled by the crank position and will not be affected by low viscosity fuels.

As for RTA engines, the combustion will improve compared to HFO and allowance should be made for high peak pressures. Refer to the engine operating manual section 0420/1.

4 Cylinder oil selection

For operation on fuel with a sulphur content lower than 1.5%, the cylinder oil feed rate should be low and have 40BN. This is in order to prevent build-up of deposits, originating from un-neutralized hard calcium carbonate deposits.

Please refer to Service Bulletins RT-18.4 and RTA-66 for more information.

Prior to changing over to distillate fuels the cylinder oil should be switched over to allow for the higher BN oil to be flushed through. The time for this to be achieved depends on the layout of the piping system, and in particular the volume. The use of low BN oil with a fuel with higher sulphur content during this relatively short change over period will not have an adverse effect on the liner wear rates.

5 Fuel change over procedure

When changing over from one fuel type to another, a specific procedure applies. This is detailed in the engine operating manual, however this is to be clarified as follows:

5.1 Changing over from diesel oil to heavy fuel oil and vice versa

The changeover of the main engine operating mode HFO / DO or vice versa occurs through the three-way valve installed in the suction line from the HFO and DO tank (see the enclosed drawing, position 21).

When changing over fuels however, thermal shock to the engine fuel injection system (injection pumps, piping, etc.) has to be prevented. Sudden temperature changes may lead to seizing of the fuel pump plungers, this may affect the manoeuvrability of the ship, or result in fuel pipe leakage with the risk of fire.

Not only the temperature increase (15°C/min), when changing over from DO to HFO, is important, but also the temperature decrease (15°C/min), when changing over from HFO to DO.

The experience gained so far shows that the use of changeover valves (21) with time delay (e.g.: 10' duration from 100% on HFO to 100% DO), and

acting therefore as mixing valves, has not been very successful. This is due to the fact that to mix both fuels properly, the HFO and DO pressures at the valve inlet must be equal, which, in practice, is hardly feasible.

5.2 Change-over from DO to HFO

The fuel viscosity is controlled by the viscosimeter and the increase of the fuel temperature itself can be manually or automatically controlled. Depending on the viscosimeter type, a temperature ramp (gradient) can be set to automatically control the change in temperature. The maximum temperature gradient must not exceed 15°C/min.

5.3 Change-over from HFO to DO

In this case, the temperature change cannot be influenced by the viscosimeter, but by the fuel volume available in the fuel system (as well as by the involved steel mass of the fuel system).

The mixing unit (24) serves to equalise the fuel oil temperature between the hot surplus heavy fuel oil returning from the engine and the heavy fuel oil from the daily tank. It also provides an additional fuel volume, which limits the temperature gradients when changing over from HFO to DO or vice versa.

A large capacity mixing unit will be of advantage in further reducing the temperature gradient. This will however increase the period for which both fuels are present together, and consequently the risk of compatibility problems occurs.

6 Conclusion

Summarising the points above the following pertinent points are of particular interest.

High load indicator position	Can be compensated for to some extent. Only recommended for the long term use of low sulphur fuels.
Cylinder oils	Care should be taken when matching the cylinder oil BN to the fuel sulphur level.
Increased fuel leakage	Leakage fuel can be reused if not mixed with other drain oils (lubricating) from the engine. Leakage fuel should be returned to the relevant settling tank and re-treated.
Fuel compatibility	Change over time to be kept as short as possible to prevent excessive mixing. If possible, the compatibility of the two fuels to be used when changing over should be tested in advance.
Fuel lubrication properties	Will not be adversely affected by the commonly available fuels
Fuel treatment	Maintain the normal fuel treatment irrespective of the fuel in use

7 Layout of fuel oil system

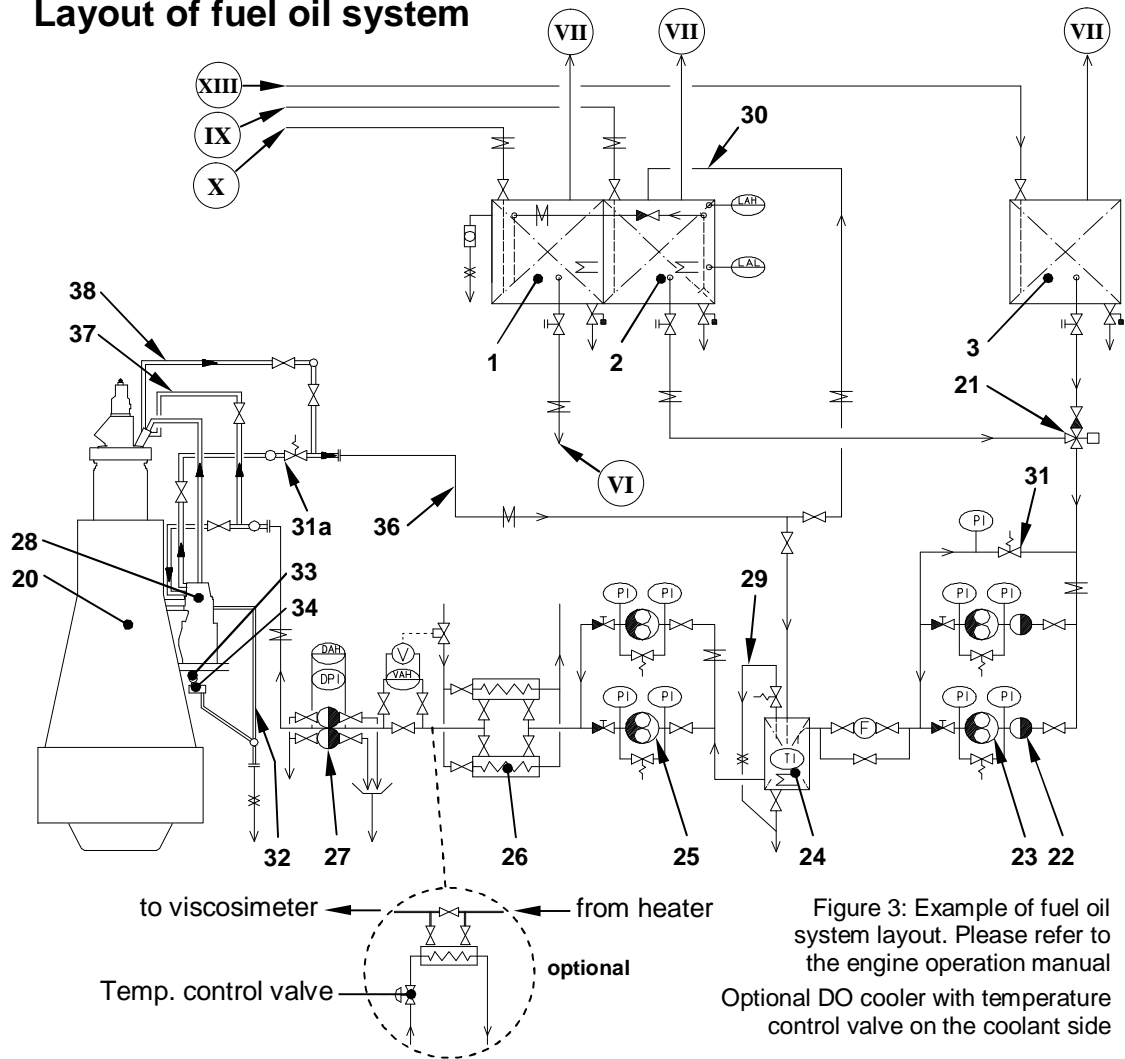


Figure 3: Example of fuel oil system layout. Please refer to the engine operation manual
Optional DO cooler with temperature control valve on the coolant side

- | | |
|--|--------------------------------------|
| 1 Heavy fuel oil settling tank | 28 Injection pump |
| 2 Heavy fuel oil daily tank | 29 Air overflow pipe |
| 3 Diesel oil daily tank | 30 Bypass pipe |
| [...] | 31 Pressure regulating valve |
| 20 Main engine | 31a Pressure retaining valve |
| 21 Three-way valve | 32 Leakage pipe from injection pump |
| 22 Suction filter | 33 Leakage pipe from fuel pipe duct |
| 23 Low pressure feed pump | 34 Fuel leakage monitoring |
| 24 Mixing unit, heatable and insulated | [...] |
| 25 Booster pump | 36 Return pipe |
| 26 End-heater | 37 Supply circulating pipe |
| 27 Fuel filter, heatable | 38 Return circulating pipe |
| VI To heavy fuel oil separator | IX From heavy fuel oil separator |
| VII To vent manifold | X From the transfer pump |
| VIII From diesel oil separator | |
| ⊕ Flow indicator | PI Pressure gauge |
| ⊞ Heated & insulated pipes | TI Thermometer |
| ⊗ Insulated pipes | DAH Differential pressure alarm high |
| ⊘ Pressure regulating valve | DPI Differential pressure indication |
| ⊙ Sight glass | LAL Fluid level alarm, low |
| ⊖ Viscosimeter | LAH Fluid level alarm high |
| | VAH Viscosity alarm high |

8 ISO 8217 Fuel standard

8.1 Marine Distillate Fuels

Parameter	Unit	Limit	DMX	DMA	DMB	DMC
Density at 15°C	kg/m ³	max.	-	890	900	920
Viscosity at 40°C	mm ² /s	max.	5.5	6.0	11.0	14.0
Viscosity at 40°C	mm ² /s	min.	1.4	1.5	-	-
Micro Carbon Residue at 10% Residue	% m/m	max.	0.3	0.3	-	-
Micro Carbon Residue	% m/m	max.	-	-	0.3	2.5
Water	% V/V	max.	-	-	0.3	0.3
Sulphur ^{c)}	% (m/m)	max.	1.0	1.5	2.0	2.0
Total Sediment Existent	% m/m	max.	-	-	0.1	0.1
Ash	% m/m	max.	0.01	0.01	0.01	0.05
Vanadium	mg/kg	max.	-	-	-	100
Aluminium + Silicon	mg/kg	max.	-	-	-	25
Flash point	°C	min.	43	60	60	60
Pour point, Summer	°C	max.	-	0	6	6
Pour point, Winter	°C	max.	-	-6	0	0
Cloud point	°C	max.	-16	-	-	-
Calculated Cetane Index		min.	45	40	35	-
Appearance			Clear & Bright		-	-
Zinc ^{d)}	mg/kg	max.	-	-	-	15
Phosphorus ^{d)}	mg/kg	max.	-	-	-	15
Calcium ^{d)}	mg/kg	max.	-	-	-	30
	^{c)}	A sulphur limit of 1.5% m/m will apply in SOx Emission Control Areas designated by the International Maritime Organization, when its relevant Protocol comes into force. There may be local variations.				
	^{d)}	The Fuel shall be free of ULO. A Fuel is considered to be free of ULO if one or more of the elements are below the limits. All three elements shall exceed the limits before deemed to contain ULO.				

Source: ISO 8217 Third Edition 2005-11-01
Petroleum products - Fuels (class F) - Specifications of marine fuels

8.2 Marine Residual Fuels

Parameter	Unit	Limit	RMA 30	RMB 30	RMD 80	RME 180	RMF 180	RMG 380	RMH 380	RMK 380	RMH 700	RMK 700
Density at 15°C	kg/m ³	max.	960	975	980	991		991		1010	991	1010
Viscosity at 50°C	mm ² /s	max.	30		80	180		380		700		
Water	% V/V	max.	0.5		0.5	0.5		0.5		0.5		
Micro Carbon Residue	% m/m	max.	10		14	15	20	18	22		22	
Sulphur ^{c)}	% m/m	max.	3.5		4.0	4.5		4.5		4.5		
Ash	% m/m	max.	0.10		0.10	0.10	0.15	0.15		0.15		
Vanadium	mg/kg	max.	150		350	200	500	300	600		600	
Flash point	°C	min.	60		60	60		60		60		
Pour point, Summer	°C	max.	6	24	30	30		30		30		
Pour point, Winter	°C	max.	0	24	30	30		30		30		
Aluminium + Silicon	mg/kg	max.	80		80	80		80		80		
Total Sediment, Potential	% m/m	max.	0.1		0.1	0.1		0.1		0.1		
Zinc ^{d)}	mg/kg	max.	15									
Phosphorus ^{d)}	mg/kg	max.	15									
Calcium ^{d)}	mg/kg	max.	30									
^{c)}	A sulphur limit of 1.5% m/m will apply in SO _x Emission Control Areas designated by the International Maritime Organization, when its relevant Protocol comes into force. There may be local variations.											
^{d)}	The Fuel shall be free of ULO. A Fuel is considered to be free of ULO if one or more of the elements are below the limits. All three elements shall exceed the limits before deemed to contain ULO.											

Source: ISO 8217 Third Edition 2005-11-01
Petroleum products - Fuels (class F) - Specifications of marine fuels