Dear Sir or Madam

This Service Letter gives information and guidance on operation using biofuel. The types of biofuel currently accepted for MAN B&W two-stroke engines are:

- Fatty acid methyl ester (FAME)
- Hydrotreated vegetable oil (HVO)
- Similar FAME-type fuels
- Blends of the above with ISO 8217-compliant fossil fuel.

The Service Letter includes the following information:

- Biofuel: definition of types and general properties
- Engine design, Tier III, and pilot fuel: biofuel use
- An overview of accepted biofuel use regarding different technologies and NO_x compliance regulations
- Biofuel analysis and standards
  - What to consider when analysing biofuels
- Technical and operational guidelines, and recommendations
  - Engine performance – ME and MC engines
  - Material, equipment, tanks, and pipe systems
  - Fuel management and cylinder lubrication
- References

Note that many guidelines and recommendations are the same as for <0.50% S VLSFO operation.

Always refer to the most recent guideline available for your specific engine type, for example, Service Letters, recommendations for fuels, lubrication, piston rings, and cylinder condition. Service Letters are available at:
https://marine.man-es.com/two-stroke/service-letters

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Yours faithfully

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Action code: WHEN CONVENIENT

Biofuel operation

MAN B&W two-stroke engines

SL2023-741/JUSV
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Concerns

Owners and operators of MAN B&W two-stroke marine diesel engines. Type: ME/ME-C/ME-B/MC/MC-C/ME-GI/ME-GIE/ME-LGIM/ME-LGIP and ME-GA engines.

Summary

Operational guidelines for biofuels: FAME, similar FAME-type fuels, HVO, and blends of these.

Relevant Service Letters

SL2023-738, SL2023-737, SL2022-726, SL2019-670, and SL2017-638. More information on fuels and fuel management: “Detailed information on Preparation and Operation on fuels with maximum 0.50% sulphur” [1].

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Biofuel: definition of types and general properties

The types of biofuel presently accepted for MAN B&W two-stroke engines are:

- Fatty acid methyl ester (FAME)
- Hydrotreated vegetable oil (HVO)
- Similar FAME-type fuels
- Blends of the above with ISO 8217-compliant fossil fuel.

The types above are commonly described as "biofuel" in this Service Letter. Table 1 shows an overview of the properties of biofuels and fossil fuels. It is important to know which kind of biofuel is offered and supplied. If this is not clear, the supplier should be asked. Refer to the latest edition of the ISO 8217 standard. At the time of writing, it is ISO 8217:2017, edition 6 [2].

FAME

FAME is commonly referred to as biodiesel. FAME properties should be according to EN 14214 or ASTM D6751 standards. If or when FAME is introduced in a new version of ISO 8217, it is recommended to follow the new revision of the standard.

FAME blended with an ISO 8217 compliant fossil fuel (distillate marine grade (DM) or residual marine grade (RM)) is often referred to as BX. For example, a B30 has around 30% FAME. This can change and different suppliers may have different naming standards.

HVO

HVO is covered by ISO 8217:2017 (clause 1 scope): "Hydrocarbons from synthetic or renewable sources, similar in composition to petroleum distillate fuels". The properties of HVO are very similar to DMA. It should be supplied according to the ISO 8217 DMA grade. It has a heating value similar to diesel, a very-low-sulphur content, and a viscosity around 2–3 cSt at 40°C. It is recommended to check the lubricity on 100% HVO, because of the very-low-sulphur content and viscosity.

HVO is commonly referred to as either renewable diesel or hydro-processed esters and fatty acids (HEFA). It is made up of paraffinic hydrocarbons that are free of oxygen, nitrogen, and aromatics.

Similar FAME-type fuels

Fuels containing predominantly FAME, or other similar FAME-type fuels such as "bottoms of FAME esterification", could be accepted under certain conditions. They should not contain significant levels of free fatty acids, methanol, glycerol, or chlorides. The phosphor content should be lower than 15 mg/kg. It should be noted that these fuels may contain molecules with various properties which can affect the cold-flow properties of the fuel. As always, it is recommended to run these fuels through the fuel cleaning system, e.g. separator and filtering.

Sustainability of biofuels

Biofuels produced sustainably from sustainable feedstocks should be preferred to support decarbonisation. Sustainability documentation can support the decision-making process when choosing a biofuel.

Overview of biofuel and fossil fuel type properties

	Properties						
Components	**FAME** FAME	**HVO** Paraffinic hydrocarbon	**Similar FAME-type** FAME + residuals from production	**Blends** FAME/HVO + fossil fuel	**ULSFO** DM-grade (diesel)	**VLSFO** RM-grade (heavy fuel)	**HSFO** RM-grade (heavy fuel)
Nitrogen [%]	~0.1	~0	~0.1	~0.1–0.4	~0.1	~0.4	~0.4
Oxygen [%]	~10	~0	~11	~0–10	~0	~0	~0
Sulphur [%]	~0	~0	~0	Low[1)]	≤0.10	≤0.50	>0.50. Average: 2.9
LCV [MJ/kg]	37	43	36–37	37–43	42–43	39–42	39–41
Kin. viscosity [mm²/s]	3–5 at 40°C	2–3 at 40°C	15–40 at 50°C	Low[1)]	2–11 at 40°C	2–500 at 50°C	200–700 at 50°C
Pour point [°C]	<-6 to >+6[2)]	low	~0	[1)]	ISO 8217	ISO 8217	ISO 8217
Stability	Low-high[2)]	Very high	Medium-high	Medium-high	Very high	High	High
Lubricity	Analyse[3)]	Analyse[3)]	Analyse[3)]	Analyse[3)]	ISO 8217	ISO 8217	ISO 8217
Standard[3)]	EN 14214, ASTM D6751	EN 15940:2016+ A1:2018+AC, ISO 8217 DMA grade	No standard	No standard[4)] ISO 8217:2017: up to 7% FAME in DM	ISO 8217	ISO 8217	ISO 8217

1) Depending on biofuel blend ratio and properties of the bio-part and the fossil fuel.
2) Depending on FAME feedstock.
3) Most relevant for fuels with lower than 0.05% sulphur (500 ppm S)
4) Standards are updated from time to time. Always refer to the latest edition.

Table 1. Overview of some important properties for different biofuel and fossil fuel types (general numbers). The table is not complete. There are other properties, elements, and components that could be important to analyse.

Potential use of other types of bio-components in fuels not covered in this Service Letter

There may be other types of non-fossils fuels available on the market. This Service Letter only covers the biofuels mentioned in the text. Other types are not covered. As it is presently unclear whether other biofuel types are suitable as a marine fuel, we advise caution in using these. There is a risk that damage may occur to the fuel system, fuel injection system, and engine. Operation on these fuel types is at your own risk.

Engine design, Tier III, and pilot fuel: biofuel use

Table 2 gives an overview of where and when biofuel use is accepted. All current engine designs are included and the biofuel should be according to specification and treated according to best practice guidelines and recommendations. The lifetime of components may be reduced as there is no long-term experience. Especially the fuel injection equipment lifetime may be reduced, see SL2022-726. Biofuels with a low calorific value and a low viscosity may be a risk factor for some of the fuel pumps and fuel injector designs.

Regulations regarding biofuel

NO_X compliance

IMO MEPC 79 has adopted a unified interpretation (UI) of MARPOL Annex VI, Regulation 18.3, permitting the use of biofuels and biofuel blends without assessment of NO_X emissions, provided the engine can be operated without changes to NO_X critical components or settings/operating values outside those given by the engine's approved Technical File.

The document (MEPC.1/Circ.795/7) [3] is available on IMO's homepage: Unified Interpretations to MARPOL Annex VI and the NO_X Technical Code 2008. Index of MEPC Resolutions and Guidelines related to MARPOL Annex VI (imo.org). Always refer to the latest revision.

For MAN B&W two-stroke engines operating on biofuels defined in this Service Letter, changes to NO_X critical components or settings/operating values outside those given by the engine's approved Technical File are not required. Furthermore, as always when changing fuel, it is the responsibility of the operator to ensure that the settings/operating values stated in the Technical File are fulfilled.

Accounting for biofuels in the Carbon Intensity Index

IMO MEPC 80 has adopted interim guidance on how to account for biofuels in the Carbon Intensity Index (CII), which will be applicable from 1 October 2023. The guidance can be found in MEPC 80/WP.11, Appendix 1, and it will be published later as an MEPC Circular on IMO's website.

Biofuels with a greenhouse gas (GHG) emission reduction of minimum 65% compared to a fossil MGO (marine gas oil equal to ISO 8217 DMA grade and part of ULSFO-DM grade) reference of 94 gCO2e/MJ on a well-to-wake basis, and which have been certified by a certification scheme recognised by the International Civil Aviation Organization (ICAO), may be assigned a C_f equal to the value of well-to-wake GHG emissions of the fuel according to the certificate (expressed in gCO2eq/MJ) multiplied by its lower calorific value (LCV, expressed in MJ/g). For blends, C_f should be based on a weighted average (by energy) of C_f of the respective number of fuels.

This interim guidance will be withdrawn when IMO Life Cycle Assessment (LCA) Guidelines have been further developed and agreed on at the IMO.

Overview of accepted biofuel use

	Biofuel			
Technology	**FAME**	**HVO**	**Similar FAME-type**	**Blends**
Engine design: MC/MC-C, ME/ME-C, ME-B, ME-GI, ME-GIE, ME-LGIM, ME-LGIP and ME-GA	Acceptable[1)]	Acceptable[1)]	Acceptable[1)]	Acceptable[1)]
Tier III: EGR, EcoEGR	Acceptable[1)]	Acceptable[1)]	Acceptable[1)]	Acceptable[1)]
Tier III: HPSCR[2)]	Acceptable[1)]	Acceptable[1)]	Acceptable[1)]	Acceptable[1)]
Tier III: LPSCR[2), 3)]	Acceptable[1)]	Acceptable[1)]	Acceptable[1)]	Acceptable[1)]
Pilot fuel in dual-fuel engines	Acceptable[1)]	Acceptable[1)]	Acceptable[1)]	Acceptable[1)]

1) Lifetime of components may be reduced.
2) Urea consumption may slightly increase due to potentially slightly increased NO_X during biofuel operation.
3) LPSCR is only for max 0.10% S fuels.

Table 2. Overview of accepted biofuel use regarding different technologies, e.g. engine design, Tier III equipment, and pilot fuel in dual-fuel engines. Check technology availability for specific engine sizes.

Biofuel analysis and standards

At the time of writing, there is no international marine fuel standard for biofuels. Until then other fuel standards as ISO 8217 and additional fuel analysis methods have to be used. Interpretations and evaluation of the results should be carefully made.

In the current ISO 8217:2017, HVO (up to 100%), and FAME (up to 7%) are included in certain distillate grades (Table 1 in ISO 8217:2017). FAME mixed with residual fuel is not included. There is no analysis method in ISO 8217:2017 for measuring FAME contents above 7%.

Note that insurances, warranties, and contracts may include clauses on ISO 8217 compliance and that biofuel may not be included in these. A fuel is considered to be ISO 8217 compliant if it adheres to the standard in its entirety. If a fuel has characteristics within the limits of, for example, Table 2 RM-grades in ISO 8217, but includes bio-components not covered in ISO 8217, then ISO 8217 compliance cannot be claimed.

Lower calorific value – net specific energy

The LCV, or the net specific energy (NSE), is normally stated in the fuel analysis report from the lab analysis. The energy content of the fuel is calculated from the properties of the fuel (density, water content, etc.) using the equations stated in ISO 8217 (annex H: Specific Energy). These equations are not valid for FAME or FAME blends. If the equation is applied for a biofuel, the resulting value will be higher than it is in reality. To know the energy content of the biofuel, the fuel must be analysed according to ASTM D240 (“Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter”).

It is important to adjust the engine according to the correct lower calorific value (energy content) for the engine to run efficiently. For 100% FAME-type fuels, the difference between a correctly measured value and a faulty calculated value, as according to ISO 8217 Annex H, can be as large as 10%.

Acid number

Acid number (AN, ASTM D664) and corrosive tendencies of fuels are complicated. Measuring the acid number can give indications of the presence of acidic compounds. Most fossil fuels have natural components with a measurable AN and the limits in ISO 8217 are based on this. Fuels with a high AN arising from acidic compounds may cause accelerated damage. Such damage is primarily found in the fuel injection equipment.

Fossil fuels made from naphthenic crude oils can have an acid number higher than 2.5 and still be acceptable for use. However, acid numbers below the limit values in ISO 8217 do not guarantee that a fuel is free from problems associated with the presence of acidic compounds. Currently, there is no recognised correlation between an acid number test result and the corrosive activity of a fossil fuel (ISO 8217:2017).

Biofuel differs from the above. Acids in FAME fuels typically originate from two sources: (i) acids used in the production of the biodiesel that are not completely removed in the production process; and (ii) as a product from degradation of the FAME. Free fatty acids may cause issues with corrosion in the fuel pumps. Excessive water can accelerate formation of acids and corrosion. Based on this, it is advisable to keep the acid number (value) as low as possible.

The fuel must be free from inorganic acids (strong acids) regardless of whether the fuel is petroleum- or bio-based, since there is a correlation between the presence of a strong acid and the corrosive activity of a fuel. The strong acid number [SAN] should be nil/0.

Lubricity

MAN Energy Solutions has adopted the limits in ISO 8217 which are most relevant for **fuels with sulphur contents lower than 0.05% S (500 ppm S)**. The lubricity limit, high-frequency reciprocating rig (HFRR) wear scar, is max. 520 µm (ISO 8217:2017). Note! You may have to ask for the lubricity to be measured at the laboratories.

Fuel analysis – considerations

1. At the time of blending, the FAME should comply with the requirements of EN 14214 or ASTM D6751.
2. Analyse the type and the amount of bio-component. E.g., FAME, 30%
3. Analyse the final fuel according to a full ISO 8217 analysis, which includes, but not limited to, below characteristics:
    a. Viscosity
    b. Cold-flow properties
    c. Water content
    d. Ash content
    e. Chemical elements (e.g. phosphor (P) and calcium (Ca), and potassium (K) should be included).
    f. Acid number for distillate (incl. HVO) and residual fuel, and acid value (for 100% FAME).
        i. The AN should be low. The AN of the biofuel part should fulfill EN14214 or ASTM D6751.
        ii. HVO as according to DMA-grade in ISO 8217:2017 or latest edition.
        iii. Measured according to ISO 8217 for biofuel blends and HVO, and according to EN 14214 (or ASTM D6751) for 100% FAME.

   g. Lubricity (if the fuel contains less than 0.05% S) according to ISO 8217.
4. Lower calorific value – use the measured value (ASTM D240).

Technical and operational guidelines, and recommendations

Before starting biofuel operation, ensure that the engine and associated systems are in good working condition and suited for biofuel operation. Prepare the crew and the ship in advance. The crew should know that a new type of fuel will be bunkered, so that they can prepare appropriately.

Materials

FAME and other biofuels may not be compatible with all materials and elastomers. The materials and elastomers (Teflon or Viton type) used in the high-pressure fuel system on the engine are compatible with FAME, FAME-type fuels, and HVO. We recommend checking that elastomers (sealing material) and materials in the fuel oil auxiliary system are compatible with the biofuel or biofuel blend.

Equipment

Since biofuels often have a low viscosity, it is important to check that the fuel system and the fuel injection system are in a good, acceptable condition (see SL2022-726).
If the high-pressure fuel pumps are heavily worn and the fuel has a very low viscosity, i.e. leading to a high drain leakage (SL2019-670), individual cylinder units may not be able to reach the peak load. This is especially important for MC and MC-C engines.

Biofuel may have a lower LCV (MJ/kg) than normal marine distillate fuel. Therefore, it should be evaluated whether the fuel oil supply pump capacity is sufficient or an increased capacity is needed. The assessment can be carried out using Eq. 1.

Installed fuel oil pump capacity [m^3/h] > $SFOC_{100\%} \times Power_{100\%} \times [42.7/(density_{bio} \times LCV_{bio})] [m^3/h]$ Eq. 1

- $SFOC_{100\%}$ [g/kWh] – specific fuel oil consumption at 100% load
- $Power_{100\%}$ [kW] – power at 100% load
- 42.7 kJ/g is the LCV_{ref}, the lower calorific value for the reference fuel: 42,700 kJ/kg / 1000 g/kg = 42.7 kJ/g
- $Density_{bio}$ is the density of the biofuel or biofuel blend [kg/m^3]
- LCV_{bio} is the lower calorific value for the biofuel or the biofuel blend [kJ/kg]

Compare the installed fuel oil pump capacity [m^3/h] with the calculated value. The installed pump capacity is sufficient, if it is larger than the calculated value. The capacity of the existing pump may be reduced due to age and wear, which should also be considered in the overall evaluation of whether the pump capacity is sufficient or not. Note that Eq. 1 can be used for an assessment only and not for design purposes.

If the fuel pumps are heavily worn, or other equipment is not working acceptably, it is, as always, recommended to carry out maintenance.

Fuel management

General good practice for fuel management processes should be implemented. The considerations, preparations, and procedures used for biofuel are basically the same as for ULSFO and VSLFO operation.

Before testing a new type of fuel, it is important to understand the concepts of viscosity, temperature, cold-flow properties, and how to manage fuel on board. Information is available in the paper “0.50% S fuel operation 2020” [1]. (https://www.man-es.com/marine/products/planning-tools-and-downloads/technical-papers)

Performance

Common FAME or FAME-type fuels have a heating value of around 36–37 MJ/kg. This can be a challenge for the engines, which cannot automatically adjust the intended injection quantity at a given engine load to compensate for the lower calorific value of the fuel.

FAME blends, for example B30, give a smaller difference in heating value. The same effects are still valid, but the impact will be significantly smaller for the blends compared to B100.

ME engines

1. Key in the correct LCV (NSE) in the engine control system (ECS) – use the measured value (ASTM D240).
2. Optimise and monitor the engine combustion using the autotuning feature, if available, in the ECS. It may help to automatically adjust the engine in response to changes in the fuel. (Contact PrimeServ: DT-CPH@man-es.com for more information.)
   a. The newest autotuning control feature ACCo might not be able to handle 100% biofuel (FAME), since the heating value of the biofuel could be too low for the standard settings. The ACCo can then be set to manual, and care must be taken to keep the performance parameters as stated in the Technical File.

MC and MC-C engines

1. If necessary, adjust the fuel pump timing (injection timing) to ensure that the correct maximum cylinder pressure is attained.
2. Adjustment of limiters in the governor may be needed if the LCV is low. The lower LVC is compensated for by the governor which increases the fuel index to maintain the requested RPM.
3. Verify the maximum operating load and engine-out smoke emissions when operating on a biofuel.
4. If MAN Energy Solutions' engine power limitation (EPL) is installed, the maximum power may be reduced when a fuel with a low calorific value is used.

Tanks and pipe systems

1. Fuel tanks should be cleaned/stripped or at least emptied as much as possible before bunkering biofuel.
   a. This is to avoid any compatibility issues.
   b. If fuels are mixed – ensure that the fuels are compatible.
2. Adjust the temperature in the fuel tank and fuel system to a suitable temperature for the fuel.
   a. Check the viscosity and cold-flow properties and adjust the system accordingly.
   b. The fuel temperature should be kept minimum 10°C above the pour point.
3. Remove water by ensuring that excess water can be drained.
   a. Removing water decreases the risk of microbial growth and the risk of fuel instability.
4. Fuel filters – monitor the flow. Suitable, stable, and normal flow should be obtained.
5. Fuel cleaning – always important and should be done. See SL2017-638.

Viscosity and temperature

The recommended biofuel viscosity range for MAN B&W two-stroke engines at engine inlet is shown in Table 3, which is from SL2019-670.

Recommended biofuel viscosity

Range	Biofuel viscosity at engine inlet
Minimum	2 cSt
Normal (HVO, 100% FAME, FAME or HVO blends with DM grade)	3 cSt or higher
Normal (FAME blends with RM grade, similar FAME-type)	3–18 cSt
Maximum	20 cSt

Table 3. Recommended biofuel viscosity at the engine inlet

Always refer to the latest specification for the specific engine type. Suitable fuel injection temperature and viscosity need to be established. It may not be the same as for an equivalent fossil fuel.

Cylinder lubrication

The currently used cylinder oil and feed rate can be kept as a starting point, if the cylinder condition is acceptable for normal VLSFO and ULSFO operation.
Subsequent adjustments in cylinder oil type and feed rate may be necessary based on scavenge drain oil analyses and scavenge port inspections. It is recommended to carry out scavenge port inspections before and after biofuels usage, or when required by the operating conditions.
Refer to the latest lubrication guidelines, at the time of writing these are: SL2023-737 and SL2023-738.

Liner temperatures could potentially increase slightly because of the longer injection duration. Careful drain oil monitoring is recommended to avoid potential issues.

Nevertheless, it remains the responsibility of the owner/operator of an engine to ensure that suitable fuels and lubes are conditioned and used to prevent damage to the engine and other equipment on board.

References

1. MAN Energy Solutions, Detailed information on Preparation and Operation on fuels with maximum 0.50% sulphur.
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2. ISO 8217:2017 Sixth edition. "Petroleum products – Fuels (class F) – Specifications of marine fuels". Use the latest issued edition.
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