

Diesel Fuel Quality and Function

Marine Commercial Engines

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Fuel Quality Requirements for “Marine Commercial Diesel Engines”

1. General

This Service Bulletin applies to all Volvo Penta marine commercial diesel engines.

Volvo Penta diesel engines are developed for fuels with main properties as described in appendix 1.

Volvo Penta diesel engines with emission level IMO tier 1 to IMO tier 3, EPA tier 1 to EPA tier3, IWW stage 1 to stage 2 and CCNR (River Rhine) stage 1 and stage 2, are certified for compliance with emission legislations with the diesel test fuels specified by law.

These fuels correspond with diesel fuel standards EN 590, ASTM D975 and JIS K2204 and paraffinic diesel fuel standard EN 15940 as specified below. The engine must be used as intended and serviced according to operator's manual to fulfill the exhaust emissions

Volvo Penta also approves the use of other fuels as specified below.

However, emission legislation compliance or fulfillment of expected lifetime may not be fulfilled with these fuels.

For IWW stage V, only diesel fuels acc to EN 590 and EN 15940 is approved for use according to emission regulations. The engine must be used as intended and serviced according to operator's manual to fulfill the exhaust emissions.

NOTICE! Operators must check permission for usage of these fuels according to regional, national or local regulations.

The fuel suppliers shall always ensure that their fuels meet relevant requirements and are fit for their intended purpose. Their responsibility includes any use of additives for proper engine performance and function. Special requirements are placed on cold-flow properties, i.e. temperature limit values of fuel filterability during operation in winter conditions. In this paper *exhaust after-treatment systems* is mentioned, that means *SCR* (Selected Catalytic Reduction).

2. Diesel fuels

Volvo Penta approves the use of diesel fuels as specified in Table 1, with corresponding appendices. Note the restrictions and information for each fuel. Note also that diesel engines with exhaust aftertreatment systems (SCR) have restrictions of max sulfur and max FAME limit.

Table 1 - Summary					
Fuel/Emission level	Fuel standard	Restrictions and more information Chapter/ Appendix	IWW stage V *	IMO III*	IMO I IMO II EPA Tier 1 EPA Tier 2 EPA Tier 3 EU IWW stage 1 to IIIa CCNR stage 1 and 2
EN590	EN590	3/2	Yes	Yes	Yes
ASTM D975 No 2D	ASTM D975-17	3/3	No	Yes	Yes
JIS K 2204	JIS K 2204	3/4.	No	Yes	Yes
NATO F-54	A-A-52557/ ASTM D975	3/5	No	Yes(If sulfur is ≤ 1000 mg/kg)	Yes
Minimum requirements diesel fuels	-	3/6	No	Yes	Yes
Paraffinic diesel fuels	EN 15940	4/7	Yes	Yes	Yes
High FAME diesel fuels (10 to 30% FAME)	EN 16734	5/8	No	Yes	Yes
	EN 16709	5/8	No	No	Yes
	ASTM D7467-15c	5/9	No	Yes, if FAME is < 10%	Yes
	Minimum requirements	5/10	No	No	Yes
Marine distillate fuels	ISO 8217 DMX/DMA/DFA	6/11	No	No Yes(If sulfur is ≤1000 mg/kg)	Yes
Jet fuels	ASTM D1655 (Jet A-1)	7/12	No	No	Yes

*With SCR (Selective Catalytic Reduction)

IMO = International Maritime Organization

EPA = Environmental Protection Agency (USA)

IWW = Inland Waterway (Europe)

CCNR = Central Commission for the navigation of the Rhine (Europe)

3. EN590, ASTM D975-17, JIS K 2204, NATO F-54 and other diesel fuels

Table 2 - Diesel fuels		
Fuel	Specification	Comments
EN 590	Appendix 2	
ASTM D975 No 2-D	Appendix 3	• Cetane number below 45 will give starting difficulties and increased emissions. • Density above 860 kg/m³ will give excessive power. • Lubricity (wsd 1.4) above 460 µm will decrease the durability of the fuel injection equipment.
JIS K 2204	Appendix 4	Lubricity (wsd 1.4) above 460 µm will decrease the durability of the fuel injection equipment.
NATO F-54	Appendix 5	Sulfur level may differ between different countries.
Other diesel fuels	Appendix 6	Minimum requirements in countries where the above fuels are not available
Restrictions		
• For ASTM D975 the density must be max 860 kg/m³ • For JIS K 2204 the lubricity (wsd 1.4) must be max 460 µm • For NATO F-54 and other diesel fuels the sulfur content must be max - 1 000 mg/kg for engines with exhaust after-treatment systems - 5 000 mg/kg for engines without exhaust after-treatment systems		

4. Paraffinic diesel fuels (“Synthetic diesel fuel”)

Paraffinic diesel fuels have higher cetane numbers and lower densities than diesel fuels. HVO (Hydro-treated Vegetable Oil) and BTL (Bio-To-Liquid) are renewable paraffinic fuels. GTL (Gas-To-Liquid) and CTL (Coal-To-Liquid) are fossil paraffinic fuels.

The use of all paraffinic fuels will give decreased hydrocarbon and soot emissions, but also marginally higher fuel consumption and marginally lower power compared to diesel fuels.

The use of renewable paraffinic fuels will also give a substantial decrease of fossil CO2 emissions.

Volvo Penta approves the use of paraffinic diesel fuels as specified in table 3 and appendix 3 and 7.

Table 3 - Approved paraffinic diesel fuels		
Fuel	Specification	Comments
EN 15940	Appendix 7	

5. High FAME diesel fuels (between 10% to 30% FAME)

High FAME (biodiesel) diesel fuels have lower oxidation stability, higher metal and phosphorus contents, and are much more hygroscopic than diesel fuels.

The use of high FAME diesel fuels will impair durability and power, as well as increase fuel consumption and nitrogen oxide emissions, but will also decrease other exhaust emissions and fossil CO₂ compared to diesel fuels. Volvo Penta approves the use of high FAME diesel fuels as specified in table 4 and appendices 8-10 as long as the below restrictions and service requirements are followed. **High FAME diesel fuels (>10%) are only for engines without exhaust aftertreatment systems (SCR).** However, emission legislation compliance or fulfillment of expected lifetime may not be fulfilled with these fuels.

Table 4 - Approved high FAME diesel fuels		
Fuel	Specification	Comments
EN 16734	Appendix 8	B10
EN 16709	Appendix 8	B20 & B30
ASTM D7467	Appendix 9	B6 to B20. Cetane number below 45 will give poor startability and increased hydrocarbon emissions
Other high FAME diesel fuels	Appendix 10	Minimum requirements in countries where the above fuels are not available
Restrictions		
- Lube oil of quality VDS-4 or VDS-4.5 shall be used - High FAME diesel fuels shall not be used in engines with long downtime periods - The engines shall be fitted with fuel filters with water separators - A fuel heater is required, when high FAME diesel fuels are used below freezing point		
Service requirements for FAME content > 10% (V/V)		
- Lube oil change intervals shall be halved - Fuel filter housings and seals shall be changed annually - When shifting from diesel fuel to high FAME diesel fuel - the fuel hoses and sealings shall be replaced - the fuel tank shall be cleaned, and the fuel filter shall be replaced after 50 h. FAME fuel is very sensitive to water in the fuel. - If the engine has not been used for a period of four weeks or more, the tank and fuel system shall be flushed clean by running the engine on at least one full tank of diesel fuel.		

6. Marine distillate fuels

Marine distillate fuels typically have lower cetane number, higher density, higher viscosity, lower lubricity and higher sulfur level than diesel fuels.

The use of marine distillate fuels will impair durability and emissions compared to diesel fuels.

Volvo Penta approves the use of marine distillate fuels as specified in table 5 and appendix 11 as long as the below restrictions and service requirements are followed.

In normal case, marine distillate fuels are only for engines without exhaust aftertreatment systems (SCR).

If fuel sample test show that the sulfur level is below 1000 mg/kg, the fuel can also be used in IMO3 engines.

However, emission legislation compliance or fulfillment of expected lifetime may not be fulfilled with these fuels.

Table 5 - Approved marine distillate fuels		
Fuel	Specification	Comments
ISO 8217 DMX	Appendix 11	• Cetane number below 45 will give poor startability and increased hydrocarbon emissions. • Density above 860 kg/m3 will give excessive power and decreased durability of the fuel injection equipment. • Lubricity (wsd 1.4) above 460 μm will decrease the durability of the fuel injection equipment. • Sulfur level above 5000 mg/kg will decrease the lube oil life.
ISO 8217 DMA/DFA	Appendix 11	
Restrictions		
• Lube oil of quality VDS-3, VDS-4 or VDS-4.5 shall be used • For density above 860 kg/m3 and viscosity above 4.5 mm2/s the fuel for D4/D6/D8 engines shall be pre-heated to 50°C, measured at the fuel inlet connection • The max sulfur is 10 000 mg/kg (D4,D6 and D8 max sulfur level 5000 mg/kg), provided that oil change intervals are reduced in accordance with engine operator's manual		
Service requirements		
Fuel injection equipment replacement intervals shall be halved		

7. Jet fuels

Jet fuels have lower cetane number, lower viscosity, lower lubricity and higher sulfur content than diesel fuels.

The use of jet fuels will impair durability, emissions, power and fuel consumption compared to diesel fuels.

Volvo Penta approves the use of ASTM D1655 (Jet A-1) as specified in table 6 and appendix 12, as long as the below restrictions are followed.

However, emission legislation compliance or fulfillment of expected lifetime may not be fulfilled with these fuels.

Table 6 - Approved jet fuels		
Fuel	Specification	Comments
ASTM D1655	Appendix 12	• Cetane number below 45 will give poor startability and increased hydrocarbon emissions • Density below 820 kg/m³ and viscosity below 1.5 mm²/s will give decreased power and increased fuel consumption • Lubricity, wear scar above 460 µm will decrease the durability of the fuel injection equipment
Restrictions		
Lubricity additives shall be used to ensure lubricity (wsd 1.4) max 460 µ m		

Appendix 1 - Main properties of fuels for diesel engines

Property
Cetane number The cetane number is a measure of a diesel fuel's ignitability. An insufficient cetane number will give poor startability and increased hydrocarbon emissions.
Cetane index The cetane index is calculated from the density and distillation range of the fuel. The cetane index does not correlate to measured cetane numbers for additized diesel fuels.
Density at 15°C Low density (mass per volume unit) reduces the engine power and increases the fuel consumption. Excessive density will increase the engine power above safe limits.
Viscosity at 40°C Low viscosity reduces the engine power and increases the fuel consumption. Excessive viscosity will decrease the durability of the fuel injection equipment.
Lubricity (wsd 1.4) at 60°C Lubricity is measured as corrected wear scar diameter (wsd 1.4) in HFRR testing. Insufficient luricity will decrease the durability of the fuel injection equipment.
Polycyclic aromatic hydrocarbons Polycyclic aromatic hydrocarbons are defined as the total aromatic hydrocarbon less the mono-aromatic hydrocarbon content. Excessive content will impair exhaust emission content, especially hydrocarbons and particulates.
Aromaticity Excessive aromatic content, and particularly polycyclic aromatic hydrocarbons, will impair exhaust emission content, especially particulates.
FAME (Fatty Acid Methyl Ester) content FAME (biodiesel) is blended into diesel fuels in order to reduce fossil CO2 emissions. An excessive FAME content or poor FAME quality will impair the engine and exhaust after-treatment functions, power, fuel consumption and nitrogen oxide emissions.
Oxidation stability Oxidation stability is a measure of the chemical stability of the fuel, which is especially important for biodiesel blends in the 20-30% range.
Sulfur content Sulfur is an inherent part of fossil fuels. An excessive sulfur content will impair the engine and exhaust after-treatment functions and emissions of sulfur oxides and particulates.
Water content Excessive water content will cause corrosion and wear of engine parts, particularly in the fuel injection system. Water also enables microbial growth in the fuel tank, which can lead to clogging of the fuel filter.

Total contamination

Organic contaminants (bacteria, fungi etc.) can lead to clogging of the fuel filter.
Inorganic contaminants (dust, rust, sand) can cause severe damage to the fuel injection system.

Water and sediments

This is an alternative to separate demands on Water content and Total contamination.

Particulate matter

This is a measure of particulate contamination.

Cold flow properties

The **cloud point** is the temperature below which wax crystals begin to form in the fuel.
The **cold filter plugging point (CFPP)** is the lowest temperature at which the fuel still passes through a standardized filtration device.
The **pour point** is the temperature below which the fuel becomes semi solid and loses its flow characteristics.

Flash point

The flashpoint is a measure of a fuel's flammability, without significance for engine operation.
The flashpoint is important for classification of fuels into hazard classes for transport and insurance.

Appendix 2 - Diesel fuel EN 590

General requirements and test methods			
Property	Unit	Limit	Test method
Cetane number	-	≥ 51	EN ISO 5165
Cetane index	-	≥ 46	EN ISO 4264
Density at 15°C	kg/m ³	820 - 845	EN ISO 3675
Viscosity at 40°C	mm ² /s	2.0 - 4.5	EN ISO 3104
Lubricity (wsd 1.4) at 60°C	µm	≤ 460	EN ISO 12156-1
Polycyclic aromatic hydrocarbons	% (m/m)	≤ 8	EN 12916
FAME content ¹	% (V/V)	≤ 7	EN 14078
Oxidation stability ²	g/m ³ h	≤ 25 ≥ 20	EN ISO 12205 EN 15751
Sulfur content	mg/kg	≤ 10	EN ISO 20846 EN ISO 20884
Water content	mg/kg	≤ 200	EN ISO 12937
Total contamination	mg/kg	≤ 24	EN 12662
Flash point	°C	> 55	EN ISO 2719
Comments			
¹ FAME shall meet the requirements of EN 14214.			
² When diesel contains more than 2% (V/V) FAME, oxidation stability as determined by EN 15751 is the requirement.			

Climate-related requirements and test methods – Temperate climates								
Property	Unit	Limit						Test method
		Grade A	Grade B	Grade C	Grade D	Grade E	Grade F	
CFPP	°C	≤ +5	≤ 0	≤ -5	≤ -10	≤ -15	≤ -20	EN 116

Appendix 3 - Diesel fuel ASTM D975 - 17

Detailed requirements and test methods				
Property	Unit	Limit		Test method
		No 1-D S15	No 2-D S15	
Cetane number ¹	-	≥ 40		ASTM D613
Cetane index or Aromaticity	-	≥ 40		ASTM D976-80
	% (V/V)	≤ 35		ASTM D1319
Viscosity at 40°C ²	mm ² /s	1.3 - 2.4	1.9 - 4.1	ASTM D445
Lubricity (wsd 1.4) at 60°C	µm	≤ 520		ASTM D6079
FAME content ³	% (V/V)	≤ 5		ASTM D7371
Sulfur content	mg/kg	≤ 15		ASTM D5453
Water and sediment	% (V/V)	≤ 0.05		ASTM D2709
Cloud point ^{2, 4}	°C	-		ASTM D2500
Flash point ²	°C	≥ 38	≥ 52	ASTM D93
Comments				
¹Low ambient temp as well as operation at high altitudes may require higher cetane ratings. ²When a cloud point below -12°C is specified, as can occur during winter, it is permitted to combine Grades No 1 and No 2 to meet the low temp requirements. In that case the min flash point shall be 38°C and the min viscosity at 40°C shall be 1.7 mm²/s. ³FAME shall meet the requirements of ASTM D6751. ⁴Appropriate low temperature operability properties should be agreed upon between the fuel supplier and purchaser for the intended use and expected ambient temperatures.				

Required qualities of diesel fuels							
Property	Unit	Limit					Test method
		No 1S	No 1	No 2	No 3	No 3S	
Cetane index ¹	-	≥ 50		≥ 45			JIS K 2280
Density at 15°C	kg/m ³	≤ 860					JIS K 2249
Viscosity at 30°C	mm ² /s	≥ 2.7		≥ 2.5	≥ 2.0	≥ 1.7	JIS K 2283
FAME content ²	% (m/m)	≤ 0.1					-
Sulfur content	mg/kg	≤ 10					JIS K 2541
Pour point	°C	≤ +5	≤ -2.5	≤ -7.5	≤ -20	≤ -30	JIS K 2269
CFPP	°C	-	≤ -1	≤ -5	≤ -12	≤ -19	JIS K 2288
Flash point	°C	≥ 50			≥ 45		JIS K 2265-3
Comment							
¹ Instead of cetane index, cetane number may be used. ² Petroleum diesel is defined as having max 0.1% (m/m). B5 blends are allowed to contain 0.1-5.5 % (m/m) [JIS K 2390:16]							

Appendix 5 - Diesel fuel NATO F-54 [STANAG 7090]

General requirements and test methods			
Property	Unit	Limit	Test method
Cetane number	-	≥ 49	EN ISO 5165
Cetane index	-	≥ 46	EN ISO 4264
Density at 15°C	kg/m ³	820 - 845	EN ISO 3675
Viscosity at 40°C	mm ² /s	1.2 - 4.5	EN ISO 3104
Lubricity (wsd 1.4) at 60°C	µm	≤ 460	EN ISO 12156-1
Polycyclic aromatic hydrocarbons	% (m/m)	≤ 8	EN 12916
FAME content ¹	% (V/V)	≤ 7	EN 14078
Oxidation stability	h	≥ 20	EN 15751
Sulfur content ²	mg/kg	≤ 15	EN ISO 20846 EN ISO 20884
Water content	mg/kg	≤ 200	EN ISO 12937
Total contamination	mg/kg	≤ 24	EN 12662
Cloud point	°C	≤ -10	EN 23015
CFPP	°C	≤ -20	EN 116
Flash point	°C	> 52	EN ISO 2719
Comment			
¹ FAME shall meet the requirements of EN 14214			
² Note that sulfur amount can vary between different countries/regions. See appendix 6 for sulfur rules regarding engines with SCR.			

Appendix 6 - Diesel fuel - minimum requirements. To use when ordinary diesel fuels are not available.

Detailed requirements and test methods			
Property	Unit	Limit	Test method
Cetane number	-	> 40	EN ISO 5165 ASTM D613
Density at 15°C	kg/m ³	≤ 860	EN ISO 3675
Viscosity at 40°C	mm ² /s	≤ 4.6	EN ISO 3104 ASTM D445
Lubricity (wsd 1.4) at 60°C	µm	≤ 520	EN ISO 12156-1 ASTM D6079
Polycyclic aromatic hydrocarbons	% (m/m)	≤ 10	EN12916
FAME content	% (V/V)	≤ 10	EN 14078 ASTM D7371
Oxidation stability	g/m ³	≤ 25	EN ISO 12205
	h	≥ 20	EN 15751
Sulfur content for IMO III engines with exhaust aftertreatment systems	mg/kg	≤ 1 000	EN ISO 20846 EN ISO 20884 ASTM D5453
Sulfur content for engines without exhaust aftertreatment systems	mg/kg	≤ 5 000	
Water content	mg/kg	≤ 200	EN ISO 12937
Total contamination	mg/kg	≤ 24	EN 12662
Water and sediments (alternative to water content & total contamination)	% (V/V)	≤ 0.05	ASTM D2709
CFPP ¹	°C	-	EN 116
Flash point	°C	> 55	EN ISO 2719 ASTM D93
Comments			
¹ Appropriate low temperature operability properties should be agreed upon between the fuel supplier and purchaser for the intended use and expected ambient temperatures.			

Appendix 7 - Paraffinic diesel fuel EN 15940

Detailed requirements and test methods				
Property	Unit	Limit		Test method
		Class A	Class B	
Cetane number	-	≥ 70	≥ 51	EN 15195
Density at 15°C	kg/m3	765-800	780-810	EN ISO 12185
Viscosity at 40°C	mm/s2	2.0 - 4.5		EN ISO 3104
Lubricity (wsd 1.4) at 60°C	µm	≤ 400		EN ISO 12156-1
Total aromatics content	% (m/m)	≤ 1.1		EN12916
FAME content ¹	% (V/V)	≤ 7		EN 14078
Oxidation stability ²	g/m3	≤ 25		EN ISO 12205
	h	> 20		EN 15751
Sulfur content	mg/kg	≤ 5		EN ISO 20846
Water content	mg/kg	≤ 200		EN ISO 12937
Total contamination	mg/kg	≤ 24		EN 12662
Flash point	°C	> 55		EN ISO 2719
Comments				
¹ FAME shall meet the requirements of EN 14214				
² For FAME content above 2% (V/V) the limit in hours is an additional requirement				

Climate-related requirements and test methods – Temperate climates								
Property	Unit	Limit						Test method
		Grade A	Grade B	Grade C	Grade D	Grade E	Grade F	
CFPP	°C	≤ +5	≤ 0	≤ -5	≤ -10	≤ -15	≤ -20	EN 116

Appendix 8 - High FAME diesel fuels EN 16734 and EN 16709

General requirements and test methods					
Property	Unit	Limit			Test method
		EN 16734	EN 16709		
Cetane number	-	≥ 51			EN ISO 5165
Cetane index	-	46	-		EN ISO 4264
Density at 15°C	kg/m3	820 - 845	820 - 860	825 - 865	EN ISO 3675
Viscosity at 40°C	mm2/s	2.0 - 4.5	2.0 - 4.6	2.0 - 4.7	EN ISO 3104
Lubricity (wsd 1.4) at 60°C	µm	≤ 460	-		EN ISO 12156-1
Polycyclic aromatic hydrocarbons	% (m/m)	≤ 8			EN 12916
FAME content ¹	% (V/V)	≤ 10	14 - 20	24 - 30	EN 14078
Oxidation stability ²	g/m3	≤ 25	-		EN ISO 12205
	h	≥ 20			EN 15751
Sulfur content	mg/kg	≤ 10			EN ISO 20846
Water content	mg/kg	≤ 200	≤ 260	≤ 290	EN ISO 12937
Total contamination	mg/kg	≤ 24			EN 12662
Flash point	°C	> 55			EN ISO 2719
Comment					
¹ FAME shall meet the requirements of EN 14214					
² For FAME content above 2% (V/V) the limit in hours is an additional requirement					

Climate-related requirements and test methods – Temperate climates								
Property	Unit	Limit						Test method
		Grade A	Grade B	Grade C	Grade D	Grade E	Grade F	
CFPP	°C	≤ +5	≤ 0	≤ -5	≤ -10	≤ -15	≤ -20	EN 116

Appendix 9 - High FAME diesel fuel ASTM D7467-15c

Detailed requirements and test methods			
Property	Unit	Limit	Test method
Cetane number ¹	-	≥ 40	ASTM D613
Cetane index or Aromaticity	-	≥ 40	ASTM D976-80
	% (V/V)	≤ 35	ASTM D1319-03
Viscosity at 40°C ²	mm/ s2	1.9 - 4.1	ASTM D445
Lubricity (wsd 1.4) at 60°C	µm	≤ 520	ASTM D6079
FAME content ³	% (V/V)	6 - 20	ASTM D7371
Oxidation stability	h	≥ 6	EN 15751
Sulfur content	mg/kg	≤ 15	ASTM D5453
Water and sediment	% (V/V)	≤ 0.05	ASTM D2709
Cloud point ⁴	°C	-	ASTM D2500
Flash point ⁵	°C	≥ 52	ASTM D93
Comments			
¹ Low ambient temperature as well as engine operation at high altitudes, may require the use of fuels with higher cetane ratings. ² If grade No 1-D or blends of Grade No 1-D and Grade No 2-D diesel fuel are used, the minimum viscosity shall be 1.3 mm2/s. ³ FAME shall meet the requirements of ASTM D6751. ⁴ Appropriate low temperature operability properties should be agreed upon between the fuel supplier and purchaser for the intended use and expected ambient temperatures. ⁵ If grade No 1-D or blends of Grade No 1-D and Grade No 2-D diesel fuel are used, or a cloud point below -12°C is specified, the minimum flash point shall be 38 °C.			

Appendix 10 - High FAME diesel fuel - minimum requirements. To use when ordinary FAME diesel fuels are not available.

General requirements and test methods			
Property	Unit	Limit	Test method
Cetane number	-	> 40	EN ISO 5165 ASTM D613
Density at 15°C	kg/m ³	≤ 860	EN ISO 3675
Viscosity at 40°C	mm ² /s	≤ 4.6	EN ISO 3104 ASTM D445
Lubricity (wsd 1.4) at 60°C	µm	≤ 520	EN ISO 12156-1 ASTM D6079
Polycyclic aromatic hydrocarbons	% (m/m)	≤ 10	EN 12916
FAME content ¹	% (V/V)	≤ 30	EN 14078 ASTM D7371
Oxidation stability	g/m ³	≤ 25	EN ISO 12205
	h	≥ 20	EN 15751
Sulfur content for engines with exhaust aftertreatment systems	mg/kg	≤ 1 000	EN ISO 20846 EN ISO 20884 ASTM D5453
Sulfur content for engines without exhaust aftertreatment systems	mg/kg	≤ 5 000	EN ISO 20846 EN ISO 20884 ASTM D5453
Water content	mg/kg	< 290	EN ISO 12937
Total contamination	mg/kg	≤ 24	EN 12662
Water and sediments (alternative to water content & total contamination)	% (V/V)	≤ 0.05	ASTM D2709
CFPP ²	°C	-	EN 116
Flash point	°C	≥ 55	EN ISO 2719 ASTM D93
Comments			
¹ FAME shall meet the requirements of EN 14214 or ASTM D7467			
² Appropriate low temperature operability properties should be agreed upon between the fuel supplier and purchaser for the intended use and expected ambient temperatures.			

Appendix 11 - Marine distillate fuels ISO 8217

Detailed requirements and test methods					
Property	Unit	Limit			Test method
		DMX	DMA	DFA	
Cetane index	-	≥ 45	≥ 40		ISO 4264
Density at 15°C	kg/m3	-	≤ 890		ISO 3675
Viscosity at 40°C	mm/s2	1.4 - 5.5	2.0 - 6.0		ISO 3104
Lubricity (wsd 1.4) at 60°C	µm	≤ 520			ISO 12156-1
FAME content ¹	% (V/V)	0	< 0.1	≤ 7	ASTM D7963
Oxidation stability	g/m3	≤25			ISO 12205
Sulfur content	mg/kg	(4)			ISO 8754 ASTM D4294
Water content ²	mg/kg	-			ISO 12397
Cloud point winter ³	°C	≤ -16	report		ISO 3015
CFPP winter ³	°C	-	report		IP 309
Pour point winter ³	°C	-	≤ -6		ISO 3016
Flash point	°C	≥ 43	≥ 60		ISO 2719
Comments					
¹ FAME shall meet the requirements of EN 14214 or ASTM D7467					
² These fuel grades shall appear clear and bright. In some countries they are dyed and not transparent. Then the water content shall not exceed 200 mg/kg.					
³ The purchaser should confirm that the cold flow characteristics are suitable for the ship's design and intended voyage. Issues with low temp operability can occur. Therefore, for winter grades of DMA and DFA, the cloud point and CFPP shall be reported.					
⁴ The buyer is expected to define maximum sulfur level according to statutory limitations. Volvo Penta recommend as little as possible. Do not exceed 5000 mg/kg for engines without SCR and maximum 1000 mg/kg for SCR engines.					

Appendix 12 - Jet fuel ASTM D1655 (Jet A-1)

Detailed requirements and test methods			
Property	Unit	Limit	Test method
Cetane number ¹	-	-	ASTM D976
Density at 15°C	kg/m3	775 - 840	ASTM D4052
Viscosity at -20°C ²	mm/s2	≤ 8.0	ASTM D445
Lubricity (wsd 1.4) at 60°C	µm	-	ASTM D6079
Aromatics	% (V/V)	≤ 25	ASTM D1319
Sulfur	mg/kg	≤ 3 000	ASTM D4294
Particulate matter	mg/L	≤ 1	ASTM D5452
Freezing point	°C	≤ -47	ASTM D2386
Flash point	°C	≥ 38	ASTM D56
Comments			
¹ Cetane number is around 40-43 ² Viscosity at 40°C is around 1.5-1.7 ³ Lubricity (wsd 1.4) at 60°C is around 750			