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X SERIES ENGINE


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FUEL SELECTION STEYR- MOTORS MARINE ENGINES

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Introduction

This document will give you an overview of the fuels released to be used in Steyr-Motors for Marine applications as well as operational requirements.

STEYR MOTORS M1 MARINE ENGINES are developed to meet the specified power, emissions and fuel consumption only with Diesel fuel according to **EN590**.

For any other fuel, restrictions in operational performance and restrictions of emission must be considered and accepted.

To achieve the specified engine power output when using fuel with different density than in the Diesel EN590 specification, Steyr-Motors developed a Fuel Density Compensation Kit.

For best performance and trouble-free engine operation, Steyr-Motors recommends that an adequately sized fuel filter system with water separator and including a water in fuel sensor is installed.


Furthermore it is a basic requirement that the installed fuel system on the vessel meets the Steyr-Motors specification, please refer to the Installation Manual.

Under the „special requirements“ (labeled in each fuel type description) you can find information about the influences and requirements regarding engine-operation.

Please NOTE:

- Every fuel used must comply with the corresponding, released specification and the special, minimum requirements from Steyr-Motors (labeled with *)
- It is the responsibility of the fuel supplier to ensure, that the fuel can be used at the expected given geographical and other local conditions such as minimum temperatures, so that correct engine operation is guaranteed!
- An engine operation with low fuel quality can cause damage or functional disorders!
- Fuels with higher contamination, viscosity or lower lubricity (>460µm HFRR wear scar) will definitely decrease the lifetime of the fuel supply pump!
- High sulfur content (≥ 0,5%) may cause corrosion and more frequent engine oil change intervals
- Engine operation with fuels with higher sulfur content require an engine oil with higher base number (BN) to counteract the corrosion which may occur (e.g. Shell Rimula R6M 10W40)
- The Fuel Density Compensation Kit only compensates for the engine power output regarding fuel density, it is not a „Safety Tool“ where you can operate the Steyr-Motors engine with each fuel type!

Biofuel usage: please consider that all components of the fuel system which are used on the vessel have to be released for Biofuel usage. The material of the fuel tank, fuel pipes and other fuel components should not include copper, lead or zinc. The material for O-ring seals or rubber gaskets should be FKM/FPM Viton®.

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Service interval

Further information can be found on our homepage:

<http://www.steyr-motors.com/download/manuals-spare-parts/option-equipment>

Please also refer to the disclosures in the „Overview Fuel Data“

This fuel selection document will be amended or supplemented when needed.
Before usage, please make sure that you have the latest version of this document.

Fuel Density Compensation / Function

The fuel density sensor is a novel fluid property sensor that will directly and simultaneously measure the density and temperature of fluids. Kindly note that the sensor does not measure other fluid properties, sulphur or contaminants!

The information about density and temperature is computed and engine injection quantity is corrected accordingly to achieve the specified rated power.

This device is an active sensor and is communicates with the ECU via the CAN Bus system.


For further information please contact Steyr-Motors.

Fuel Density Compensation Availability

NOTE: all content is subject to change due to further development.

Table 1

Engine type	Fuel Density Compensation available
SE144E38	X
SE164E40	X
SE126E25	✓
SE156E26	✓
SE156E32	X
SE196E35	✓
SE236E40	✓
SE236S36	✓
SE266E40	✓
SE266S36	✓
SE286E40	✓
SE306J38	✓

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Measures for extended engine storage periods

Extended engine storage periods greater than 1 year lead to depletion of the fuel anti-oxidation and anti-corrosion additives especially with diesel/FAME blends.

Fuel ageing leads to the formation of gum and residue in the fuel. Such aged fuel may lead to sticking of moving parts in the fuel system and as a consequence to fuel system malfunction. Therefore, during extended engine storage periods suitable measures have to be implemented: e.g. regularly check the diesel fuel ageing reserve and if necessary purge and replace with fresh fuel followed by flushing of the fuel system by a suitable engine run period.

Overview Fuel Data

Cetane:


- Cetane number is a more accurate measurement than Cetane index (Cetan number and index do correlate)
- Cetane number is an indication of how easily diesel ignites under high pressure and compression temperature conditions
- Cetane number which is too low leads to starting difficulties and white smoke
- EN590: Cetane number min. 51 (cetane index min. 46)
- SMO experience: Cetane number min. 46 (cetane index min. 38) is adequate for cold starts based on jet fuel testing

Density:

- Mass per volume
- The higher, the more mass, the more energy
- Deviations outside the EN 590 specification lead to either too much or too little power
- EN590: 820 – 845 kg/m³ at 15°C
- Ca. -1kg/m³/°C
- SMO experience: Diesel fuel up to 852kg/m³ at 15°C and jet fuel at 790kg/m³ at 15°C may be used
- A Fuel Density Compensation Kit is available

Aromatics:

- Main focus is on emissions and this is usually not an issue with engine performance or durability if the total aromatic content is under 10% m/m
- EN590: max. 8% (m/m = mass %)

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Sulfur content:

- A too high sulfur content ($\geq 0,5\%$) may cause corrosion and thus more frequent engine oil change intervals are recommended
- A high sulfur content causes numerous problems if exhaust gas recirculation and particulate filters are used
- Engine operation with fuel with higher sulfur content requires an engine oil with higher base number (BN)
- Very low sulfur content can cause issues with fuel lubricity (depends on the fuel manufacturers blending and use of additives in the fuel)
- EN590: max. 10mg/kg (=10ppm=Ultra low sulfur diesel [ULSD])

Flash Point:

- No directly relevant for engine operation
- Defines the fuel classification in one of the hazard classes
- Not to be confused with self-ignition temperature
- EN590: min. 55°C

Carbon residue:


- Or coke residue
- Is a reference to the tendency of a specific fuel to form residues in the combustion chamber – also known as coking of the injector nozzle
- EN590: max. 0,3% (m/m = mass %)

Ash content:

- Is a carbon-free combustion residue
- Can lead to wear of engine parts and the turbocharger
- EN590: max. 0,01% (m/m = mass %)

Water content:

- Causes corrosion of the fuel system, especially if salt water is present
- Causes deposits, especially if salt water is present
- EN590: max. 200mg/kg (=200ppm)
- A water separator has to be used in any case
- A water separator may become ineffective if the water content is above 2%

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Total contamination:

- Sediment, overall solid particle count
- Dust, rust, organic matter, fibres, etc.
- Causes wear in the injection- and fuel supply system and of the valves and seats
- EN590: max. 24mg/kg

Copper corrosion:


- Represents the chemical stability of the fuel as regards the sulphur compound and acid corrosion tendency
- Should typically not be an issue with high quality fuels
- May be an issue in case of too high water content
- May be an issue in the case of bio-fuels
- EN590: max. class 1 (3h at 50°C)

FAME content:

- Should not be of an issue as long as the diesel meets EN590: max. 7% (V/V=vol.), FAME according to EN14214
- Higher content up to 100% leads to issues regarding fuel ageing and fuel storage.
- STEYR M1 engines are essentially able to run on any content but with the following conditions:
 - Fuel ageing is not under control of STEYR MOTORS – any damages due to fuel ageing is not covered by warranty
 - All parts of the fuel and injection system (supplied by STEYR MOTORS) are capable of operating on biofuels meeting EN14214 (including any blends with EN590), but with reduced engine lifetime
 - A reduced engine oil change interval shall be considered as the oil is diluted by biofuel and there is a tendency for the oil to have a significant viscosity increase over time

Oxidation stability:

- Chemical stability against the formation of acids
- Especially a concern in case of biofuels and biofuel blends
- 20-30% biofuel blends are the worst case
- May decrease during storage (and therefore destroy the fuel)
- EN590: min. 20h
- EN14214: min. 6h

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Lubricity:

- Wear scar diameter (wsd 1,4) at 60°C, also known as HFRR
- Defines the wear depth when lubricating with the fuel tested
- EN590: max. 460µm
- SMO experience: successfully tested values up to 750µm have shown that lubricity is not an issue for the STEYR MOTORS Unit Injector

Viscosity:

- „fluidity“ of the fuel
- Correlates partly with the density
- However, should stay within certain limits
- EN590: min. 2,0mm²/s, max. 4,5mm²/s (at 40°C)
- Viscosity lower than 2,0mm²/s can lead to hot start problems and may increase wear rate in the fuel pump

Distillation properties:

- Describes, how the fuel evaporates as temperature increases
- Higher temperatures / higher residues mean more residues after combustion
- EN590:
 - Max. 65% (V/V=vol.%) at 250°C
 - Min. 85% (V/V=vol.%) at 350°C
 - 95% (V/V=vol.%) at max 360°C

Cold filter plugging point (CFPP):

- At temperatures below the CFPP, fuel filters (and fuel pipes) may get blocked by the fuel, even if the fuel is still liquid
- Several classes defined in EN590
- Engines shall not be used with fuel temperatures below CFPP
- Other definitions for cold temperature behaviour of fuels may be:
 - Solidification point: the fuel does not flow under its own weight
 - Pour point: 3°C above the solidification point
 - Cloud point: solid precipitation (paraffin wax becomes visible)
- It is the responsibility of the fuel supplier to ensure that the fuel can be used at the expected given geographical and other local conditions minimum temperatures, so that a correct engine operation is guaranteed!



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Additives:

- Most fuels contain additives for different reasons (lubricity, chemical stability, ignition improvers, etc.)
- Producers and suppliers of fuels must blend appropriate additives to ensure that specifications are met
- Good quality fuel supply therefore does not need additional additives
- After market additives are usually not effective, do not guarantee correct dosing and may interact with other additives
- After market additives must be avoided, unless if they are supplied or approved by STEYR MOTORS. Currently there are no additives approved respectively available from STEYR MOTORS.
- An engine operated with after market additives can cause damage or functional disorders! If you use unsuitable additives, STEYR MOTORS are not liable for warranty claims!

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Diesel Fuels

Legend:

- ✓ Fuel density kit available
- X Fuel density kit not available
- ☑ Fuel released
- ☒ Fuel not released
- ! Fuel released with special requirements (more information can be found in the description of each fuel type)

Engine Type	Fuel Density Kit (FDK) available	Diesel EN 590	Biodiesel EN14214	ASTM D975		GTL DIN15940	C.A.R.E. DIN15940
				1-D	2-D		
				S15, S500, S5000			
SE144E38	X	☑	☒	☒	☒	☑	☑
						without FDK reduced power output	without FDK reduced power output
SE164E40	X	☑	☒	☒	☒	☑	☑
						without FDK reduced power output	without FDK reduced power output
SE126E25	✓	☑	!	!	!	☑	☑
SE156E26	✓	☑	!	!	!	☑	☑
SE156E32	X	☑	☒	☒	☒	☑	☑
						without FDK reduced power output	without FDK reduced power output
SE196E35	✓	☑	!	!	!	☑	☑

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Engine Type	Fuel Density Kit (FDK) available	Diesel EN 590	Biodiesel EN14214	ASTM D975		GTL DIN15940	C.A.R.E. DIN15940
				1-D	2-D		
				S15, S500, S5000			
SE236E40	✓	☑	⚠	⚠	⚠	☑	☑
SE236S36	✓	☑	⚠	⚠	⚠	☑	☑
SE266E40	✓	☑	⚠	⚠	⚠	☑	☑
SE266S36	✓	☑	⚠	⚠	⚠	☑	☑
SE286E40	✓	☑	⚠	⚠	⚠	☑	☑
SE306J38	✓	☑	⚠	⚠	⚠	☑	☑

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Diesel fuel according to EN590

Climate-dependent behaviour (CFPP grades):

Summer grade (1 April to 30 September), maximum +5 °C (grade A)

 Winter grade (1 October to 28 February), maximum -20 °C (grade F)
 (1 March to 31 March), maximum -15 °C (grade E).

Property Diesel EN 590	Unit	Limits		Test method
		Minimum	Maximum	
Cetane number		51	-	EN ISO 5165 (b) EN 15195 EN 16144
Cetane index		46	-	EN ISO 4264
Density at 15 °C	kg/m ³	820	845	EN ISO 3675 (c) EN ISO 12185
Polycyclic aromatic hydrocarbons (d)	% (m/m)	-	8,0	EN 12916
Sulfur content	mg/kg	-	10,0	EN ISO 20846 (e) EN ISO 20884 EN ISO 13032
Manganese content (f) until 2013–12–31 from 2014 to 01–01 onwards	mg/l	- -	6,0 2,0	prEN 16576
Flash point	°C	Above 55,0	-	EN ISO 2719
Carbon residue (g) (on 10 % distillation residue)	% (m/m)	-	0,30	EN ISO 10370
Ash content	% (m/m)	-	0,01	EN ISO 6245
Water content	mg/kg	-	200	EN ISO 12937
Total contamination	mg/kg	-	24	EN 12662 (h)
Copper strip corrosion (3 h at 50 °C)	rating	class 1		EN ISO 2160
Fatty acid methyl ester (FAME) content (i)	% (V/V)	-	7,0	EN 14078
Oxidation stability	g/m ³ h	- 20 (j)	25 -	EN ISO 12205 EN 15751
Lubricity, corrected wear scar diameter (wsd 1,4) at 60 °C	µm	-	460	EN ISO 12156-1
Viscosity at 40 °C	mm ² /s	2,0	4,5	EN ISO 3104
Distillation (k, l) % (V/V) recovered at 250 °C % (V/V) recovered at 350 °C 95 % (V/V) recovered at	% (V/V) % (V/V) °C	85	< 65 360	EN ISO 3405 (m) EN ISO 3924

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Biofuel according to EN14214, FAME, RME

FAME: Fatty Acid Methyl Esters are esters of fatty acids. The physical characteristics of fatty acid esters are closer to those of fossil diesel fuels than pure vegetable oils, but properties depend on the type of vegetable oil. A mixture of different fatty acid methyl esters is commonly referred to as biodiesel, which is a renewable alternative fuel. FAME has physical properties similar to those of conventional diesel. It is also non-toxic and biodegradable.

RME: Rape Methyl Ester produced from raw rapeseed oil reacted with methanol


Special, requirements:

- Only released in combination with the Fuel Density Kit
- Not released for long term usage or storage
- After operation the whole fuel system has to be flushed sufficiently with Diesel meeting EN 590
- Installation of a fuel pre filter with a water separator is necessary
- Oil change, oil filter and fuel filter service intervals are reduced to 50% of the normal recommendation
- A reduced lifetime of sealing gaskets, fuel hoses, fuel density sensor and fuel supply pump can be expected
- After 50 hours of operation with Biodiesel EN14214, all fuel filters have to be replaced. (This is done to remove the sediment which Biodiesel dissolves from the fuel system)
- Please ensure that all components of the fuel system which are used on the vessel have to be released for Biofuel usage.

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Property Biofuel EN14214	Units	lower limit	upper limit	Test-Method
Ester content	% (m/m)	96.5	-	EN 14103
Density at 15°C	kg/m ³	860	900	EN ISO 3675 / EN ISO 12185 / EN12185.
Viscosity at 40°C	mm ² /s	3,5	5,0	EN ISO 3104 / EN 14105
Flash point	°C	> 101	-	EN ISO 2719 / EN ISO 3679.
Sulfur content	mg/kg	-	10	- EN ISO 20846 / EN ISO 20884.
Cetane number	-	51	-	EN ISO 5165
Sulfated ash content	% (m/m)	-	0,02	ISO 3987
Water content	mg/kg	-	500	EN ISO 12937
Total contamination	mg/kg	-	24	EN 12662
Copper band corrosion (3 hours at 50 °C)	rating	Class 1	Class 1	EN ISO 2160
Oxidation stability, 110°C	hours	8	-	EN 15751 / EN 14112
Acid value	mg KOH/g	-	0,5	EN 14104
Iodine value	-	-	120	EN 14111
Linolenic Acid Methylester	% (m/m)	-	12	EN 14103
Polyunsaturated (>= 4 Double bonds) Methylester	% (m/m)	-	1	EN 14103
Methanol content	% (m/m)	-	0,2	EN 14110
Monoglyceride content	% (m/m)	-	0,7	EN 14105
Diglyceride content	% (m/m)	-	0,2	EN 14105
Triglyceride content	% (m/m)	-	0,2	EN 14105
Free Glycerine	% (m/m)	-	0,02	EN 14105 / EN 14106
Total Glycerine	% (m/m)	-	0,25	EN 14105
Group I metals (Na+K)	mg/kg	-	5	EN 14108 / EN 14109 / EN 14538
Group II metals (Ca+Mg)	mg/kg	-	5	EN 14538
Phosphorus content	mg/kg	-	4	EN14107

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ASTM D975 1-D & 2-D (S15, S500, S5000)

Special requirements:

- Only released in combination with the Fuel Density Kit
- **S5000:** Engine oil with higher BN (>12mg KOH/g) needed! Oil change, oil filter and fuel filter service interval reduced to 50% of the normal recommendation (e.g. Shell Rimula R6M 10W40)
- Low Lubricity leads to higher wear of fuel system components and reduced lifetime of fuel system components
- Low Cetan number (min. 40) leads to worse cold start behaviour

ASTM Specifications for Diesel Fuel Oils (D975-97)

Diesel fuel is characterized in the United States by the ASTM standard D 975. This standard identifies five grades of diesel fuel described below.

Grade No. 1-D and Low Sulfur 1-D: A light distillate fuel for applications requiring a higher volatility fuel for rapidly fluctuating loads and speeds as in light trucks and buses. The specification for this grade of diesel fuel overlaps with kerosene and jet fuel and all three are commonly produced from the same base stock. One major use for No. 1-D diesel fuel is to blend with No. 2-D during winter to provide improved cold flow properties. Low sulfur fuel is required for on-highway use with the sulfur level < 0.05%.

Grade No. 2-D and Low Sulfur 2-D: A middle distillate fuel for applications that do not require a high volatility fuel. Typical applications are high-speed engines that operate for sustained periods at high load. Low sulfur fuel is required for on-highway use with the sulfur level < 0.05%.

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Property D975	ASTM D975-08a		ASTM D6751-12		
			2-B	1-B	Test
Flash point, min	No 1D 38°C	D93	93°C		D93
	No 2D 52°C				
Water & sediment, max	0.05% vol	D2709	0.050% vol		D2709
Water, max					
Total contamination, max					
Distillation temperature (% vol recovered)	90%:	D86	90%: 360°C max		D1160
	1D 288°C max				
	2D 282-338°C				
Kinematic viscosity	1D 1.3-2.4 mm ² /s	D445	1.9-6.0 mm ² /s		D445
	2D 1.9-4.1 mm ² /s				
Density max.	876 Kg/m ³				
Ester content	5% vol. max	EN 14078			
Ash, max	0.01% wt	D482			
Sulfated Ash, max			0.020% mass		D874
Sulfur, max (by mass)	1D and 2D:	D5453 D2622 D129 ²	Two grades:		D5453
	S15 15 mg/kg		S15 15 ppm		
	S500 0.05%		S500 0.05%		
	S5000 0.50%				
Copper strip corrosion, max	No 3	D130	No 3		D130
Cetane number, min	46*	D613	47		D613

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Property D975	ASTM D975-08a		ASTM D6751-12		
			2-B	1-B	Test
- cetane index	40 min	D976-80			
- aromaticity	35% vol max	D1319			
PAH, max					
Operability, one of:	Report	D2500 D4539 D6371			
- cloud point					
- LTFT/CFPP					
Cloud point			Report		D2500
CFPP					
Carbon residue on 10% distillation residue, max	1D: 0.15% wt 2D: 0.35% wt	D524	0.030*% wt⁵		D4530
Acid number, max			0.50 mg KOH/g		D664
Oxidation stability			3 hrs min		EN 14112
Iodine value, max					
Linolenic acid methyl ester, max					
Polyunstatured methyl esters, max					
Alcohol control			0.2% wt methanol max, or 130°C flash point min		EN14110 D93
Monoglycerides, diglycerides & triglycerides, max				MG 0.40% wt	D6584
Group I metals (Na + K), max			5 mg/kg		EN 14538
Group II metals (Ca + Mg), max			5 mg/kg		EN 14538
Free glycerin, max			0.020% wt		D6584
Total glycerin, max			0.240% wt		D6584
Phosphorous, max			0.001% wt		D4951
Lubricity, max	520 µm	D6079			

*special, minimum requirements from Steyr-Motors

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SHELL GTL GASOIL according to DIN 15940

Special requirements:

- Without the Fuel Density Kit a restricted engine performance has to be accepted

Product description:

Shell (Gas to Liquids) GTL Gasoil is a new innovative fuel designed to lower local emissions.

Shell GTL Gasoil is virtually free of aromatics, poly-cyclic aromatics, olefins, sulphur, nitrogen and metals. The fuel is colourless and almost odourless. GTL Gasoil predominantly contains straight chain normal paraffins and branched iso-paraffins. Due to its composition the fuel has a very high cetane number and will burn cleaner, (lower NOX, particulate matter and SOX emissions) compared to conventional diesel.

Specification:


Shell GTL Gasoil meets the following specification:

CEN TS 15940 "Automotive fuels – Paraffinic diesel from synthesis or hydrotreatment – Requirements and test methods"

Product data:

Fuel properties of GTL Gasoil will show variations due to the production process. Indicative values are shown below:

Characteristic GTL DIN 15940	Unit	Test method reference	Minimum	Maximum
Cetan number	-	ISO 5165	70	-
Density at 15°C	kg/m ³	ISO 3675	770	800
Sulfur content	mg/kg	ISO 14596	-	3.0
Total aromatic content	% (m(m))	EN 12916	-	0.5
Polycyclic Aromatics content	% (m(m))	EN 12916	-	0.1
Total Olefin content	% (m(m))	ASTM D1159	-	0.1
Viscosity at 40°C	mm ² /s	ISO 3104	2	4,5
Flashpoint	°C	EN 2719	60	-
Distillation		ISO 3405		
% (v/v) recovered at 250°C	% (v/v)		-	65
% (v/v) recovered at 350°C	% (v/v)		85	-
95% (v/v) recovered at	°C			360
Cold filter plugging point	°C	EN 116	-	-9(-20)**
** values between brackets are valid for the Winter period				

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C.A.R.E. diesel according to DIN 15940

Special requirements:

- Without the Fuel Density Kit a restricted engine performance has to be accepted

C.A.R.E. Diesel® significantly exceeds the quality requirements (EN 590) for diesel fuels (with the exception of the minimum density) and is clearly superior in performance to both conventional biodiesel and fossil diesel. It has, by virtue of the very high cetane number and purest composition, a performance enhanced quality without requiring additional additives. In addition, C.A.R.E. Diesel® has a very slow ageing and high storage stability factor, this diesel fuel has favourable cold flow properties at very low temperatures.

Characteristic C.A.R.E.		Unit	Limit	C.A.R.E	Test method reference
Kinematic viscosity at 40 °C (a)		mm ² /s	max.	2,0	
			min.	4,0	
Density at 15 °C		kg/m ³	min.	770	
			max.	790	
Cetane number		–	min.	70	
Sulfur (b)		mg/kg	max.	5	
Flash point		°C	min.	60	
Copper strip corrosion		class		1	
Acid number		mg KOH/g	max.	0,2	
Total sediment		mg/kg	max.	10	
Oxidation stability		h	min.	20	
Carbon residue: micro method on the 10 % volume distillation residue		% (wt.)	max.	0,3*	
Cloud point		°C	max.		
Pour point (upper) (c)	winter quality	°C	max.	-35	
	summer quality	°C	max.	-22	
FAME		vol%	–	0,0	
Water		mg/kg	max.	200	
Ash		% (wt.)	max.	0,01	
Lubricity, corrected wear scar diameter (wsd 1,4) at 60 °C (h)		µm	max.	460	

*special, minimum requirements from Steyr-Motors

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Marine Distillates

Legend:

- ✓ Fuel density kit available
- X Fuel density kit not available
- ☑ Fuel released
- ☒ Fuel not released
- ! Fuel released with special requirements (more information can be found in the description of each fuel type)

Engine Type	Fuel Density Kit (FDK) available	DMA (MGO) ISO8217	DMX ISO8217	NATO F-75	NATO F-76
SE144E38	X	☒	☒	☒	☒
SE164E40	X	☒	☒	☒	☒
SE126E25	✓	!	!	!	!
SE156E26	✓	!	!	!	!
SE156E32	X	☒	☒	☒	☒
SE196E35	✓	!	!	!	!
SE236E40	✓	!	!	!	!
SE236S36	✓	!	!	!	!
SE266E40	✓	!	!	!	!
SE266S36	✓	!	!	!	!
SE286E40	✓	!	!	!	!
SE306J38	✓	!	!	!	!

 STEYRMOTORS <small>INNOVATION WITH LIGHTNESS</small>	Fuel selection Steyr Motors Marine Engines		Version: 01	
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DMA (MGO), DMX according to ISO 8217

Special requirements:

- Only released in combination with the Fuel Density Kit
Engine oil with higher BN (>12mg KOH/g) needed! (e.g. Shell Rimula R6M 10W40) Oil change, oil filter and fuel filter service interval reduced to 50% of the normal recommendation
- Installation of a fuel pre filter with a water separator is necessary
- Higher sulfur content may cause corrosion in the combustion chamber, cylinder liners, injection nozzles, valves, exhaust, turbo charger, exhaust elbow assembly
- Low Lubricity leads to higher wear of fuel system components and reduced lifetime of fuel system components e.g. fuel supply pump

Characteristic DMX, DMA		Unit	Limit	DMA (acc.to ISO8217)	DMX (acc.to ISO8217)	Test method reference
Kinematic viscosity at 40 °C (a)		mm ² /s	max.	4,5*	4,5*	ISO 3104
			min.	2,0	2,0*	
Density at 15 °C		kg/m ³	max.	890	890*	ISO 3675 or ISO 12185
Cetane index		–	min.	40	45	ISO 4264
Cetane number		–	min.	46*	46*	
Sulfur (b)		mass %	max.	1,0*	1,0	ISO 8754, ISO 14596
Flash point		°C	min.	60	43	ISO 2719
Hydrogen sulfide		mg/kg	max.	2,0	2,0	IP 570
Acid number		mg KOH/g	max.	0,5	0,5	ASTM D664
Total sediment by hot filtration		mass %	max.	–	–	ISO 10307-1
Oxidation stability		g/m ³	max.	25	25	ISO 12205
Carbon residue: micro method on the 10 % volume distillation residue		mass %	max.	0,3	0,3	ISO 10370
Cloud point		°C	max.	–	-16	ISO 3015
Pour point (upper) (c)	winter quality	°C	max.	-6	–	ISO 3016
	summer quality	°C	max.	0	–	ISO 3016
Appearance		–	–	Clear and bright (h)		
Water		vol%	max.	0,5*	0,5*	ISO 3733
Ash		mass %	max.	0,01	0,01	ISO 6245
Lubricity, corrected wear scar diameter (wsd 1,4) at 60 °C (h)		µm	max.	520	520	ISO 12156-1

*special, minimum requirements from Steyr-Motors


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NATO F-75 MIL-DTL-16884M, NATO STANAG-1385

- Only released in combination with the Fuel Density Kit

Characteristic F-75	Unit	Limit	NATO F-75	Test method reference
Kinematic viscosity at 40 °C	mm ² /s	min.	1,8	DIN 51562 Part 1
		max.	4,3	
Density at 15 °C	kg/m ³	max.	860	DIN 51757
Cetane number	–	min.	46*	DIN 51773
Sulfur	mass %	max.	0,05	DIN 51400 Part 1 and 6
Flash point	°C	min.	61	DIN EN 22719
Hydrogen sulfide	mg/kg	max.		
Acid number	mg KOH/g	max.	0,3	D974, D664
Corrosion, at 100 °C (max)	Class		No 1	D130
Particulate Contamination	mg/liter	max.	10	D6217, D5452
Carbon Residue on 10% bottoms	wt %	max.	0,3*	D524, D189, D4530
Total contamination	mg/kg	max.	24*	
Cloud point	°C	max.	-13	DIN EN 230515
Pour point (upper)	°C	max.	-18	DIN ISO 3016
Appearance	–	–		Clear, bright, and free of visible particulates D4176
Water content	mg/kg	max.	200*	
Ash	mass %	max.	0,01	DIN EN ISO 6245
Lubricity, corrected wear scar diameter (wsd 1,4) at 60 °C	µm	max.	460	D6079, D7688

*special, minimum requirements from Steyr-Motors

 STEYRMOTORS <small>INNOVATION WITH LIGHTNESS</small>	Fuel selection Steyr Motors Marine Engines		Version: 01
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NATO F-76 MIL-DTL-16884M, NATO STANAG-1385

- Only released in combination with the Fuel Density Kit

Characteristic F-76	Unit	Limit	NATO F-76	Test method reference
Kinematic viscosity at 40 °C	mm ² /s	min.	1,7	IP 71
		max.	4,3	
Density at 15 °C	kg/m ³	max.	880	IP 160
Cetane number	–	min.	46*	ASTM D 613
Sulfur	mass %	max.	0,05	IP 336
Flash point	°C	min.	61	IP 34
Hydrogen sulfide	mg/kg	max.		
Acid number	mg KOH/g	max.	0,3	D974, D664
Corrosion, at 100 °C (max)	Class		No 1	D130
Particulate Contamination	mg/liter	max.	10	D6217, D5452
Carbon Residue on 10% bottoms	wt %	max.	0,3*	D524, D189, D4530
Total contamination	mg/kg	max.	24*	
Cloud point	°C	max.	-13	IP 219
Pour point (upper)	°C	max.	-18	IP 15
Appearance	–	–		Clear, bright, and free of visible particulates D4176
Water content	mg/kg	max.	200*	D7171, D4808, D5291
Ash	mass %	max.	0,01	IP 4
Lubricity, corrected wear scar diameter (wsd 1,4) at 60 °C	µm	max.	460	D6079, D7688

*special, minimum requirements from Steyr-Motors

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Jet Fuels

Special requirements:

- Released in combination with the Fuel Density Kit
- Without the Fuel Density Kit a restricted engine performance has to be accepted
- Low Lubricity can lead to higher wear of fuel system components and the reduced lifetime of fuel system components e.g. fuel supply pump
- High viscosity can lead to higher stresses on the fuel system components and reduced the lifetime of fuel system components e.g. fuel supply pump

Legend:

- ✓ Fuel density kit available
- X Fuel density kit not available
- ☑ Fuel released
- ☒ Fuel not released
- ! Fuel released with special requirements (more information can be found in the description of each fuel type)

Engine Type	Fuel Density Kit (FDK) available	Jet A	Jet A-1	MIL JP-5	MIL JP-8	NATO F-34	NATO F-35	NATO F-44	NATO F-63	NATO F-65
SE144E38	X	!	!	!	!	!	!	!	!	!
SE164E40	X	!	!	!	!	!	!	!	!	!
SE126E25	✓	!	!	!	!	!	!	!	!	!
SE156E26	✓	!	!	!	!	!	!	!	!	!
SE156E32	X	!	!	!	!	!	!	!	!	!
SE196E35	✓	!	!	!	!	!	!	!	!	!
SE236E40	✓	!	!	!	!	!	!	!	!	!
SE236S36	✓	!	!	!	!	!	!	!	!	!

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NOTES Jet A/A1

- (1) Jet A-1 is similar to Jet A in all properties except Freezing Point at -47°C max.
- (2) Fuel shall be visually free of undissolved water, sediment and suspended matter.
- (3) Simulated distillation by ASTM D2887 allowed for Jet A/A-1; test limit in parentheses.
- (4) Results obtained by method D3828 may be up to 2°C lower than those obtained by method D56.
- (6) With method D4305, use procedure A only. This method shall not be used on samples with viscosities greater than 5.0 cSt at -20°C.
- (7) D5972 may produce a higher (warmer) result than D2386 on wide-cut fuels.
- (8) Test at control temperature of 260°C, but if requirements are not met, the test may be conducted at 245°C. in this case report results at both temperatures.
- (9) No abnormal or peacock colour deposits allowed.
- (10) For fuel without static dissipating additive. For fuel containing static dissipator additive, a minimum MSEP rating of 70 applies. Limits apply only at point of manufacture.
- (11) When electrical conductivity additive is specified by the purchaser, conductivity shall be 50-450 pS/m under the conditions at point of delivery.
- (12) DiEGME additive conforming to requirements of D4171, Type III, may be used at 0.10-0.15 vol % concentration.
- (13) Stadis 450 additive limited to 3 mg/L max. at manufacture, and cumulative total 5 mg/L max on retreatment.

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JP-5 MIL-DTL-5624's Grade JP-5 interchanged under NATO code **number F-44**; contains only kerosene fractions; not considered volatile.

- MIL-DTL-5624, DEF STAN 91-86
- Freeze Point: $\leq -46^{\circ}\text{C}$ (-50.8°F)
- Density @15°C: 0.788 to 0.845 kg/L
- Flash Point: $\geq 60^{\circ}\text{C}$ (140°F)

Property JP-5	GRADE JP-5	ASTM or IP Test
		Method
Color, Saybolt	Report	D156 or D6045
Total acid number, mg KOH/g, max	0.015	D3242
Aromatics, vol percent, max	25.0	D1319
Sulfur, Mercaptan, mass percent, max	0.002	D3227
or		
Doctor test	Negative	D4952
Sulfur, total, mass percent, max	0.20	D129, D1266, D2622, D3120, D4294 or D5453
Distillation temperature, ° C		D86 or D2887
Initial boiling point	Report	
10 percent recovered, temp	205, max	
20 percent recovered, temp	Report	
50 percent recovered, temp	Report	
90 percent recovered, temp	Report	
End point, max temp	300, max	
Residue, vol %, max (for D86)	1,5	
Loss, vol %, max (for D86)	1,5	
Flash point, ° C, min	60.0	D56, D93, or D3828
Density, at 15° C		D1298, D4052 or D7777
kg/L, min (API max)	0.788	
kg/L, max (API min)	0.845	
Freezing point, ° C, max	-46	D2386, D5972 D7153, or D7154
Viscosity, at -20° C, max, mm ² /s	8,5	D445
Net Heat of combustion, MJ/kg, min	42.6	D3338, D4529, or D4809

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Property JP-5	GRADE JP-5	ASTM or IP Test
		Method
Hydrogen content, mass percent, min	13,4	D3701 or D7171
Copper strip corrosion, 2 hr at 100° C, max	No. 1	D130
Fuel system icing inhibitor volume percent min	0.10	D5006
volume percent max	0.15	
Lubricity, μm , max	760*	D5001

*special, minimum requirements from Steyr-Motors

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JP-8 MIL-DTL-83133 interchanged under NATO code **number F-34**; contains only kerosene fractions; not considered volatile. Identical to ASTM D 1655 Jet A-1, except Jet A-1 does not include fuel system icing inhibitor, corrosion inhibitor, or static dissipator additive, which are all mandatory under MIL-DTL-83133.

- MIL-DTL-83133, DEF STAN 91-87
- Freeze Point: $\leq -47^{\circ}\text{C}$ (-52.6°F)
- Density @15°C: 0.775 to 0.840 kg/L
- Flash Point: $\geq 38^{\circ}\text{C}$ (100.4°F)

COMPOSITION JP-8		JP-8 Kerosine	Test Method ASTM
Appearance		C & B (2)	
Acidity, Total (mg KOH/g)	Max.	0.015	D3242
Aromatics (vol %)	Max.	25	D1319
Sulphur, Total (wt %)	Max.	0.30	D4294 (3)
Sulphur, Mercaptan (wt %)	Max.	0.002	D3227
or Doctor Test		Negative	D4952
Colour, Saybolt		Report	D156, D6045
VOLATILITY			
Distillation Temperature:			D86, D2887
Initial BP (°C)	Min.	Report	
10% Recovery (°C)	Max.	205 (186) max.	
20% Recovery (°C)	Min.	Report	
50% Recovery (°C)		Report	
90% Recovery (°C)	Max.	Report	
Final BP (°C)	Max.	300 (330)	
Distillation Residue (vol %)	Max.	1.5	
Distillation Loss (vol %)	Max.	1.5	
Flash Point (°C)	Min.	38	D56, D3828
Density @ 15°C (kg/L)		0.775-0.840	D1298, D93, D4052
or Gravity, API @ 60°F		51.0-37.0	D1298
FLUIDITY			
Freezing Point (°C)	Max.	-47	D2386, D5901, D5972, D445
Viscosity @ -20°C (cst)	Max.	8.0	D445
COMBUSTION			
Net Heat of Comb. (MJ/kg)	Min.	42.8	D3338, D4809
Cetane Index (calculated)		Report	D976
Smoke Point (mm)	Min.	25	D1322
or Smoke Point (mm)	Min.	19	D1322
and Naphthalenes (vol %)	Max.	3.0	D1840
Hydrogen Content (wt %)	Min.	13.4	D3701, D3343 (6)
CORROSION			
Copper Strip (2h @ 100°C)	Max.	1	D130


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COMPOSITION JP-8		JP-8 Kerosine	Test Method ASTM
THERMAL STABILITY			
JFTOT ΔP @260°C (mm Hg)	Max.	25	D3241 (7)
Tube Deposit Rating (Visual)	Max.	<3 Visual (8)	
CONTAMINANTS			
Existent Gum (mg/100mL)	Max.	7	D381
Particulates (mg/L)	Max.	1.0	D2276, D5452
Filtration Time (min)	Max.	15	-11
Water Reaction Interface	Max.	1b	D1094
MSEP Rating	Min.	90 (12)	D3948
OTHER			
Conductivity (ps/m)		(13)	D2624
ADDITIVES			
Anti-icing (vol %)		0.10-0.15 (14)	D5006
Antioxidant (ppm)		Required (15)	
Corrosion Inhibitor (ppm)		Required (16)	
Metal Deactivator		Agreement	
Static Dissipator		Required	

NOTES

- (2) Fuel shall be clear and bright at 21°C; JP-8 may contain no more than 1.0 mg/L of particulate matter.
- (3) D1266, D2622 and D3120 are permitted alternatives for JP-8 (which also accepts D129 and D5453).
- (6) May use calculation (D3343) or measurement method (D3701).
- (7) Test conditions for JP-8 fuel at 260°C for 2.5h.
- (8) No peacock or abnormal colours allowed.
- (11) Filtration time determined according to procedure in Appendix A of MIL-DTL-83133E.
- (12) Limit for fuel containing antioxidant and metal deactivator. Limit reduced to 85 when third additive is icing inhibitor; to 80 when third additive is corrosion inhibitor; to 70 with all four additives present.
- (13) Conductivity limits are 150-450 pS/m for F-34 (JP-8), 50-450 pS/m for F-35, and 150-700 pS/m for JP-8+100 fuel. Conductivity must be within range at ambient fuel temperature or 29,4°C, whichever is lower.
- (14) Fuel system icing inhibitor is mandatory for F-34 grade, by agreement in F-35.
- (15) Required for fuel containing hydrogen-treated blending stocks. Optional for fuel not containing hydrogen-treated blending stocks.
- (16) PWA-536 lubricity additive shall be added to JP-7 fuel. Corrosion inhibitor conforming to MIL-PREF-25017 shall be added to F-34 fuel, but is optional for F-35.

 STEYRMOTORS <small>INNOVATION WITH LIGHTNESS</small>	Fuel selection Steyr Motors Marine Engines	Version: 01
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F-44 is a kerosine grade of aviation fuel suitable for most turbine-engined aircraft. This military fuel grade is intended specifically for use on naval aircraft carriers, where a fuel with a higher flash point than standard Jet A-1/JP-8 is required for on-board safety reasons.

F-54 (Diesel fuel) middle distillate fuel used for automotive diesel and gas turbine engines.
– ASTM D975
– Density @15°C: ~ 0.820 to 0.840 kg/L
– Flash Point: ≥ 52°C (125.6°F)

F-63 same as F-35 (Jet A-1) incl. wear and ignition improver additive.

F-65 mixture from F-54, F-34 and F-35

Warranty:

Compliance with the fuel specification document is an integral part of the warranty conditions.

The fuel supplies are responsible for the worldwide consistent quality of the above products.

STEYR-MOTORS accept no liability for improper or non-specified use of the released fuels.

In case of warranty, the claimed fuel components must be forwarded inclusive of a fuel sample from the fuel tank (at least 1 litre) and the fuel filter(s).

For the examination of any warranty claim, we need the following as a minimum requirement:

- Customer name, telephone number, E-mail details and postal address
- Engine type
- Engine number
- Running time of the claimed components
- Fuel samples (at least 1 litre of each) and fuel filter(s)
- Description of the warranty claim

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