YANMAR SERVICE NEWS

Subject	Use of Low Sulfur (1.5%～0%) Fuel Oil (Rev.5: Assessment of FO's lubrication performance (HFRR) added)		No.:06-2-G-07-009-S-Rev. 5 June 2009 Rev. Jan. 2015
Engine Model	ALL	Use	Marine Main & Aux. Engines
		Engine Nos.	――――――――――――

IMO's regulation on SOx emissions from ships, (MARPOL 73/78 Annex VI), specifies the limit of sulfur content in fuel oils in SOx Emission Control Area, (SECA) and in other general areas respectively to be 0.1% and 3.5% as of now, (Jan. 2015). (For details, please refer to IMO's home page, shipping classification organizations or the proper authorities.)

When using low sulfur fuel oils, please refer to the points and cautions as follows:

Table 1, Upper Limit of Sulfur Content in Fuel Oil

Effective Date	**Status Quo (after Jan. 2015)**	**After Jan. 2020 ※1**
General Area	**Under 3.5%**	**Under 0.5%**
SOx Emission Control Area (SECA)	**Under 0.1%**	**Under 0.1%**

※1 Application timing be decided according to the review of 2018.

YANMAR CO.,LTD. LARGE POWER PRODUCTS OPERATIONS BUSINESS. QUALITY ASSURANCE DIVISION.	Approved	Checked	Prepared
	N. Matsunaga	[signature]	A. Yoshida

<Standard for Using Low Sulfur Fuel Oil (1.5%~0%)>

1.Effect of Using Low Sulfur Fuel Oil on the Engine:

We specify the alkalinity value of lube oil that matches the sulfur content in fuel oils in our booklet titled, Marine Generator Engines Operated on HFO. This is for the purpose of selecting lube oil that matches the sulfur content in fuel oils since the fuel oils need to be neutralized constantly irrespective of conducting low load operation or not.

When the engine was operated on the low sulfur content fuel oil and the lube oil with high alkalinity value (total base number: TBN) was used, the additive in lube oil (calcium carbonate) together with carbon residues, deposits on the extreme temperature parts and accumulates on the upper piston and combustion chamber. This can hinder normal performance of piston rings, cause scuffing in the cylinder liner and other parts or can cause blow-by when caught inside the exhaust valve. In addition, the combustion product (hard resin-like matter) of resin, asphaltene in fuel oil can deposit on the honing loops of liner surface to make specular surface or cause 'lacquering phenomenon". This causes lube oil consumption to increase and can cause scuffing.

2. Recommended Procedures for Using Low Sulfur Fuel Oils

We recommend to use lube oil that matches the sulfur content in fuel oils when using M.D.O., H.F.O. and Low Sulfur Fuel Oils (sulfur content 1.5% ~ 0%). In recent years, the sulfur content in fuel oils used has come to be limited in the special areas due to the environmental pollution issue. This means that the navigation with the use of high sulfur content H.F.O. must be switched to the use of low sulfur content fuel oil in the regulated areas. However, to switch the engine's lube oil to the lube oil with optimum alkalinity value during navigation is hard to implement in practice. As described in our Heavy Fuel Oil Literature, we have verified that the use of lube oil with the alkalinity value that matches low grade fuel oils was allowable for the operation on M.D.O. when change over between M.D.O. and H.F.O. fuel oils as far as the operation continues for short hours, (i.e., within 300 hours). Based on this experience, we recommend to implement following procedures when using low sulfur content fuel oils:

1) When using high sulfur fuel oil for regular navigation and switching to low sulfur fuel oil only before entering the regulated areas:
Based on the said result above, there is no problem if the engine operation remains within 300 hours, (approx. 2 weeks). Accordingly, use the high alkalinity lube oil for use of high sulfur fuel oil as it is, navigate outside the regulated area within 2 weeks and switch to high sulfur fuel oil.

2) When using low sulfur fuel oil (1.5%~0%) constantly:
Select the lube oil with the alkalinity value (TBN) of 9~15 that matches the sulfur content of fuel oil and supply it to the engine.

3) When the engine is operated on low and high sulfur fuel oils alternately for long hours continuously, (more than 300 hours), on an irregular base:
Use the different types of lube oil that matches each type of fuel oil. If it is not practical to use 2 types of lube oil in view of the ship's equipment, follow to the procedures under 1) or 2) above.

If lacquering phenomenon arose, refer to our Service News, (No.97-2-E-12-047-L), for the corrective measure.

3.Cautions for Using Low Viscosity Fuel Oils, (MARINE GAS OIL, etc.)

Yanmar recommends the use fuel oils of which properties comply with the standard of DMA and DMB, specificed by ISO8217, (usually called MDO). (The flash point of fuel oils equivalent to DMX is too low at 45℃ min. and Yanmar does not recommend the use of these fuel oils in view of safety.)

On the other hand, when selecting the low sulfur fuel oil, MGO is selected usually. However, the min kinetic viscosity of MGO, which is equivalent to DMA oil, can be on the 1.5cSt at 40 deg. level. The kinetic viscosity can be low considerably depending on the bunker.

The extremely low viscosity can cause seizure of the plunger and barrel of the FO injection pump. Accordingly, check the viscosity of the bunkered fuel oil against the property table and convert the viscosity by the fuel oil temperature supplied for ensuring the viscosity over 1,8cSt min. at engine inlet.

When it is not possible to ensure the fuel oil viscosity at 1.8cSt min. at engine inlet, we recommend you to install the FO cooling equipment, (FO cooler, chill cooler, etc.) in the MGO/MDO system.

In general, sulfur in fuel oils has lubricity and the sulfur content exerts influence on the fuel oil properties. Small sulfur content means small lubricity of the fuel oil. In particular, when using fuel oils of which sulfur content is under 0.5%, take care of the following points:

- Use fuel oils of which HFRR wear scar diameter by the lubricity index is under 460μm（※）
- Calculate the viscosity by the temperature of fuel oil fed by the engine. Secure the minimum viscosity at engine inlet to be over 18cSt.
- When the viscosity specified above cannot be obtained, install the FO cooler.
- When the appropriate lubricity index mentioned above or the minimum viscosity cannot be obtained, examine the addition of the lubricity improvement agent.

（※)Concerning the assessment of the lubricity of fuel oils, HFRR (High Frequency Reciprocating Rig) test method has been established. In this test, the index shows that the larger wear scar, the lower lubricity of the fuel oil.

4. Change over of Fuel Oil

For change over fuel oils, follow to the instructions of the operation manual as has done before. We confirmed that the plunger barrel would not stuck due to temperature change even upon change over fuel oil instantaneously as shown in <Reference> below. We think that same applies to M.G.O.

<Reference>

Fig.1 shows if or not the plunger and the plunger barrel of the FO injection pump would stuck when the high temp. H.F.O. was changed over instantaneously to the low temp. M.D.O. or vice versa at the FO injection pump inlet. Although FO temp. inside the FO injection pump varies rapidly, the plunger barrel temperature varies moderately. In both cases, there arose no sticking of the parts.

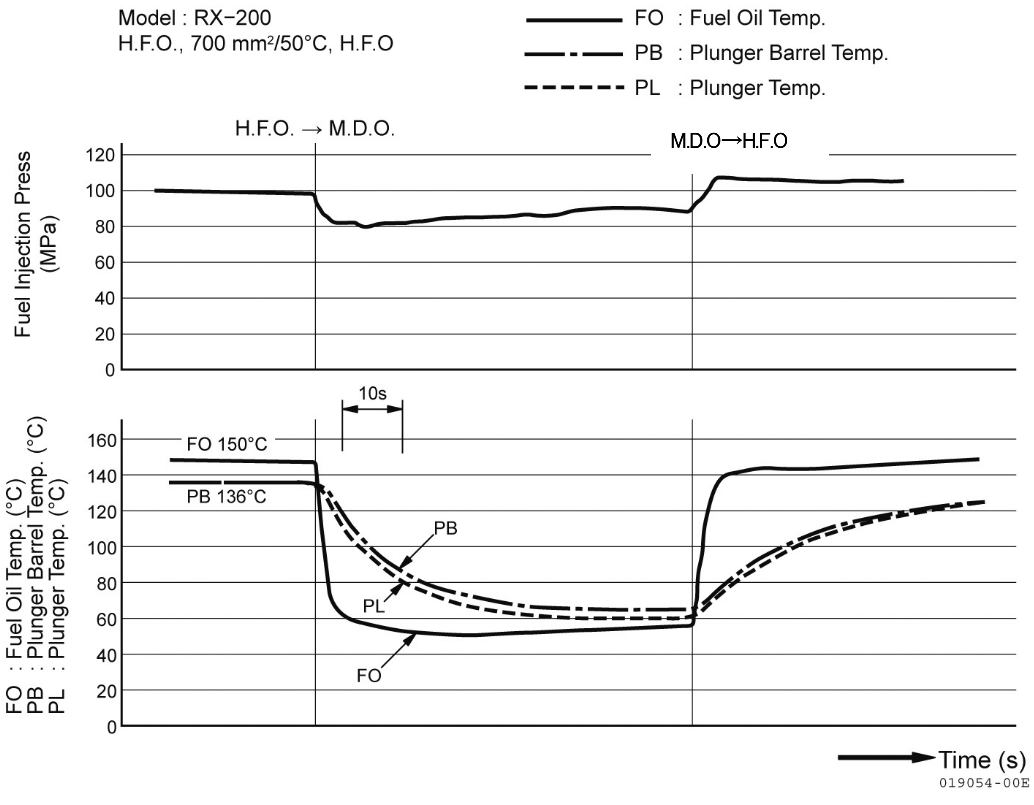

fig.1.H.F.O and M.D.O. Switch Test

5. FO Cooler

An example diagram of FO cooler installation and the selection standard are shown below for your reference. (For details, please refer to our System Development Division via your contact of Yanmar Engineering Co., Ltd. or Large Power Products Operations Div. of Yanmar.)

1) Example of FO Cooler Installation

Low sulfur fuels such as MARINE GAS OIL [Light Diesel oil, DMA (ISO8217: 2005)] include a low viscosity fuels (min. 1.5 cSt at 40 deg). Fuels with extremely low viscosity can cause seizure of the plunger and barrel of fuel injection pump. Accordingly, when using such low viscosity fuels, keep the fuel oil viscosity at engine inlet over 1.8 cSt at minimum.

The following "Installation of FO Cooler at MGO circulation line" is one of the examples to keep the fuel oil viscosity over 1.8 cSt at engine inlet. (Fig.2: Circulation Line)

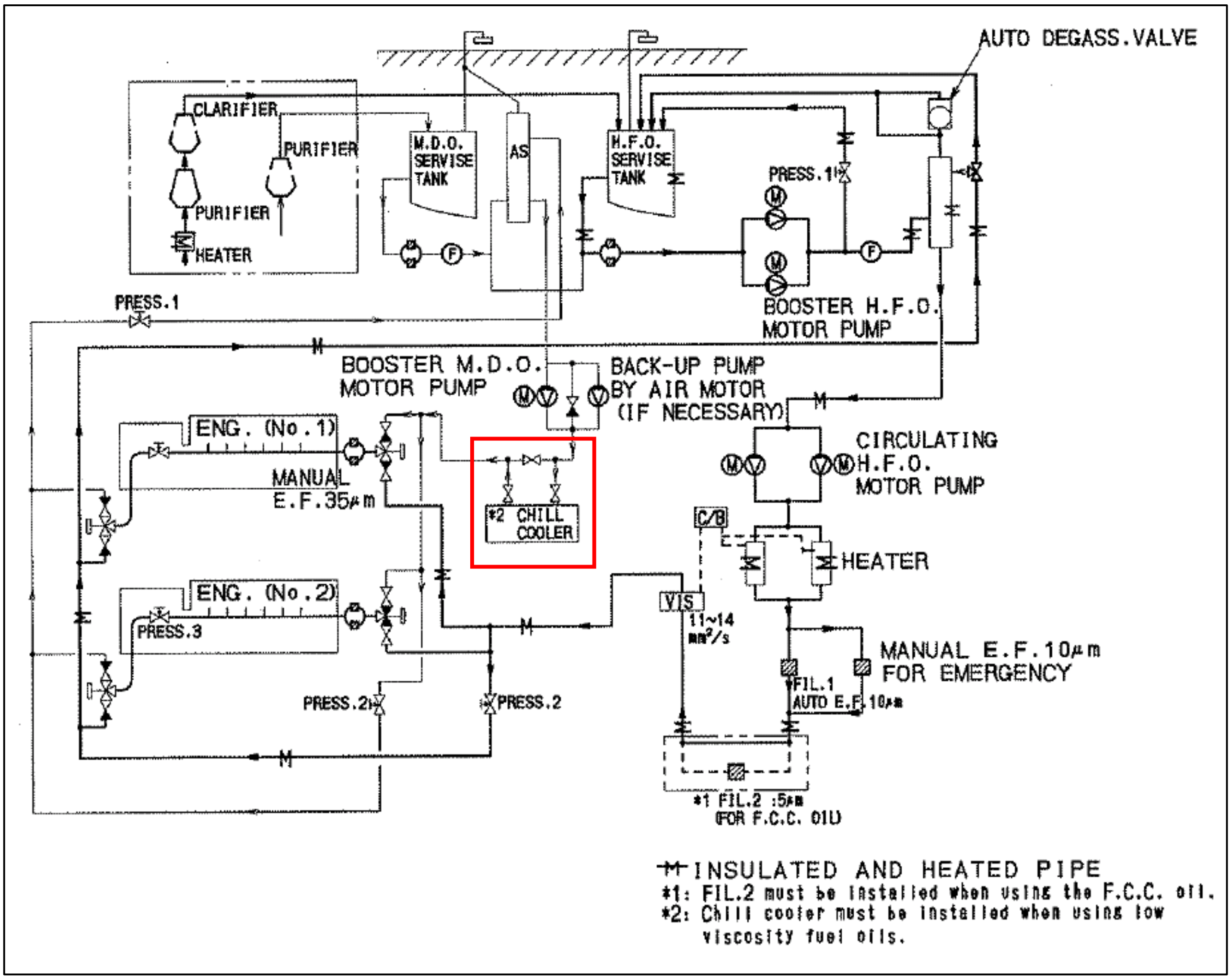

Fig.2: Circulation Line

2) Selection of FO Cooler Capacity

(Refer to Table1.) The FO cooler design data with our engine, 8N21L-SV, as an example are as follows:

〔Design Condition〕

- Density of MARINE GAS OIL : (min. 1.5 cSt at 40deg)/ISO8217: 2005 DMA
- Temperature at FO Service Tank : 45deg
- Capacity of FO Circ. Pump : 0.70 m3/h
- FO Temperature which Viscosity 1.8 cSt : Less than 20deg (min. : More than 10deg)
- This calculation sheet is for one engine.(In case of plural engines. Please multiply the No. of engine.)

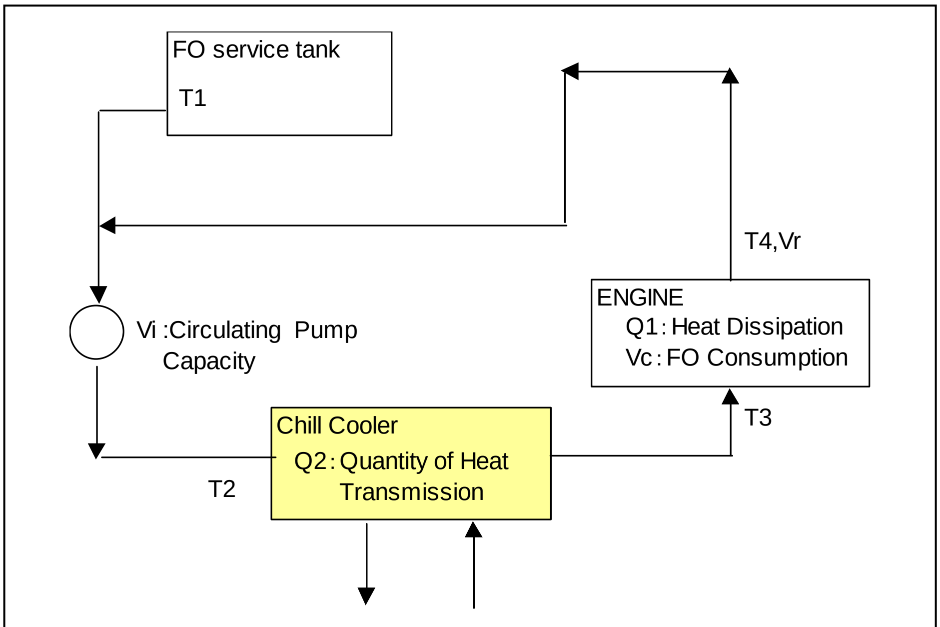

Fig 3.

Table 1.

R : FO Density	kg/m^3	890	: Based on the Property Table
		-	
C : FO Specific heat capacity	kJ/Kg°C	2	: Constant
kW : Engine Power	kW	880	: From completion specifications
FOC : Specific Fuel Oil Consumption	g/k Wh	199	
Q 1 : Heat Dissipation from Engine to Fuel Oil.	MJ/h	9.2	: Heat dissipation from engine (Table 2) to FO.
	kW	2.56	=MJ/h /3.6
T1 : Temperature at FO Serv.T.	Deg	45	: Assumption (engine room temp, max.)
T3 : FO Temperature at Eng. Inlet	Deg	20	for keeping over 1.8 cSt.
Vi : Capacity of FO Circ. Pump .	m^3/h	0.700	: From completion specifications
Vc : FO Consumption	m^3/h	0.197	=kW x FOC / R
Vr : FO Return Flow from Eng.	m^3/h	0.503	= Vi-Vc
ΔT : FO Temp. Diff. Eng. In-Out	Deg	10.3	= Q/(Vr*R*C)
T4 : FO Temperature at Eng. Outlet	Deg	30.3	= T3 + ΔT
T2 : FO Temperature at Chill Cooler Inlet	Deg	34.4	=(((Vr x ΔT)+(Vc x (T1-T3)))/Vi)+ T3
Q2 : Quantity of Heat Transmission at Chill Cooler	MJ/h	18.0	= Vi x R x C x (T2-T3)
	kW	4.99	=MJ/h /3.6

3) Standard for Selecting FO Cooler

-1：Determine the engine inlet FO temperature, (FO cooler outlet FO temperature), based on the properties of FO used actually.

-2：FO Cooler Capacity

Heat Dissipation: Use (Amount of heat supplied to FO from the engine) + (Amount of heat of FO itself supplied from the service tank).

FO Circulation and Return Amount: Circulation amount is the FO circulation pump capacity.

FO return amount is: (Circulation Pump Capacity) – (FO Consumption).

-3：Use data in Table 2 to determine heat dissipation to FO from the engine.

Table 2. Heat Dissipation to FO from Engine

Model	Engine Output	Rev.speed	Heat Dissipation to FO from Engine (Q1)
	kW	min-1	MJ/h
6NY16L(W)	265~441	1200	**5.6**
6N165L(W)	441~530	1200	**6.7**
6EY18L(W)	400~615	720	**5.1**
	445~800	900	**9.8**
6N21L(W)	615~800	720	**6.9**
	745~1020	900	**12.9**
8N21L(W)	880~1065	720	**9.2**
	1100~1360	900	**17.1**
6EY22L(W)	660~1080	720	**9.3**
	880~1370	900	**17.3**
6EY26L(W)	1400~1840	720	**13.9**
8EY26L(W)	1900~2450	720	**30.2**
6N330L(W)	2059~2648	720	**22.9**
8N330L(W)	2795~3530	720	**40.7**