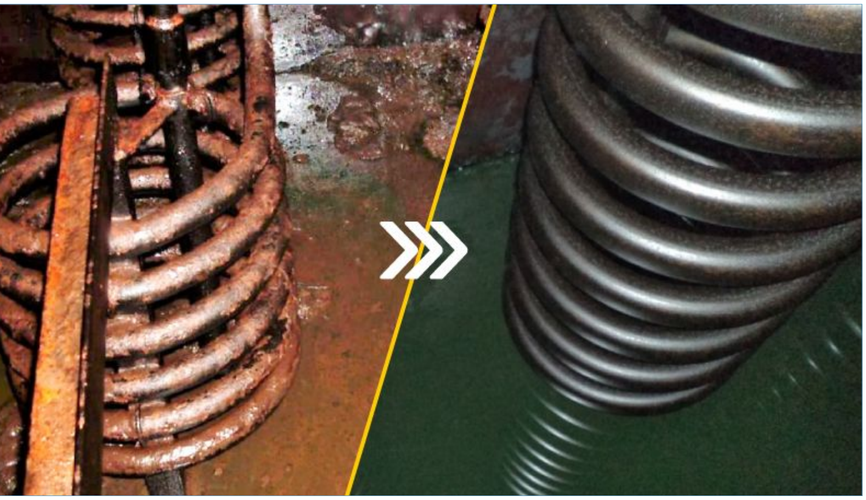
SOLVING FUEL COMPATIBILITY PROBLEMS

ON JANUARY 1, 2020 MARPOL regulations have forced virtually the entire global marine industry to have made a tough choice: stick with HFO and install expensive sulphur scrubbers and become floating chemical processing plants, or switch to more costly low sulphur distillate blends.

Yet simply switching to distillate blends such as low sulphur marine gas oil (LSMGO) is not without problems. The property of a fuel to keep asphaltenes dispersed is known as aromatic or stability reserve. When aromatic based fuels with high asphaltenes are mixed with parafinnic-based fuels or cutter stocks, the fuel's stability reserve can be disturbed. Asphaltenes begin to flocculate, eventually leading to precipitation and the formation of sludge. High molecular weight paraffins or waxes may also precipitate and more fuel is lost to sludge. The presence of oxygen and saltwater contribute to a highly corrosive sludge, further destabilizing the fuel.



Excessive sludge often forms in fuel tanks when different fuel types are mixed. When combined with saltwater, the sludge becomes a corrosive brew leading to higher fuel system maintenance and combustion problems, as well as increased rates of metal loss.

The *M/V Paivi* first started using **XBEE** in 2012 to resolve a sludge problem caused by incompatible IFO 180 bunkers. In 2016 she was brought into dock to have her fuel tank cleaned in preparation for switching from HFO to MGO.

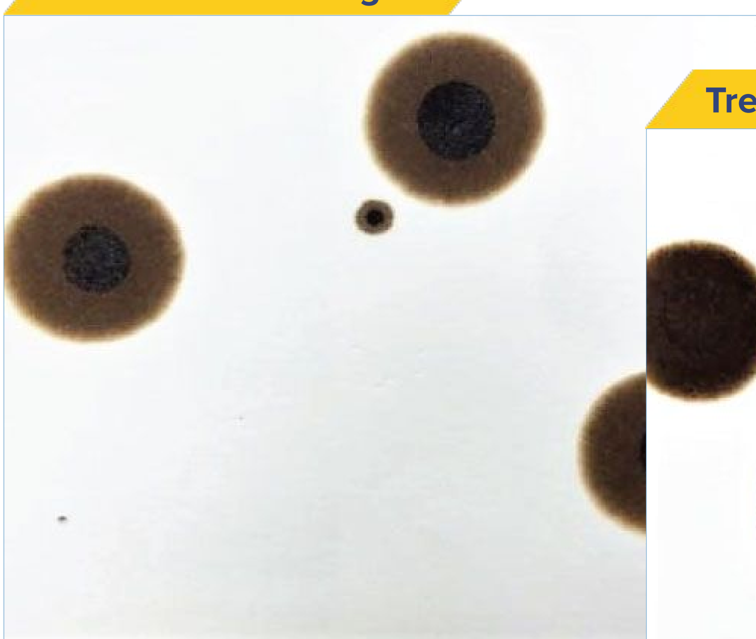
According to Mr. Rolf Laufer, Technical Superintendent of Interscan Schiffahrt, after inspection, it turned out the *M/V Paivi*'s fuel tanks did not need cleaning. Reducing sludge saves time and money, especially for those vessels requiring mechanical tank cleaning prior to switching over to distillate fuels.

Stability test by Intertek

Fuel instability often occurs when the aromatic solvency of the fuel is disturbed, typically by paraffinic solvents used as cutter stocks, or fuels based on paraffinic crudes. Bunkers from different fuel sources may separately pass ISO 8217 certification tests, yet when blended and subjected to age and heat on board the vessel, the bunkers become incompatible. Heavy sludge affects the fuel system, causing increased maintenance costs and operational problems.

ASTM D 4740 measures fuel compatibility and resistance of mixed fuels to form sludge under a ship's high-temperature fuel handling conditions. Demonstrated in this test by Intertek Caleb Brett laboratory in California, USA, a mixture of 3.5% sulphur HFO 380 bunker samples that were initially ISO 8217 compliant, but when aged and mixed, became highly unstable, **XBEE** enzymes improved the compatibility rating from an unusable "5" to a usable "2 to 3".

Neat fuel · Rating 5



Treated fuel · Rating 3

Stability test by Intertek

In February 2019, Intertek Caleb Brett was commissioned to study our enzymes' effects on improving stability in unstable HFO. To simulate a realistic shipboard fuel scenario of blended fuels with different ages, five individual 1-litre and 750-ml laboratory retains from five different bunkering operations were acquired from a California fuel jobber. Fuel certifications (ISO 8217-2017) had been performed between February 2018 and August 2018. The HFO came from a sole source. The refinery and crude oil source is not known.

The five samples were blended together, totalling approximately 3.8 litres. An additional 200 ml of an aged IFO 380 sample from a different vendor was added. The total volume was approximately 4 litres. The fuel samples were mixed and delivered to Intertek. The Laboratory split the fuel into two equal portions, and additized one sample at 0.5 ml (~4,000:1). The fuel was set aside for one week.

The primary goal of this test was to create a blend of HFO that was unstable due to commingling of different batches of different aged fuels, in order to determine what characteristics **XBEE** is likely to improve, at the most economical dose rate.

The most remarkable response was the ASTM D 4740 Compatibility rating going from a "5" to a "3". This indicates the blended fuel went from being unsafe to use to being safe to use, but with warnings to not overheat the fuel. Ratings can be subjective, as there are no fractional ratings. The "5" for the neat fuel is obvious. The treated fuel falls in between "2" and "3". As it does lean closer to "3" (not easily visible in the photograph), the rating must go to the higher number. (See images, chart, and description below.)

The other notable change was ASTM D 445, which is viscosity. The neat fuel was 374.3 cSt, and the treated fuel was 357.7 cSt. This represents a 4.5% reduction in viscosity, with no reduction in fuel density.

Stability test by Intertek

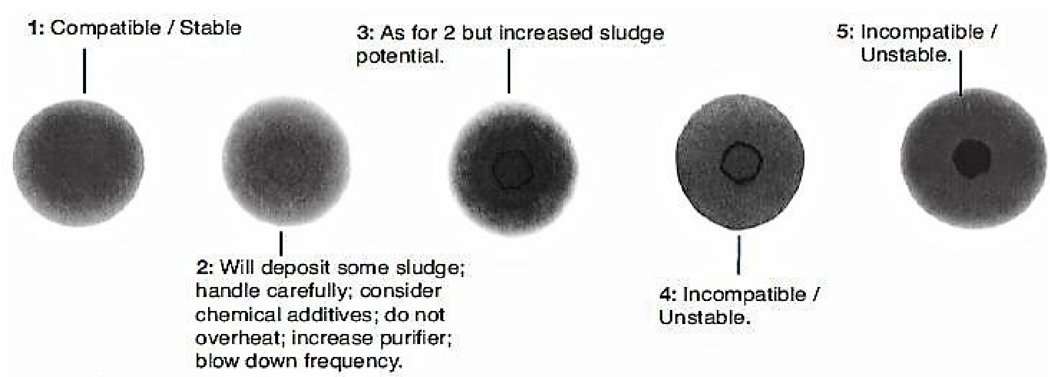
Other results of interest include:

- ASTM D 664: a 12% reduction in acidity
- ASTM D 6560: a 3% reduction in asphaltenes
- ASTM D 482: a 45% reduction in ash

These fuel characteristics are known to contribute to fuel instability, sludge formation, corrosion, and injector fouling or even injector damage. While these are small improvements, collectively they are all contributing factors towards the total improvement of this fuel blend.

CONCLUSIONS

In this study, **XBEE Enzyme Fuel Technology** greatly improved the compatibility and stability in an unstable HFO blend. For shipboard applications, **XBEE** can significantly reduce sludge formation due to commingling and aged fuel, and improve fuel system function and engine cleanliness. (Following are photographs of the ASTM D 4740 compatibility spot tests, as well as the full Intertek Caleb Brett Report of Analysis.)



Annexes

Original report

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Report of Analysis

Client: GTR, Inc.
Job Location: Los Angeles, CA, USA
Vessel: GTR, INC.
Our Reference Number: US260-0027747
Lab Reference Number: 2019-LOSA-000149

Client Reference Number:
PO# 477683

Description	Method	Test	Result	Units
HFO 04-Feb-2019 Submitted Fuel Oil (Neat)				
2019-LOSA-000149-001	ASTM D4740	Compatibility Rating	5	
	ASTM D4052	Density @ 15°C/59°F	0.9738	g/mL
		API Gravity @ 60°F	13.8	°API
	ASTM D4530	Average Micro Method Carbon Residue	13.6	Wt %
	ASTM D4294	Sulfur Content	2.58	Wt %
	ASTM D482	Ash	0.096	Wt %
	ASTM D95	Water Content	0.1	Vol %
	ISO 10307-2	Accelerated Total Sediment by Hot Filtration	0.01	% (m/m)
	ASTM D97	Pour Point	-9	°C
		Pour Point	15.8	°F
	ASTM D93	Procedure Used	B	
		Corrected Flash Point	87.0	°C
		Corrected Flash Point	189	°F
	ASTM D664	Procedure Used	A	
		Acid Number	0.33	mg KOH/g
	ASTM D445	Kinematic Viscosity 50 °C	374.3	cSt
	IP 501	Aluminium	10	mg/kg
		[1] Silicon	9	mg/kg
		Sodium	14	mg/kg
		Vanadium	212	mg/kg
		Calcium	11	mg/kg
		Zinc	4	mg/kg
		Aluminium + Silicon	19	mg/kg
	ASTM D6560	Asphaltene Content	10.7	Wt %
	ISO 8217 F	CCAI	805.3	
	IP 570	[1] Hydrogen Sulfide Content	0.00	mg/kg
HFO 04-Feb-2019 Submitted Fuel Oil (with 0.5 ml Soltron)				
2019-LOSA-000149-002	ASTM D4740	Compatibility Rating	3	
	ASTM D4052	Density @ 15°C/59°F	0.9738	g/mL
		API Gravity @ 60°F	13.8	°API
	ASTM D4530	Average Micro Method Carbon Residue	13.4	Wt %
	ASTM D4294	Sulfur Content	2.57	Wt %
	ASTM D482	Ash	0.053	Wt %
	ASTM D95	Water Content	0.1	Vol %
	ISO 10307-2	Accelerated Total Sediment by Hot Filtration	0.01	% (m/m)
	ASTM D97	Pour Point	-9	°C
		Pour Point	15.8	°F

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Report of Analysis

Description	Method	Test	Result	Units
	ASTM D93	Procedure Used	B	
		Corrected Flash Point	87.0	°C
		Corrected Flash Point	189	°F
	ASTM D664	Procedure Used	A	
		Acid Number	0.29	mg KOH/g
	ASTM D445	Kinematic Viscosity 50 °C	357.7	cSt
	IP 501	Aluminium	10	mg/kg
		[1] Silicon	9	mg/kg
		Sodium	15	mg/kg
		Vanadium	226	mg/kg
		Calcium	12	mg/kg
		Zinc	4	mg/kg
		Aluminium + Silicon	19	mg/kg
	ASTM D6560	Asphaltene Content	10.4	Wt %
	ISO 8217 F	CCAI	805.8	
	IP 570	[1] Hydrogen Sulfide Content	0.00	mg/kg

[1] *Out of Scope of the Method*

Signed: Jose Gutierrez
Intertek

Date: 03-05-19

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US260-0027747