Predicting compatibility of VLSFO fuels

VLSFO's sensitivity to mixing will likely result in more cases of incompatibility, affecting suppliers and owners alike

Overview

Compatibility of residual bunker fuels has always been relevant. Mixing fuels onboard is often considered bad practice, however it is generally unavoidable.

Instances of HSFO incompatibility have been relatively rare in the past, given the mostly similar nature of different HSFO streams. This is not going to be the case with VLSFO. With varying nature and quality parameters, these fuels are particularly sensitive to mixing, which will likely result in more instances of incompatibility, affecting fuel suppliers and owners alike.

As part of IMO2020 preparation, Integr8 Fuels conducted a study where VLSFO samples were gathered from various suppliers across the world. Knowing individual fuel properties, a theoretical methodology was used to assess stability of a blend of two different VLSFOs without testing the actual blend. Such a methodology could prove to be extremely helpful for bunker procurement going into 2020 and beyond.

In order to confirm the accuracy and practical usefulness of this methodology, each case of predicted compatibility was compared with actual physical compatibility tests, which involved mixing the fuels in question to see how they react with each other. The study concluded that the proposed methodology can be used to predict compatibility with a high level of accuracy and be a very useful tool for buyers of VLSFO.

Why does commingling occur?

To a certain degree, commingling is unavoidable and the risks of commingling occur even if the bunker tanks have been emptied, as sludge and un-pumpable volumes may still be present.

Mixing fuels can happen at different stages in the vessel's fuel system – in storage, settling or service tanks. While it is often not possible to avoid mixing in service tanks, most owners try to avoid mixing in storage tanks. According to our survey of common practices, some owners allowed up to 20/80 percent HSFO commingling in storage tanks for economic and operational reasons.

The risks of commingling and the varying nature of VLSFO

The main, but not the only risk of commingling, is associated with asphaltene sludge formation. This can happen when two perfectly stable fuels are mixed together creating an unstable blend.

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Unlike HSFO, VLSFO's nature and specs are expected to vary greatly. Different suppliers will offer different fuels with a paraffinic, naphthenic or aromatic predominant base. Mixing such fuels may produce an unstable blend in which asphaltene separation occurs. This can result in clogged filters and separators and in extreme cases lead to engine power loss.

Buying VLSFO of similar nature could help minimise compatibility issues, but our study shows that even fuels of the same nature may pose compatibility challenges if mixed.

How is stability of a blend of fuels ensured today?

There are two main tests that cover stability: the spot test and the Total Sediment Potential (TSP) test. The spot test can be done onboard the vessel, but the more thorough reference test (TSP) is done in the lab normally taking over 24 hours to get the result.

Due to the nature of bunker operations it's often not possible to pre-test the fuel before taking it onboard, and even less so before fixing the stem — i.e. entering into a contractual obligation to buy it.

Integr8 Fuels compatibility study of VLSFO

This compatibility study is based on using a method to predict the ability of a blend of two VLSFOs to keep asphaltenes in suspension and, therefore, not allowing for sludge formation.

Sixteen VLSFO samples of different nature were collected for the study from various suppliers and main locations (Figure 1). These samples resulted in 120 blend combinations (50/50 ratio) to test the method on.

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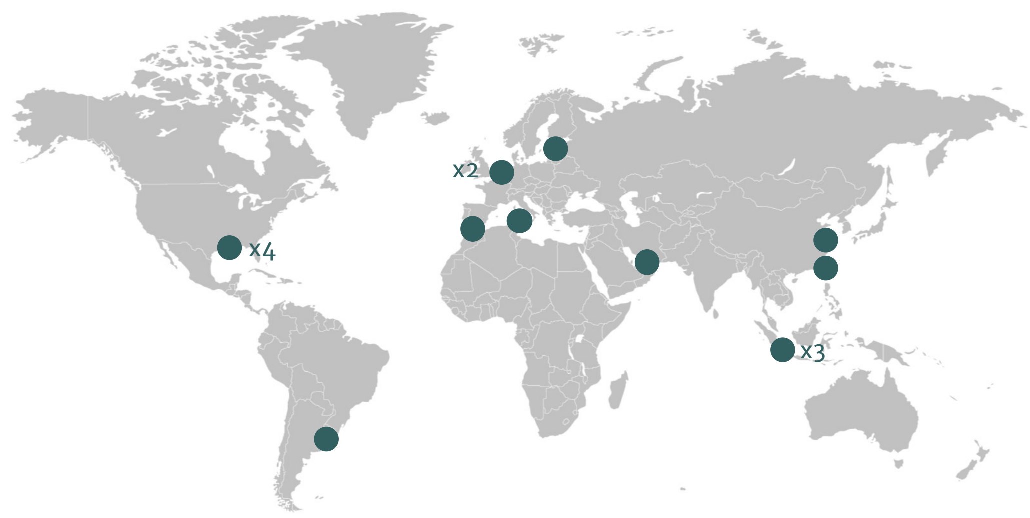
Figure 1 | **Worldwide scope of the sampling procedure**



The study results showed that around 18% of the blends were unstable, meaning the individual fuels forming those blends were incompatible with each other

ISO8217 was performed on each sample, together with the following additional tests that are necessary for the compatibility prediction methodology utilised:

- Asphaltene content
- Actual level of aromaticity (ALA) — calculated from viscosity and density
- Minimum required level of aromaticity (MRLA) to keep asphaltenes suspended

An individual fuel or a blend is deemed stable provided there is a certain buffer between ALA and MRLA. For individual fuels, the greater the buffer the greater the fuel's capacity to mix with other fuels keeping asphaltenes in suspension.

If asphaltene content, ALA and MRLA are known for the individual fuels to be mixed then, once the proportion of each fuel in the mixture is determined, the expected ALA and MRLA of the blend can be calculated using a formula.

In order to confirm the accuracy of the proposed methodology, physical compatibility tests were performed on the blends, i.e. the spot test and TSP. The predicted results were then compared with these actual physical test results.

Preliminary results

The accuracy of compatibility predictions was high

Theoretical compatibility was run on all 120 blends, with confirmatory physical spot and TSP tests performed on 17 randomly selected blends. Physical tests showed that around 18% of the blends were unstable, meaning the individual fuels used to produce the mixture were incompatible with each other. This result highlights the importance of methodologies that can predict fuel compatibility, as the likelihood of two VLSFOs being incompatible is rather high.

Table 1 summarises the results of the tests conducted, which show that the level of accuracy reached is high, having obtained only one false incompatible result — i.e. the methodology predicted fuels to be incompatible, when they could be mixed and remain stable — and no false compatible results — i.e. the methodology predicting fuels to be compatible, when they actually turned out to be unstable when mixed.

The robustness of the methodology comes from its ability to highlight instances where supposedly compatible fuels would in reality be incompatible

Table 1 | ***Compatibility prediction results***

Result	*True*	*False*	*Total*
Incompatible	3	1	*4*
Compatible	13	0	*13*
Total	*16*	*1*	*17*

From a risk management perspective, the robustness of the methodology comes from its ability to highlight instances where supposedly compatible fuels would in reality be incompatible. The methodology used requires further testing and calibration, but these preliminary results are very promising.

Working on the basis of standard ISO8217 testing

The methodology presented appears to have a great ability to predict compatibility of different fuels, but always provided these three additional properties — asphaltenes, ALA and MRLA — are tested along with ISO8217.

An interesting side result of the study is that some ISO8217 properties can be used as indicators of potential compatibility between different fuels. None of these have the predicting power of the methodology presented above, but they can still be used for compatibility guidance in the absence of extended testing.

It was noted during the study that there is a strong correlation between the asphaltene content and Micro-Carbon Residue (MCR). Figure 2 demonstrates the correlation, which shows that higher MCR was associated with the higher asphaltene content.

There seems to be a strong correlation between the asphaltene content and Micro-Carbon Residue (MCR)

Another interesting relationship between variables that arose from the study is that between ALA (Aromaticity Index) and density (Figure 3). Even though ALA is calculated from viscosity and CCAI (which is calculated from density and viscosity), data shows that viscosity plays a minor role and higher density VLSFOs can be associated with higher ALA fuels.

Figure 2 | Asphaltenes and MCR correlation

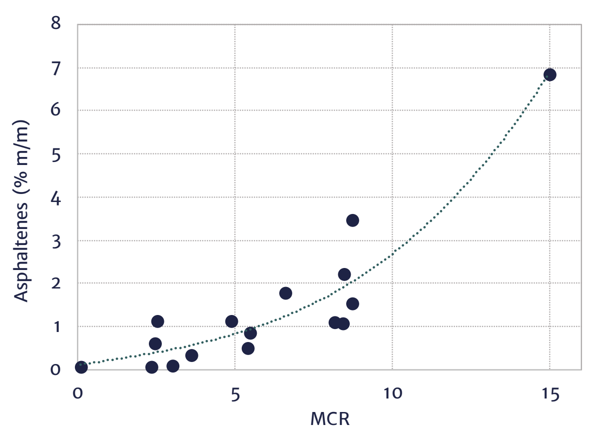
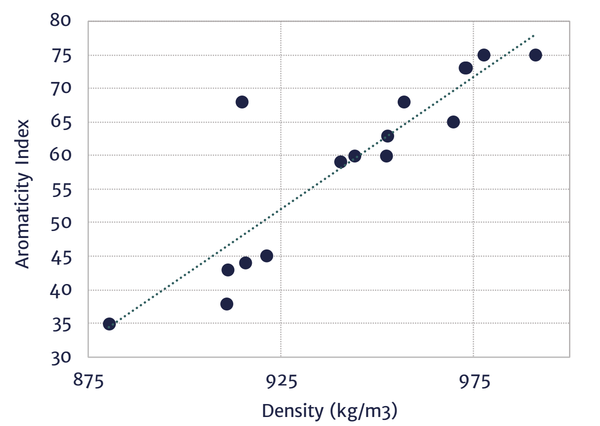


Figure 3 | Aromaticity Index and density corrlation



Data shows that higher density of VLSFO can be associated with higher aromaticity (ALA)

Based on these correlations, the following general guidelines can be set based on the test results of the standard ISO8217 fuel testing:

- The higher the MCR, the higher the asphaltene level of a fuel and the higher ALA will be required to keep asphaltenes in suspension.
- Fuels with higher density will likely have higher ALA and, presumably, the higher capacity to hold asphaltenes in suspension.
- In absence of any other information, and only for guidance purposes, it may be concluded that higher density / lower MCR fuels will tend to be more versatile in terms of mixing, than lower density / higher MCR fuels.

The study shows that it is possible to predict blend stability with high accuracy using additional testing

Conclusion

Compatibility is a cause of great concern for owners as VLSFO has proven to be more prone to stability issues when mixed, than its high-sulphur counterpart, which rightfully increases owners' concerns.

The study shows that it is possible to predict blend stability with high accuracy using additional to ISO8217 testing. In this regard, Integr8 Fuels will continue expanding its sampling program and testing the methodology to help owners navigate the new bunker space.

The proposed methodology is dependant on having additional properties tested, even though the study found a correlation between some of the additional properties and the standard ISO8217 set. In this regard, the following suggestions can be made to owners who rely on ISO8217 tests only:

- Paraffinic fuels (lower ALA) will encounter trouble mixing with more aromatic counterparts (higher ALA), as the total aromaticity of the mixture will be reduced. As shown, density can be used as a proxy to ALA, and guide judgment in this regard.
- Fuels with higher asphaltenes may be prone to forming asphaltene sludge once mixed, as the buffer between ALA and MLRA (which is in part a function of asphaltenes level) may be reduced. As shown, MCR can be used as a proxy to asphaltene content, for guidance purposes.
- Fuels with higher aromaticity (likely to present higher density) and lower asphaltene content (likely to present lower MCR), are in principle safer to mix, as there should still remain enough buffer between ALA and MLRA to keep the asphaltenes in suspension.

Integr8 Fuels have invested heavily in building the largest pool of fuel quality data to help owners in making informed decisions

VLSFOs' lower tolerance to comingling calls for better bunker planning. Owners should always consider options from different suppliers and, where possible, try to ascertain the nature and quality of the fuel before fixing or delivery.

Quality and compatibility have gone from a problem to face once fuels have been delivered onboard, to a problem better dealt with at the point of purchasing. Integr8 Fuels have invested heavily in building the largest pool of fuel quality data to help owners in making informed decisions.