

**ENGINE & MACHINERY DIVISION**

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# TECH. INFORMATION TRANSMISSION FORM

**Date** : 2009. 11. 18  
**Our Ref.** : K24109/KCM/0898  
**Tel.** : 82-52-202-7274  
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**To**

- |   |   |
|---|---|
| ■ Hyundai Heavy Industries Co.,Ltd.         | ■ Hyundai Samho Heavy Industries Co.,Ltd.             |
| ■ Hyundai Mipo Dockyard Co.,Ltd.            | ■ Daewoo Shipbuilding&Marine Engineering Co.,Ltd.     |
| ■ Samsung Heavy Industries Co.,Ltd.         | ■ Sungdong Shipbuilding & Marine Engineering Co.,Ltd. |
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| ■ Ilheung Shipbuilding & Engineering        | ■ Samwonshipbuilding                                  |
| ■ Odense Steel Shipyard Ltd.                | ■ Volkswerft Stralsund GmbH                           |
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| ■ Nanjing Wujiazui Shipbuilding Company     | ■ Samho Shipbuilding Company                          |
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|   | ■ C& Heavy Industries Co.,Ltd.                        |
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|   | ■ Herma Shipyard Inc.                                 |
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|   | ■ SEKO Heavy Industry Co.,Ltd                         |
|   | ■ Goodearth Maritime Ltd.                             |

**Subject: HiMSEN guideline - Fuel oil control by EU Directive 2005-33-EC  
and California Code of Regulations (Revision 1)**

Dear sir,

We have a pleasure of sending Technical Information Letter, ref. K24109/KCM/0898 attached herewith, which is related with our ref. K24108/KCM/1281 "HiMSEN with Low-Sulfur Fuel & Lube Oil with Low-Sulfur fuel" dated on November 05, 2008.

If you have any questions, please do not hesitate to contact us.

Best regards

  
 \_\_\_\_\_  
**B. Y. Kim / General Manager**  
**Four-Stroke Engine Design Dep't**

Encl.: Technical information (Doc. No.: K24109/KCM/0898) – 6 sheets

**Doc. No.: K24109/KCM/0898**

**18<sup>th</sup> November 2009**

■ All HiMSEN Engines  
 (H17/28, H21/32, H25/33, H32/40, H32/40V)

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**SUBJECT: HiMSEN guideline - Fuel oil control by EU Directive 2005-33-EC  
 and California Code of Regulations**

1. The regulations such as EU Directive 2005-33-EC and California Code of Regulations which will come into force on 01/Jan/2010 restrict sulfur content in fuel oil below 0.1% mass by using MGO (Marine Gas Oil, DMA as defined in ISO 8217) to reduce SOx emissions.

	<b>EU Directive 2005-33-EC</b>	<b>California Code of Regulations</b>	
Effective date	1 January 2010	1 July 2009	1 January 2012
Sulphur contents	Max 0.1% <sub>m/m</sub>	MGO: Max 1.5% MDO: Max 0.5%	Max 0.1%
Target area	Berths in EU ports	Regulated California Waters	
Target ship	Ships at berth in EU ports for two hours or more (*)	LOA: more than 400 feet; or GT: more than 10000; or Volume of one cylinder: more than 30 liter	
Target fuel oil	FO which is used during at berth	FO which is used for Main diesel engine, aux. diesel engine and aux. boiler	
Target equipment (Example)	G/E Boiler for COPT etc.	M/E, G/E Aux.boiler	

(\*): The requirement shall not apply to ships which switch off all engines and use shore-side electricity at berth in ports.

2. Effect of low sulfur MGO using on HiMSEN engine

- 1) The minimum kinematic viscosity at 40 as per ISO 8217 is 1.5 cSt for MGO. In case of too low viscosity (below 2 cSt), it may occur the damage to the fuel injection pump such as sticking.

For your reference, please find the specification for Marine Distillate Fuels (Figure 1) and viscosity ranges of 1.5 - 6cSt @40 °C based on DNV document (Figure 2) as defined in ISO 8217 as below.

- To be continued -

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18<sup>th</sup> November 2009

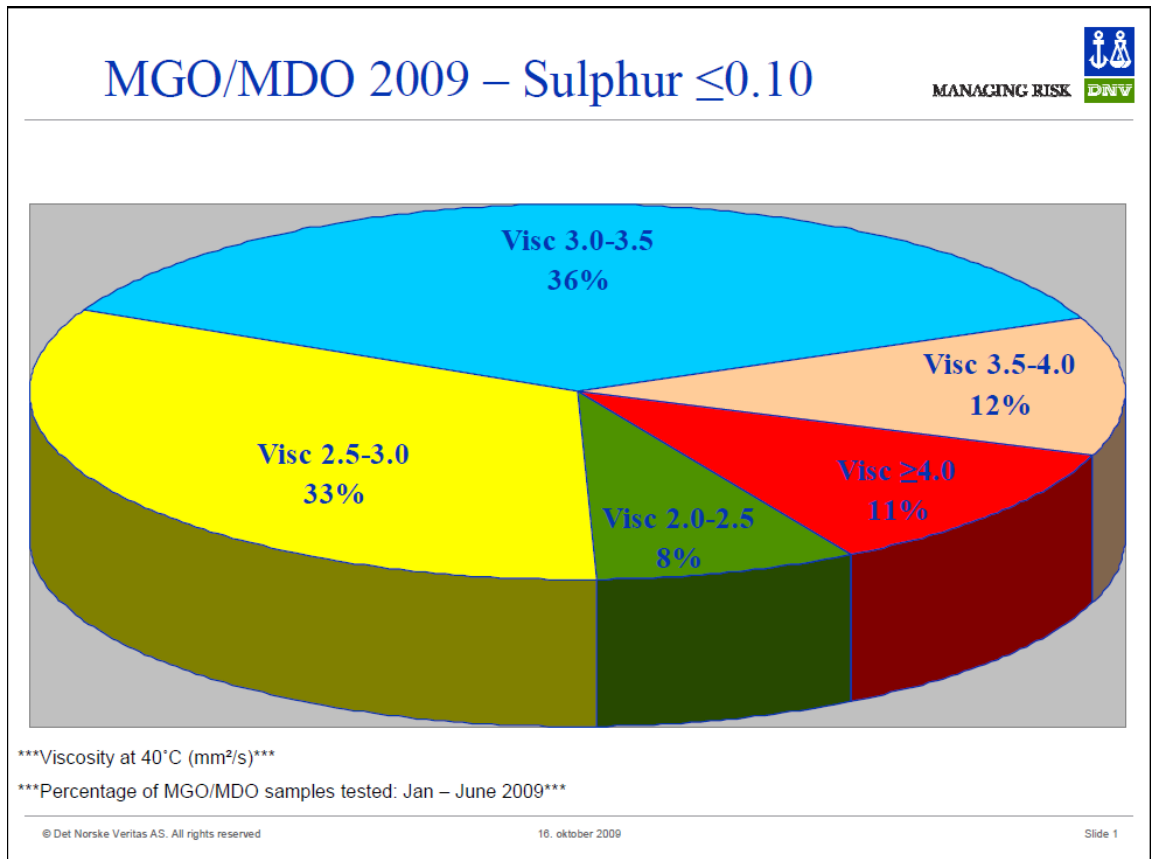
■ All HiMSEN Engines  
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**SUBJECT: HiMSEN guideline - Fuel oil control by EU Directive 2005-33-EC  
 and California Code of Regulations**

Charateristic	Unit	Limit	DMX	DMA (MGO)	DMB	DMC
Density at 15°C	kg/m <sup>3</sup>	max.	-	890.0	900.0	920.0
Viscosity at 40°C	mm <sup>2</sup> /s	min.	1.40	1.50	-	-
Viscosity at 40°C	mm <sup>2</sup> /s	max.	5.50	6.00	11.0	14.0
Flash point	°C	min.	-	60	60	60
Sulphur	%(m/m)	max.	1.00	1.50	2.00	2.00

< Figure 1 >



< Figure 2 >

- To be continued -

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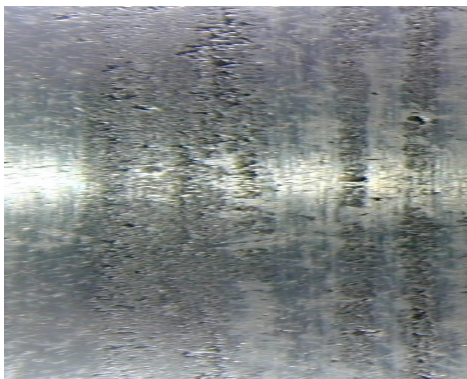
■ All HiMSEN Engines  
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SUBJECT: HiMSEN guideline - Fuel oil control by EU Directive 2005-33-EC  
and California Code of Regulations

- 2) The more drain fuel oil amount from fuel oil injection pump and fuel oil injection valve can be expected compared to operation on HFO.
- 3) Although the sulfur content of fuel oil has a lubricating effect, poor lubricity of low sulfur MGO has not been considered as a problem for fuel injection components as long as the sulfur content is above 100 ppm (=0.01 % m/m) For your reference, we are scheduled to introduce lubricity limit in HiMSEN engine fuel oil, especially MGO, specification (Max. between 460 and 520  $\mu$ m, Preliminary value) after introducing in the international specifications.
- 4) It is important that proper balance is maintained between the BN coming from the lube oil and the fuel sulfur level by choosing proper lube oil in order to avoid following problems.

- High sulfur fuel + Low BN lube oil  
→ Excessive corrosive wear



- Low sulfur fuel + High BN lube oil  
→ Excessive top land deposit formation



3. HiMSEN guideline for using low sulfur MGO

- All HiMSEN engines are suitable and developed for continuous operation on HFO as well as MDO/MGO as per attached F.O specification for HiMSEN engine. (Attached #1)

- To be continued -

4-STROKE ENGINE DESIGN DEPT

052-202-7274, FAX.: 052-202-7696

Doc. No.: K24109/KCM/0898

18<sup>th</sup> November 2009

■ All HiMSEN Engines  
(H17/28, H21/32, H25/33, H32/40, H32/40V)

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SUBJECT: HiMSEN guideline - Fuel oil control by EU Directive 2005-33-EC  
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There is no lower limit for the sulfur content of fuel oil. In connection to the low viscosity of MGO, (Marine Gas Oil, DMA as defined in ISO 8217) the viscosity at engine inlet should be kept within the value of 2 ~ 14 cSt in order to avoid possible wear or sticking of fuel injection pump due to low lubricity and in order to maintain the suitable hydrodynamic film between fuel injection pump plunger and barrel.

- Recommended stable viscosity at engine inlet: Min. 3 cSt
- Recommended minimum viscosity at engine inlet: Min. 2 cSt

So, we recommend installing a D.O cooling device (D.O cooler or chiller etc.) to keep the above mentioned viscosity (2 ~ 14 cSt) at engine inlet or between D.O outlet and MDO service tank under shipyard's scope of supply, if needed. For shipyard's designing of D.O cooling device, it is about the maximum 10 for the temperature deviation ( T ) between engine inlet and outlet when using MGO (Marine Gas Oil, DMA as defined in ISO 8217). For your reference, it should be maintained about 22 of MGO temperature to obtain viscosity of 2 cSt at engine inlet in case of MGO with 1.5 cSt at 40 .

- Considering the more drain fuel oil amount from fuel oil injection pump and fuel oil injection valve compared to operation on HFO, all HiMSEN engines are designed with improved fuel oil drain line as informed by our ref. K24109/KCM/0680. (Attached #2)
- HFO/DO change-over procedure and vice versa must be carried out according to HiMSEN engine instruction manual (Section No. G05300), which is also informed by our ref. K24109/KCM/0500. (Attached #3) to protect the fuel injection equipments against rapid temperature changes during the change-over from residual to distillate fuel and vice versa.

- To be continued -

4-STROKE ENGINE DESIGN DEPT

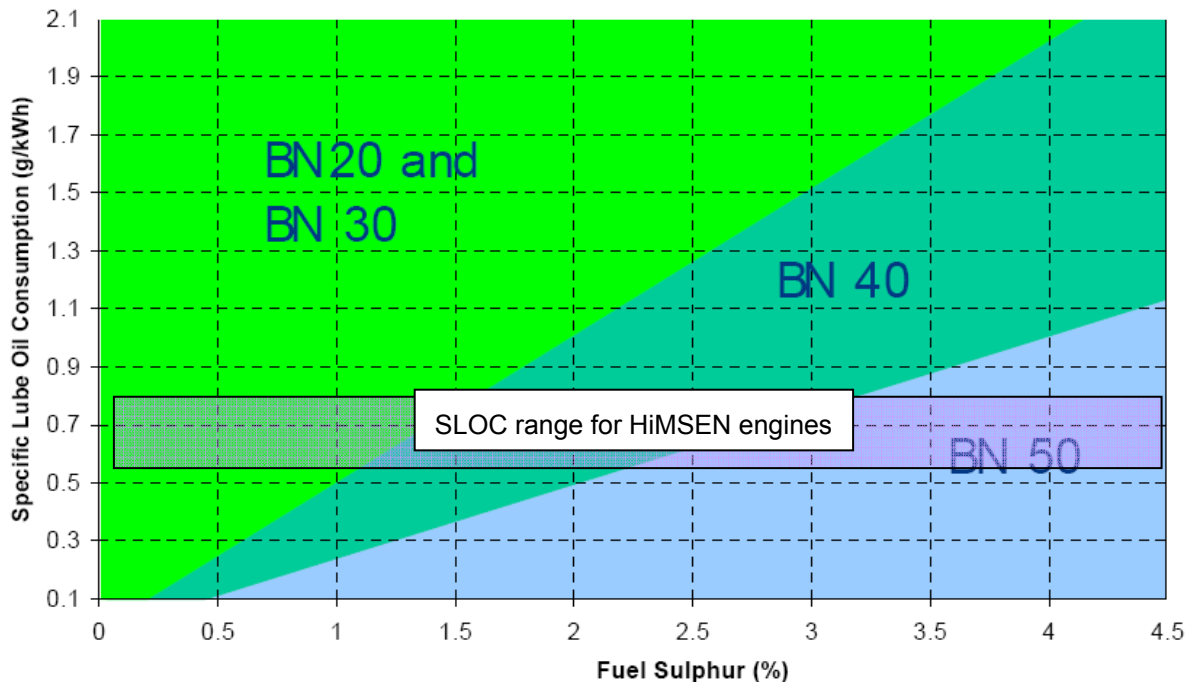
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**SUBJECT: HiMSEN guideline - Fuel oil control by EU Directive 2005-33-EC  
 and California Code of Regulations**

A special care must be carried out slowly in order to allow the temperature of the fuel injection equipments to decrease from up to 150 in residual fuel operation to a maximum 50 for MGO and 60 for MDO in disillate fuel operation. This is essential in order to avoid pump seizure due to the low viscosity of the diesel fuel and thermal shock in fuel injection pump.

4. HiMSEN guideline for lube oil using low sulfur MGO

1) Typical recommended BN depending on the fuel sulfur contents and SLOC (g/kWh)



Reference: CIMAC recommendation number 29/2008 'Guide lines for the lubrication of medium speed diesel engine'

- To be continued -

Doc. No.: K24109/KCM/0898

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■ All HiMSEN Engines  
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2) When the MGO is to be used only for temporary engine operation (e.g. in port), higher BN lube oil used for residual fuel (HFO) should not present any problems. The acceptable period of temporary operation is less than 200 hours. When engine is not operated continuously with low sulfur fuel such as MGO, lube oil should be chosen according to the highest sulfur contents of the fuel with normal operation. However, in case of continuous operation on low sulfur fuel such as MGO, it is necessary to use proper L.O based on sulfur content of low sulfur fuel as per attached L.O list for HiMSEN engine (**Attached #4**) in order to avoid excessive deposits in the combustion chamber, exhaust gas ways and turbocharger.

5. Summary

- MGO viscosity at engine inlet should be kept within the value of 2 ~ 14 cSt.
- When the MGO is to be used only for temporary engine operation (e.g. in port), the acceptable period of temporary is less than 200 hours with higher BN lube oil used for residual fuel (HFO).

Attached #1: F.O specification for HiMSEN engine – 4 sheets

Attached #2: Technical information (Our ref. K24109/KCM/0680) – 3 sheets

Attached #3: Technical information (Our ref. K24109/KCM/0500) – 3 sheets

Attached #4: L.O list for HiMSEN engine – 1 sheet

[ The end ]

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<b>Fuel Oil and Its Control</b>	<b>Fuel Oil Specification</b>	Section No.	Rev.
연료 및 관리	연료 사양	<b>G05100</b>	<b>1D</b>

## 1. 일반사항

엔진은 최고 700cSt at 50℃의 점도를 가진 중유(HFO)로 운전 가능하다. 이 값은 CIMAC Recommendation No. 21, 2003에 따라 CIMAC H700의 등급에 해당된다. 이 엔진은 저 점도의 혼합 연료뿐만 아니라 경유(MDO)로도 운전 가능하다.

요구되는 경유(MDO)의 품질은 CIMAC DA, DB 그리고 DC 등급에 따르고 있다. 엔진을 혼합 경유(A 벙커 디젤유) 즉, CIMAC DC 등급으로 운전하려면, 원심분리기 장치가 준비되어야 한다.

연료는 아래와 같이 엔진에 공급되기 전 정제되고 예열되어야 한다.

## 2. 연료 처리 과정

### 1) 정제

중유(HFO)는 항상 고체 입자, 소금 및 물 등으로 오염되어 있기 때문에 원심분리기로 정제되어야 한다.

연료의 고체 오염물질은 피스톤 링과 실린더 라이너의 과도한 마모를 유발하거나, 연료 분사 펌프와 연료 분사 밸브의 고착을 일으킬 수 있다.

연료 내에서의 액체 오염 물질은 배기 시스템과 터보과급기 뿐만 아니라 연료 분사 펌프와 연료 분사 밸브의 부식 및 공동현상을 일으킬 수 있다.

그러므로 적합한 분리 장치가 외부 연료 시스템에 설치되어야 한다. 중유(HFO) 및 경유(MDO)는 선상에서 쉽게 오염되기 때문이다.

연료를 원심분리기 전에, 반드시 점도를 낮추기 위해 예열시켜야 한다.

## 1. General

The engine can be operated on heavy fuel oil (HFO) of viscosity up to 700cSt at 50℃, which corresponds to the grades of CIMAC H700 (CIMAC Recommendation No. 21, 2003). It can be also operated on blended fuels of lower viscosity as well as diesel fuel oil (MDO).

The quality requirements for MDO shall be in accordance with CIMAC DA, DB and DC grade. If the engine is run on blended MDO (A-bunker diesel), i.e. CIMAC DC grade, a centrifugal treatment system should be prepared.

The fuel should be cleaned and preheated before entering the engine as follows.

## 2. Fuel Treatment

### 1) Purification

Heavy fuel oil should be purified by centrifuging because the fuel oils are always contaminated with solid particles, salt and water etc.

Solid contaminants in the fuel oils can cause excessive wear to the piston rings and cylinder liners or seizure of fuel injection pump and fuel valve.

Liquid contaminants in the fuel oils can cause fouling of exhaust systems and turbochargers as well as corrosion and cavitations of fuel injection pumps and fuel valves.

Therefore qualified separation equipment should be included in the external fuel oil system not only for HFO but also for MDO which is easily contaminated on board.

Before centrifuging the fuel oil, it should be preheated to lower the viscosity.

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연료 및 관리	연료 사양	<b>G05100</b>	<b>1D</b>

## 2) 가열

엔진으로 들어가는 연료는 12 ~ 18 cSt의 정도를 유지하고 있어야 한다. 그러나, 점도는 연료의 물성치 및 온도에 따라 변한다. 중유(HFO)의 최대 예열 온도는 155℃로 제한되어 있으며, 이는 연료 시스템에서 연료의 기포발생을 막기 위해서 이다. 따라서, 연료는 공급자의 권고대로 가열되어야 한다.

온도에 대한 연료의 대표적인 점도 선도가 아래에 나타나 있다.

## 2) Heating

The viscosity of fuel oil to the engine should be kept within the value of 12 ~ 18 cSt. However, the viscosity varies depending on the properties and the temperature of the fuel oil. Maximum preheating temperature of HFO is limited up to 155℃ to avoid vapouring in fuel system. Therefore, the fuel should be heated according to the suppliers' recommendation.

A typical fuel oil viscosity diagram regarding temperature is as follows.

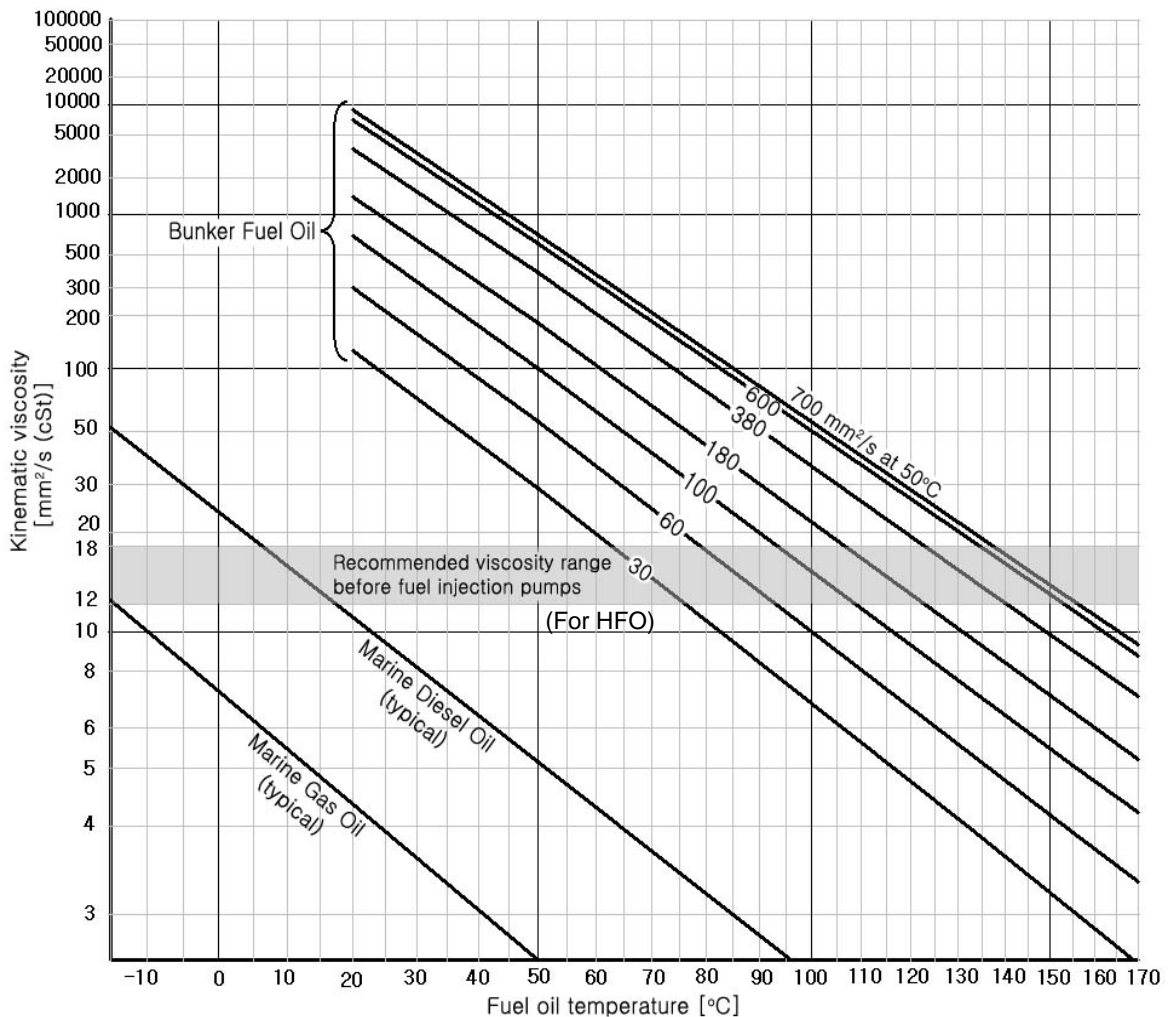


Fig.1 Fuel Oil Viscosity Diagram (연료 점도 선도)

(Note: The viscosity of MDO to the engine should be kept within the value of 2 ~ 14 cSt in order to avoid possible sticking of fuel injection pump due to low lubricity of MDO.)

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### 3) 점도의 제어

12 ~ 18 cSt의 분사 점도를 유지하기 위해, 가열기는 연료가 엔진 연료 시스템에 들어가기 전에 자동 점도 조절기에 의해 제어되어야 한다.

**⚠ 경고** 고 점도 또는 저 점도로 인해 연료분사 시스템에 심각한 손상을 초래할 수 있습니다.

### 3. 표준 연료 특성치

엔진은 정격 출력의 감소 없이 다음과 같은 사양을 가진 연료로 연속 운전되도록 설계되었다.

### 3) Viscosity Control

In order to ensure correct injection viscosity of 12 ~ 18 cSt, the heater are to be controlled by an automatic viscosity controller before the fuel enters into the engine fuel system.

**⚠ WARNING** *Higher or lower viscosity may cause serious damages on fuel injection system.*

### 3. Standard Fuel Oil Characteristics

The engine is designed to operate continuously on the fuels with the following specifications without reduction of the rated output,

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Properties	Unit	Limit	HFO (CIMAC H700)	MGO (CIMAC DA)	MDO	
					(CIMAC DB)	(CIMAC DC)
Kinematic viscosity	mm <sup>2</sup> /s (cSt)	max	700 at 50 12.0 ~ 18.0 <sup>(B)</sup>	1.5 - 6.0 at 40 2.0 ~ 14.0 <sup>(B)</sup>	2.5 - 11.0 at 40 2.0 ~ 14.0 <sup>(B)</sup>	4.0 - 14.0 at 40 2.0 ~ 14.0 <sup>(B)</sup>
Density at 15	kg/m <sup>3</sup>	max	991.0 1010.0 <sup>(A)</sup>	890.0	900.0	920.0
Flash point		min	60	60	60	60
Pour point (Winter quality)		max	30	-6	0	0
Carbon Residue	% mass	max	22 15 <sup>(B)</sup>	0.30 <sup>(C)</sup>	0.30	2.5
Asphaltenes	% mass	max	8	-	-	-
Ash	% mass	max	0.15 0.03 <sup>(B)</sup>	0.01 0.01 <sup>(B)</sup>	0.03 0.03 <sup>(B)</sup>	0.03 0.03 <sup>(B)</sup>
Total sediment, potential	% mass	max	0.10	-	-	-
Total sediment, existent	% mass	max	-	0.10	0.10	0.10
Water	% volume	max	0.5 0.2 <sup>(B)</sup>	-	0.3 0.2 <sup>(B)</sup>	0.3 0.2 <sup>(B)</sup>
Sulfur <sup>(D)</sup>	% mass	max	4.50 3.50 <sup>(B)</sup>	1.50	2.00	2.00
Cetane index	-	min	-	40	35	-
Vanadium	mg/kg	max	600 150 <sup>(B)</sup>	-	-	100
Sodium	mg/kg	max	100 30 <sup>(B)</sup>	-	-	50 30 <sup>(B)</sup>
Aluminum+Silicon	mg/kg	max	80 15 <sup>(B)</sup>	-	-	25 15 <sup>(B)</sup>
Solid Particles	mg/kg	max	20 <sup>(B)</sup>	20 <sup>(B)</sup>	20 <sup>(B)</sup>	20 <sup>(B)</sup>
		max	5 <sup>(B)</sup>	5 <sup>(B)</sup>	5 <sup>(B)</sup>	5 <sup>(B)</sup>

(A) : Adequate purifying equipment for high density is required.

(B) : Limited value before engine inlet for operation.

(C) : 10% volume distillation bottoms

(D) : A sulfur limit of 1.5% m/m will apply in SO<sub>x</sub> Emission Control Areas designated by the IMO, when its relevant Protocol comes into force. There may be local variations.

Note 1: The following kinds of fuel are not to be used:

- 1) Bunker fuel including cat-fines
- 2) Bunker fuel including land-used lubricating oil waste
- 3) Bunker fuel including acidic compounds (Acid Number  $\geq$  3 mg KOH/g)

Note 2: Additional properties are specified by the engine manufacturer, which are not included in the CIMAC fuel quality. (CIMAC Recommendation No. 21, 2003)



## ENGINE &amp; MACHINERY DIVISION

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## To

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| ■ Shanghai Zhen Hua Port Machinery          | ■ Nantong Mingde Heavy Industry                       | ■ New Times Shipbuilding        |
| ■ Liao Ning Marine&Offshore Industrial Park | ■ Shangdong Huahai Shipbuilding                       | ■ Jiujiang Tongfang Jiangxin    |
| ■ Nanjing Wujiazui Shipbuilding Company     | ■ Samho Shipbuilding Company                          | ■ SEKO Heavy Industry Co.,Ltd   |
| ■ Taizhou Sanfu Ship Engineering Co.,Ltd    | ■ Fujian Huarong Marine Shipping                      | ■ Goodearth Maritime Ltd.       |
| ■ JheJiang Changhong Shipbuilding           | ■ New Century Shipbuilding Co.,Ltd                    |                                 |

## Subject: Design Improvement of fuel oil drain line for HiMSEN engines (Revision 1)

Dear sir,

We have a pleasure of sending Technical Information Letter, ref. K24109/KCM/0680 attached herewith, which is revised against our ref. K24109/KCM/0390 dated on April 16, 2009.

If you have any questions, please do not hesitate to contact us.

Best regards

B. Y. Kim / General Manager  
 Four-Stroke Engine Design Dep't

Encl.: Technical information (Doc. No.: K24109/KCM/0680) – 2 sheets

Doc. No.: K24109/KCM/0680

November 17, 2009

■ H1728, H21/32, H25/33, H32/40  
and H32/40V

Page 1 of 2

SUBJECT: Design Improvement of fuel oil drain line for HiMSEN engines

The fuel oil drain from the generator engine contains various impurities even different medium such as lube oil, cooling water during operation and maintenance. This dirty fuel oil is collected in leakage oil tank and discharged to sludge tank through the piping. In some cases, however, some customers want to separate the clean and dirty fuel oil to recycle the former.

Our HiMSEN engines will have two drain oil lines by design modification to meet customer's demand from the point of view of economical operating cost from the new project with approval drawing submission.

More details for fuel oil drain and design modification are as follows:

1) Detail information for fuel oil drain

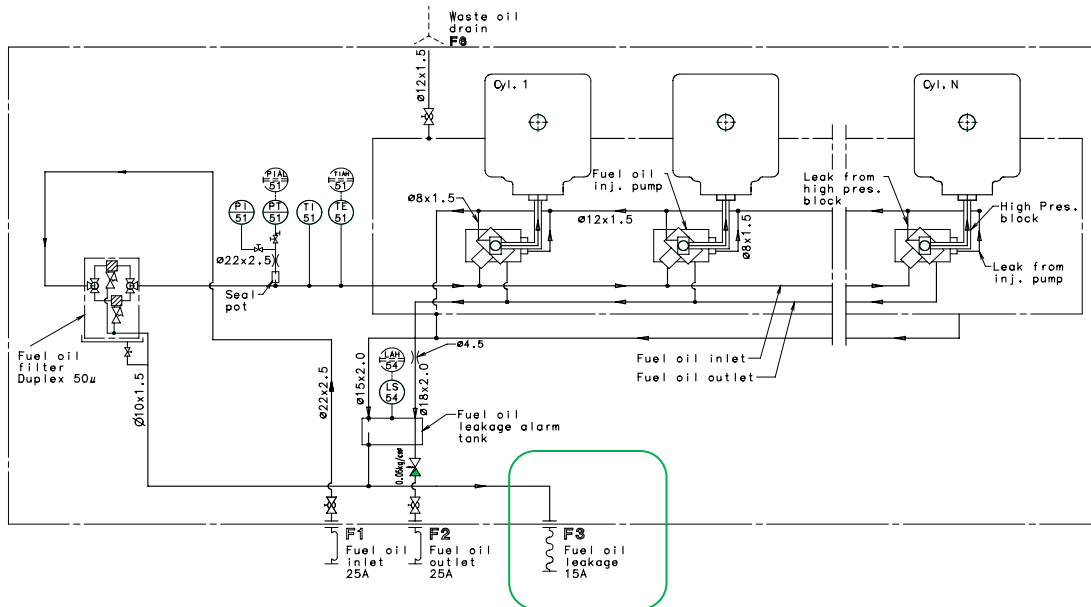
	Drainage / Leakage from	Disposal	Total leak rate *) (liter / cyl. hour)
1	High pressure block (Fuel injection valve and its connection)	Recycling fuel oil	a) H17/28: 0.13
2	Fuel injection pump		b) H21/32: 0.15 c) H25/33: 0.20
3	Engine block (F.O & L.O & C.W during overhaul)	Waste fuel oil	- Tolerance: 25%
4	F.O safety filter (F.O during overhaul)		- Amount of clean fuel oil, which can be recycled, is accounted for 70 ~ 80 % of total leak rate.
5	F.O safety filter (Periodical drained F.O from filter)		

\*) Total leak rate of fuel oil is based on MDO and one half for HFO.

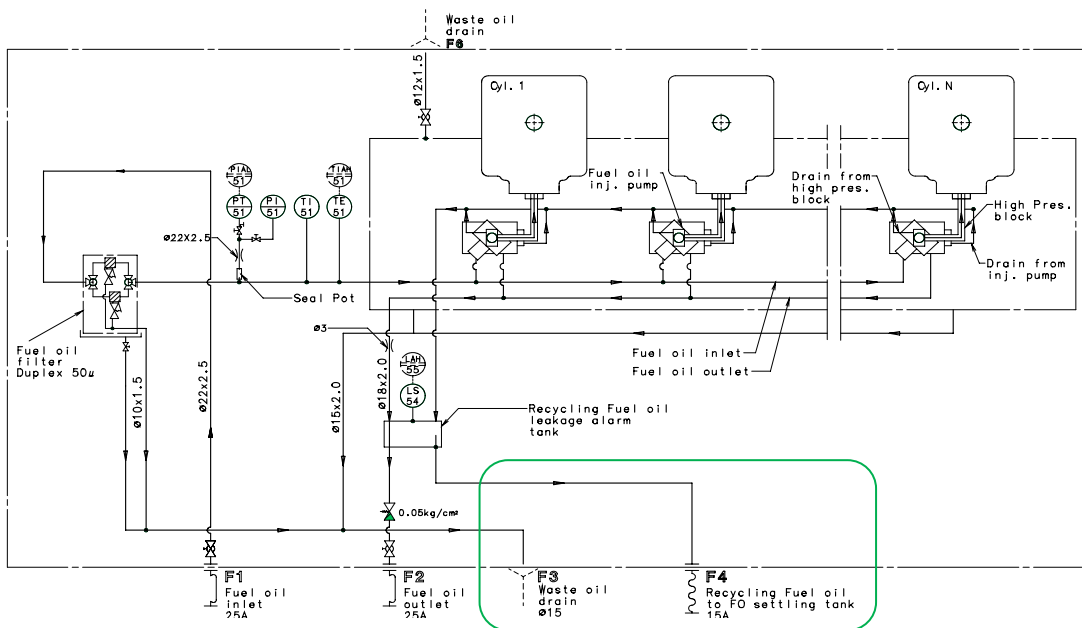
- To be continued -

1) Fuel oil diagram comparison

i) Before `



ii) After



[The end]



## ENGINE &amp; MACHINERY DIVISION

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# TECH. INFORMATION TRANSMISSION FORM

Date : 2009. 06. 01  
 Our Ref. : K24109/KCM/0500  
 Tel. : 82-52-202-7274  
 Fax : 82-52-202-7696

## To

- Hyundai Heavy Industries Co.,Ltd.
- Hyundai Mipo Dockyard Co.,Ltd.
- Samsung Heavy Industries Co.,Ltd.
- Hanjin Heavy Industries & Construction
- Geo Marine Engineering & Shipbuilding
- Ilheung Shipbuilding & Engineering
- Odense Steel Shipyard Ltd.
- Qingdao Hyundai Shipbuilding Co., Ltd.
- Zhejiang Zhenghe Shipbuilding Co.,Ltd.
- Jiangsu Yangzijiang Shpbuilding Co.,Ltd.
- Fujian Shenglong Shipbuilding Co.,Ltd.
- Qidong Daoda Heavy Industry
- Shanghai Zhen Hua Port Machinery
- Liao Ning Marine&Offshore Industrial Park
- Nanjing Wujiazui Shipbuilding Company
- Taizhou Sanfu Ship Engineering Co.,Ltd
- JheJiang Changhong Shipbuilding
- Hyundai Samho Heavy Industries Co.,Ltd.
- Daewoo Shipbuilding&Marine Engineering Co.,Ltd.
- Sungdong Shipbuilding & Marine Engineering Co.,Ltd.
- SLS Shipbuiding
- Orient Heavy Industries Co.,Ltd.
- Samwonshipbuilding
- Volkswerft Stralsund GmbH
- Shanghai Shipyard Co.,Ltd.
- Zhejiang Shipbuilding
- Penglai Bohai Shipyard
- Abg Shipyard Limited
- Zhejiang Hongguan Shipbuilding
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- Shangdong Huahai Shipbuilding
- Samho Shipbuilding Company
- Fujian Huarong Marine Shipping
- New Century Shipbuilding Co.,Ltd.
- C& Heavy Industries Co.,Ltd.
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- Kwangsung Shipbuilding
- Peene-Werft GmbH
- Yanfan Group Co.,Ltd.
- Herma Shipyard Inc.
- Tebma Shipyards Ltd.
- Zhejiang Fanshun Shipbuilding
- Ocean Marine Service
- New Times Shipbuilding
- Jiujiang Tongfang Jiangxin
- SEKO Heavy Industry Co.,Ltd
- Goodearth Maritime Ltd.

## Subject: HFO/DO change-over procedure for HiMSEN engines

Dear sir,

We have a pleasure of sending Technical Information Letter, ref. K24109/KCM/0500 and HFO/DO change-over procedure for HiMSEN engines, Section No. G05300 attached herewith, which will be added in HiMSEN engine instruction manual.

If you have any questions, please do not hesitate to contact us.

Best regards,

B. Y. Kim / General Manager

Four-Stroke Engine Design Dep't

		<b>All type</b>	Page 1/2
<b>Fuel Oil and Its Control</b>	<b>HFO/DO change over procedure</b>	Section No.	Rev.
연료 및 관리	HFO/DO 교체 절차	<b>G05300</b>	<b>1A</b>

연료 분사 펌프와 연료 분사 밸브의 고착/손상, 불완전 연소 등을 방지하기 위해 HFO/DO 교체 절차의 온도/부하 요구를 따르는 것은 매우 중요하다.

It is very important to follow the temperature/load requirement of the change-over procedure in order to prevent fuel injection pump and fuel injection valve sticking/scuffing, poor combustion and so on.

### 1. DO에서 HFO로의 교체

- HFO service tank의 Level을 50~90%로 유지하고 온도를 60~90 ℃로 유지한다.
- 엔진 부하를 30~70 %로 유지한다.
- 연료유 시스템의 Steam tracing과 Auto filter steam inlet valve를 연다.
- F.O heater의 Steam in/out valve를 연다.
- 점도 조절기의 Steam control valve를 조금 열면서 조정하여 F.O 온도를 약 1분에 2 ℃씩 60 ℃까지 서서히 올린다.

**⚠ 경고** 이때 온도보다는 점도가 우선이므로 4 cSt 이하로 떨어지지 않도록 한다. 그리고 Cylinder outlet 청수 온도를 75~85 ℃로 유지한다.

- 엔진 입구에서의 DO 온도가 50~60 ℃ 정도로 상승되면 HFO/DO 교체 밸브를 이용하여 HFO로 교체한다.
- 엔진 입구에서의 HFO 온도가 70 ℃ 정도로 상승되면 점도 조절기를 자동 모드로 한다.
- 점도와 온도 변화를 점검하면서 점도 조절기에 점도를 12~18 cSt에 Setting 한다.

### 1. Change-over from DO to HFO

- Maintain the HFO level with 50~90% and HFO temperature with 60~90 in HFO service tank.
- Maintain the engine load with 30~70 %.
- Open the steam tracing and auto filter steam inlet valve in F.O system.
- Open the steam in/out valve in F.O heater.
- Rise F.O temperature gradually until 60 ℃ at a rate of about 2 ℃ per minute through opening steam control valve in viscosity controller.

**⚠ WARNING** Maintain the F.O viscosity over 4 cSt because F.O viscosity is the first priority than temperature. And maintain the cylinder outlet cooling water temperature with 75~85 .

- When the DO temperature at engine inlet reaches 50~60 ℃, change-over from DO to HFO using HFO/MDO change-over valve.
- When the HFO temperature at engine inlet reaches 70 ℃, viscosity controller is set with auto-mode.
- When the change between viscosity and temperature to be observed, viscosity is set 12~18 cSt on viscosity controller.

		<b>All type</b>	Page 2/2
<b>Fuel Oil and Its Control</b>	<b>HFO/DO change over procedure</b>	Section No.	Rev.
연료 및 관리	HFO/DO 교체 절차	<b>G05300</b>	<b>1A</b>

## 2. HFO에서 DO로의 교체

- 엔진 부하를 50 % 이하로 낮춘다.
- F.O의 급격한 온도 변화에 의한 연료 분사 펌프와 연료 분사 밸브의 고착 및 손상을 방지하기 위해 점도 조절기의 점도 값이 25 cSt가 될 때까지 F.O heater의 Steam in/out valve를 서서히 닫는다.
- 연료유 시스템의 Steam tracing과 Auto filter steam inlet valve를 닫는다.
- HFO/DO 교체 밸브를 이용하여 DO로 교체한다.
- DO의 온도가 약 60 ℃일 때 점도가 4~5 cSt임을 확인한다. 단, MGO의 경우 약 40 ℃일 때 점도가 약 2~3 cSt임을 확인한다.

**⚠ 경고** Section No. G05100에 엔진 입구에서의 DO 점도를 2~14 cSt로 제한하고 있지만 연료 분사 펌프와 연료 분사 밸브의 고착/손상을 방지하기 위해 DO의 점도가 3 cSt 이하로 떨어지지 않도록 한다.

## 2. Change-over from HFO to DO

- Reduce the engine load below 50 %.
- Close the steam in/out valve slowly in F.O heater until 25 cSt viscosity in viscosity controller to protect the F.O injection equipment against rapid temperature changes.
- Close the steam tracing and auto filter steam inlet valve in F.O system.
- Change-over from HFO to DO using HFO/DO change-over valve.
- Confirm that DO viscosity is 4~5 cSt when the DO temperature is about 60 ℃. In case of MGO, confirm that MGO viscosity is about 2~3 cSt when the MGO temperature is about 40 ℃.

**⚠ WARNING** Although DO viscosity range at engine F.O inlet is limited 2 ~ 14 cSt in Section No. G05100, DO viscosity should not drop 3 cSt for safety as this might cause fuel injection pump and fuel injection valve sticking/scuffing.

		<b>All type</b>	Page 1/1
<b>Lubricating Oil and Its Control</b>	<b>List of Lubricating Oil</b>	Section No.	Rev.
윤활유 및 관리	윤활유 목록	<b>G06200</b>	<b>1E</b>

Oil brand	Engine system lubricating oil				Governor oil
Oil company	Brand name	SAE	BN	Fuel grade	
<b>Shell</b>	Shell Gadinia 40	40	12	A, B	Same as Engine system Lub. Oil  Note) Refer to the governor manual for detailed L.O specification of governor.  *) Initial filling: Oil filled
	Shell Argina S 40		20	B, C	
	Shell Argina T 40		30	C, D	
	Shell Argina X 40		40	D, E	
	Shell Argina XL 40		50	E	
<b>Total (Lubmarine)</b>	DISOLA M 4012	40	12	A, B	
	DISOLA M 4015		14	A, B	
	DISOLA M 4020		20	B, C	
	AURELIA XL 4030		30	C, D	
	AURELIA XL 4040		40	D, E	
	AURELIA XL 4055		55	E	
	AURELIA TI 4030		30	C, D	
	AURELIA TI 4040		40	D, E	
AURELIA TI 4055	55	E			
<b>FAMM (TEXACO+Chevron)</b>	DELO 1000 Marine 40	40	12	A, B	
	TARO 20 DP 40		20	B, C	
	TARO 30 DP 40		30	C, D	
	TARO 40 XL 40		40	D, E	
	TARO 50 XL 40		50	E	
<b>ExxonMobil (Exxon+Mobil)</b>	Mobilgard 412	40	15	A, B	
	Mobilgard M430		30	C, D	
	Mobilgard M440		40	D, E	
<b>BP Amoco (BP+Castrol)</b>	BP ENERGOL DL-MP 40	40	9	A, B	
	BP ENERGOL DS3-154		15	A, B	
	CASTROL MLC 40		12	A, B	
	CASTROL MHP 154		15	A, B	
	BP IC-HFX 204		20	B, C	
	BP IC-HFX 304		30	C, D	
	BP IC-HFX 404		40	D, E	
	BP IC-HFX 504		50	E	
	CASTROL TLX PLUS 204		20	B, C	
	CASTROL TLX PLUS 304		30	C, D	
CASTROL TLX PLUS 404	40	D, E			
<b>SK</b>	SUPERMAR 13TP 40	40	13	A, B	
	SUPERMAR 24TP 40		24	C	
	SUPERMAR 30TP 40		30	C, D	
	SUPERMAR 40TP 40		40	D, E	
<b>Oil volume</b>	See separate data for sump volume as per each engine type.				UG-8D: 1.9 Liter UG-15D: 2.3 Liter UG-25+: 2.1 Liter

\*) This list is given as guidance only.

#### Fuel grade

A: Distillate fuels (MGO or MDO)  
(S: Max. 0.2% m/m)

C: Residual fuels (HFO)  
(S: 1.5 ~ 2.5% m/m)

B: Distillate fuels (MGO or MDO)  
(S: 0.2 ~ 1.5% m/m)

D: Residual fuels (HFO)  
(S: 2.5 ~ 3.5% m/m)

or

Residual fuels (HFO)  
(S: 0.2 ~ 1.5% m/m)

E: Residual fuels (HFO)  
(S: 3.5 ~ 4.5% m/m)

\*) Lubricating oil quantity (Initial filling: Oil empty, Without oil overflow system)

Engine type	Engine rpm	Lubricating Oil Quantity (Max. volume), Unit : Liter				
		5 cyl.	6 cyl.	7 cyl.	8 cyl.	9 cyl.
H17/28	900 / 1000 rpm	530	620	700	780	-
	720 / 750 rpm	820	950	1070	1180	1270
H21/32	900 / 1000 rpm	930	1040	1170	1350	1420
	720 / 750 rpm	-	1240	1380	1530	1670
H25/33	900 / 1000 rpm	-	1460	1630	1800	1970
	720 / 750 rpm	-	2730	3200	3600	4010