VPS ARTICLE

Effect of FAME Contamination on Engine Oils

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Engines running on Bio-blends containing Fatty Acid Methyl Esters (FAME), especially pure FAME, e.g. 100% FAME can experience decreased engine oil viscosity over time.

Fuel oil contamination in engine lubricants is a known phenomenon, and most marine-grade engine oils are formulated to tolerate certain levels of such contamination while maintaining operational performance.

The impact of FAME contamination is more pronounced in four-stroke trunk piston engines due to their design and operational characteristics. These engines use a common oil sump for both crankcase and cylinder lubrication, making them more vulnerable to fuel ingress through injector leaks or blow-by gases. Unlike two-stroke crosshead engines, which have separate lubrication systems that limit fuel-oil interaction, four-stroke engines continuously recirculate the same oil, allowing FAME (which has a high boiling point and low volatility), to accumulate over time. This leads to a more significant reduction in oil viscosity and faster degradation of lubricating properties.

A typical SAE (Society of Automotive Engineers) 30 grade engine oil has a viscosity of about 90 to 110 cSt at 40°C and a B100 (100% FAME) or its fossil counterpart such as DMA (distillate fuel) has a viscosity in the range of 4 cSt at 40°C. Any contamination of the fuel (distillate or Bio distillate blends contain FAME) into the used engine oil can therefore significantly reduce the viscosity of the used engine oil.

Most OEMs specify both minimum and maximum viscosity limits for engine oils, beyond which the engine must not be operated to avoid wear or lubrication failure. For example, a common condemning limit is a 25% reduction in viscosity at 40°C from the fresh oil value. In the case of an SAE 30 grade oil (with a typical fresh viscosity of around 90 cSt at 40°C), this corresponds to a minimum allowable limit of approximately 67 cSt.

When comparing the viscosities of distillate fuel and B100, there is no significant difference (both typically range between 3 to 5 cSt at 40°C). However, a noticeable drop in engine oil viscosity is not usually observed when engines operate on conventional distillate fuel. This is likely due to the higher volatility and lighter fractions present in fossil fuels, which tend to evaporate over time. Additionally, the routine top-up of fresh oil during engine operation, needed to compensate for losses from evaporation and leakage, helps maintain a more stable overall oil viscosity. As a result, the dilution effect is minimised, and the lubricating oil retains its properties for a longer duration compared to operation on B100.

Distillation Behaviour Analysis of FAME

ISO 3405 is an international standard that outlines a laboratory method for determining the distillation characteristics of petroleum and related products at atmospheric pressure. This tests helps us to understand the composition and behaviour of fuel during storage and use including the tendency to form vapours.

Typically in this method, the sample is distilled under controlled conditions. Throughout the distillation, the temperature at which specific volumes of the sample evaporate is recorded. Key measurements include, Initial Boiling Point (IBP) -Temperature at which the first drop of condensate is collected, Final Boiling Point (FBP) -Temperature at which the last drop of liquid evaporates and temperature at Specific Recovery Percentages, temperatures corresponding to 10%, 50%, and 90% volume recovery, among others. The collected data is used to construct a distillation curve, which illustrates the boiling behaviour of the sample.

In order to understand this phenomenon we compared the distillation characteristic of a 100% FAME (B100), 30% FAME (B30) and pure straight run distillate fuel using the ISO 3405 method. Below is a graph illustrating the differences in the distillation characteristics.

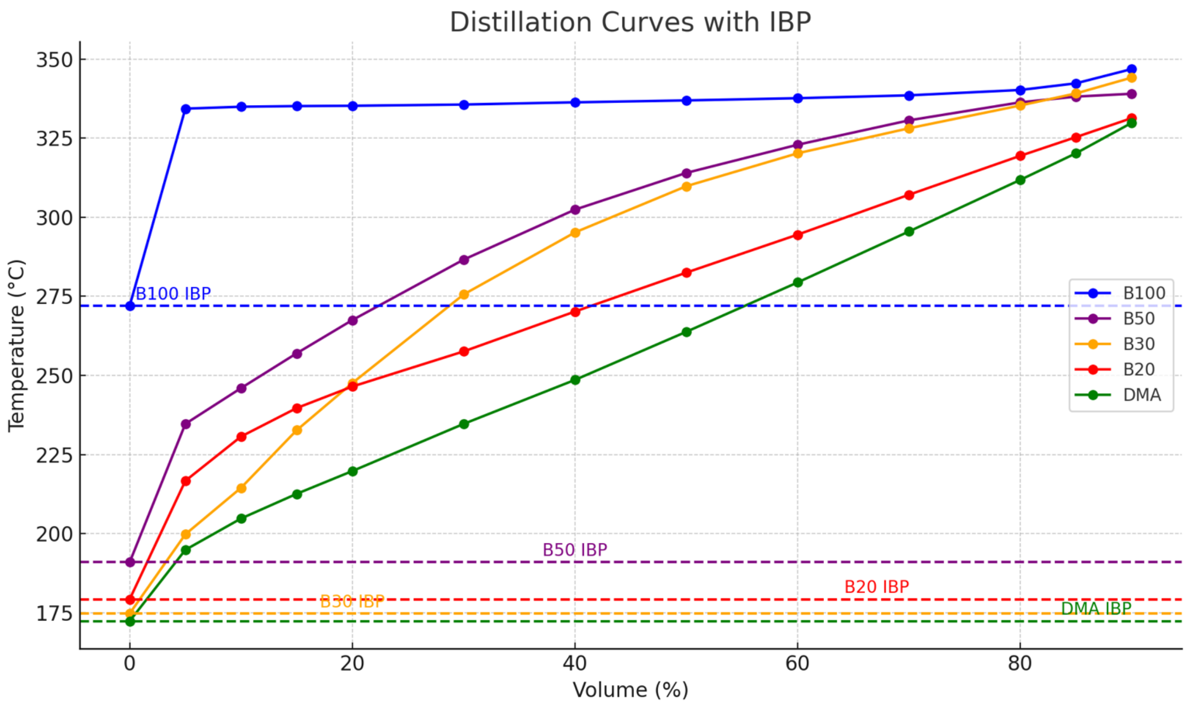

Figure 1: Distillation curves of 100%, 50%, 30% and 20% FAME along with 100% DMA

Initial Boiling Point

From the above figure we can see that a B100 has a very high IBP as compared to a B30 and Distillate fuel.

B100: ~272°C	High — FAME starts evaporating late, indicating low volatility.
B30+DMA70: ~175°C	Blend behaviour — initial light fractions (from DMA) start boiling early.
100% DMA: ~172°C	Volatile — begins boiling almost immediately.

Impact – Higher IBP in B100 means relatively poor cold start and atomisation; DMA ignites easily

Shape of curve and implication

B100	Flat and elevated	Narrow boiling range, all components are heavy.
B30	Gradual and intermediate	Balanced volatility — mix of light and heavy fractions.
DMA	Steep rise from early stage	Broad volatility, good combustion over temperature range.

Impact: B100 may cause issues in engines designed for distillates due to poor vaporisation. Due to the heavy components in the B100 any fuel oil that is leaked into the sump, remains in the sump oil and does not easily evaporate where as in the case of DMA or (B30) the lighter fractions evaporate. This means the vessel may witness a reduction in the topping-up of fresh oil when a B100 is used, as the sump oil may tend to rise due to the FAME contamination.

B30 offers a compromise, cleaner burn than B100, whilst DMA gives optimal performance in terms of ignition and combustion.

Case study

VPS examined a few vessels operating on B100 for extended periods of time, in order to monitor the reduction of viscosity and relationship with FAME contamination. The study includes tests that were carried out on four-stroke auxiliary engine oils (SAE 40) over a period of two years' operating on B100.

The below graph shows a comparison of change in viscosity over the given time period.

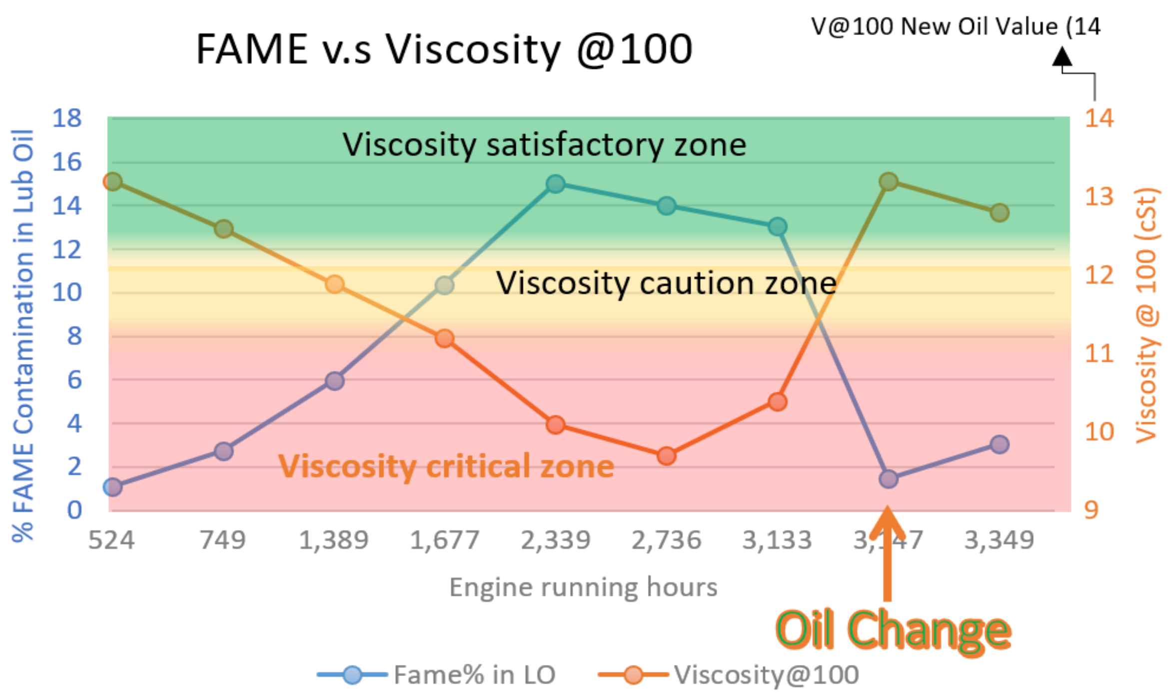

Figure 2: Decreasing viscosity with increase in FAME dilution.

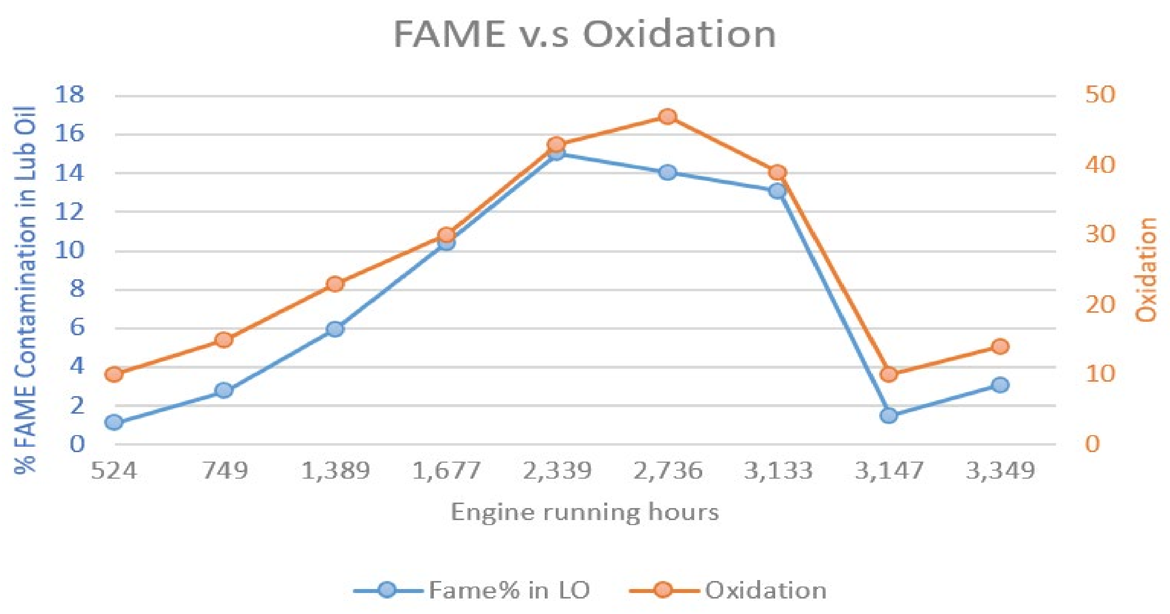

Figure 3: Increasing oxidation (oil degradation) with increase in FAME dilution.

Due to the above stated impact of FAME on engine oil, measuring the FAME in used engine oil when operating on Bio blends with FAME becomes very critical.

FAME Detection in Lubricating Oil

FAME content is routinely measured in distillate fuels using techniques such as Nuclear Magnetic Resonance (NMR) , chromatography and FTIR (Fourier Transform Infrared Spectroscopy).

FTIR detects FAME by its characteristic absorption band at around 1745 cm^{-1}, which is due to the ester carbonyl bond.

This bond is absent in hydrocarbon distillate fuels and the same principle can be applied to petroleum-based lubricants.

The FAME content of a petroleum based lubricating oil can be found by measuring the carbonyl bond around 1745 cm^{-1}.

Since there are typically no overlapping bonds with the lubricating oil, the percentage FAME content can be calculated from a typical Lambert-Beer law calibration curve.

FTIR offers high speed, repeatable determinations requiring very little sample preparation.

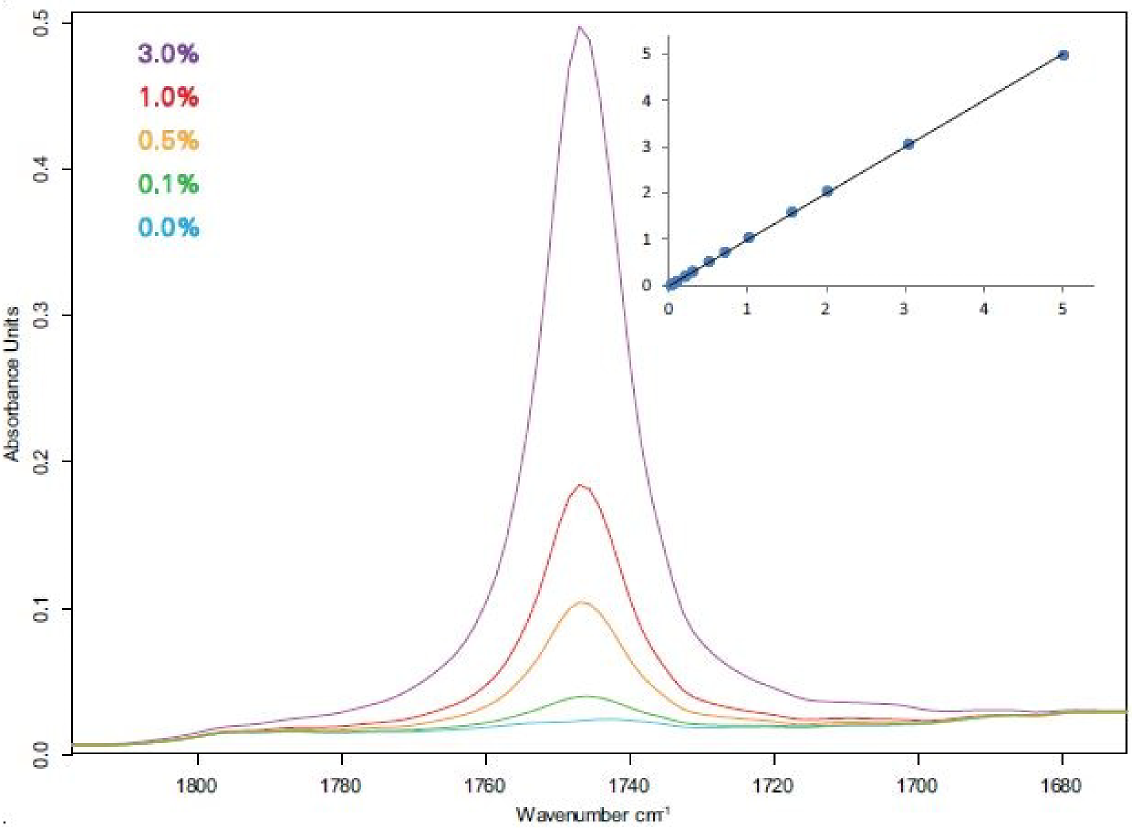

Figure 4: Percentage FAME content calculated from a typical Lambert-Beer law calibration curve.

VPS recommends that vessel operators using Bio blends containing FAME routinely monitor the FAME content in the engine oil and take appropriate measures to maintain the lubricating oil quality.

Mitigation and Preventive Measures:

To mitigate the effects of FAME contamination in engine oils, operators should implement routine monitoring of oil viscosity, oxidation, and FAME content using FTIR analysis. This allows early detection of degradation and helps adjust oil change intervals based on actual condition rather than fixed hours. Maintaining fuel injector integrity is essential to reduce fuel ingress, and operators should review OEM viscosity limits in light of operational experience with biofuels. Together, these steps help preserve lubricant performance and protect engine components when running on high-FAME or pure biofuel blends

Key Takeaways

Engines operating on B100 biofuels are more susceptible to rapid oil viscosity degradation due to FAME dilution. Unlike conventional fuels, FAME does not evaporate easily, leading to cumulative effects. Proactive monitoring, using FTIR-based FAME quantification, and adjusting maintenance schedules accordingly, are essential to mitigate the operational risks associated with biofuel use in four-stroke marine engines.

For further information and support regarding the use and effect management of lubricating oils when using FAME-based biofuels and your general oil condition monitoring requirements, please contact: marketing@vpsveritas.com