VPS

Additive Assessment Report

For SulNOx

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INTRODUCTION

Ten samples were selected to evaluate the efficacy of SulNOx Eco (B-6430BFDC1L1121) in improving the distillate lubricities at a specific dosing rate. The samples were tested both with and without the additive at a requested concentration with SulNOx Eco according to ISO 12156-A.

While SulNOx Eco is anticipated to enhance the lubricity properties of marine fuel, the assessment of the additive's impact on fuel economy is beyond the scope of this report.

SAMPLE PREPARATION

For the assessment of SulNOx Eco (B-6430BFDC1L1121), a total of twenty samples were prepared, consisting of 10 blank and 10 dosed samples. All samples were homogenized with a mechanical shaker at 240 rpm for 5 minutes before being poured, dosed, and tested.

Table 1 displays the original physical and chemical properties of the selected blank samples. To investigate the efficacy of SulNOx Eco (B-6430BFDC1L1121), 500 ppm (mass concentration) of the additive was added to each of the ten blank samples. The dosed samples were mixed using a mechanical shaker at 240 rpm for 30 minutes before undergoing further tests.

Table 1: Testing Properties of the Selected Blank Samples

Property	Method	Unit	H29539	H29743	H29786	H31038	H31889	H00206	H01087	H01246	H01433	H02675
Density 15°C	A-D7042	kg/m³	828.2	842.8	876.7	832	829.5	842.9	847	816.1	830	818.5
Visc 40°C	A-D7042	mm²/s	2.282	3.277	3.13	2.458	2.804	2.539	2.434	3.582	2.485	2.005
Water	A-D6304	%V/V	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sulfur	ISO 8754	%m/m	<0.030	0.038	<0.030	<0.030	<0.030	<0.030	<0.030	0.032	0.036	<0.030
MCR	ISO 10370	%m/m	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Flash Point	ISO 2719	°C	67	>70.0	>70.0	70	66.5	64	62	61	>70.0	68
Pour Point	LP 1304	°C	<-6	<-6	<-6	<-6	<-6	<-6	<-6	-6	<-6	<-6
Dist-10	ISO 3405	°C	198	236	239	201	211	196	205	250	206	208
Dist-50	ISO 3405	°C	235	278	270	256	272	262	258	295	259	238
Dist-90	ISO 3405	°C	334	334	331	330	329	330	321	333	320	299
TAN	A-D664	mg KOH/g	<0.10	<0.10	0.10	0.11	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
FAME	EN 14078	%V/V	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
CP	LP 1305	°C	-18	-6	-10	-11	NA	NA	NA	NA	-13	NA
CFPP	IP 309	°C	<-6	-8	<-6	<-6	NA	<-6	NA	NA	NA	NA
Ash	LP 2605	%m/m	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Vanadium	LP 1105	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sodium	LP 1105	mg/kg	<1	1	<1	<1	<1	<1	1	<1	<1	<1
Aluminium	LP 1105	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Silicon	LP 1105	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Iron	LP 1105	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Nickel	LP 1105	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Calcium	LP 1105	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Magnesium	LP 1105	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Zinc	LP 1105	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Phosphorus	LP 1105	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Potassium	LP 1105	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
HFRR	ISO 12156	µm	545	525	550	640	615	585	630	530	630	650
CCAI	ISO 8217	SI	797	798	834	798	790	807	813	768	795	792
Net Specific Energy	ISO 8217	MJ/kg	43	42.83	42.43	42.96	42.99	42.83	42.78	43.14	42.98	43.11
Gross Specific Energy	ISO 8217	MJ/kg	45.87	45.65	45.14	45.81	45.85	45.65	45.59	46.04	45.84	46.01
CCI	ISO 8217	SI	48	54	41	51	56	47	46	72	52	53

RESULT AND DISCUSSION

Table 2 shows the average wear scar diameter (WSD) results obtained from testing the blank and dosed samples using the HFRR method. The testing acceptance limit, set at 0.59R with a 95% confidence level, was calculated based on the reproducibility limit outlined in ISO 12156-A, as well as the uncertainty requirement specified in ISO 8217 and ISO 4259.

Table 2: HFRR Results and Result Limits of Blank and Dosed Samples

Sample Number	HFRR Average WSD (µm)		Result Range (95 % Confidence, µm)			
	Blank	Dosed	Blank		Dosed	
HOU22F029539	510	390	463	557	343	437
HOU22F029743	480	380	433	527	333	427
HOU22F029786	540	450	493	587	403	497
HOU22F031038	620	560	573	667	513	607
HOU22F031889	600	520	553	647	473	567
HOU23F000206	550	420	503	597	373	467
HOU23F001087	610	520	563	657	473	567
HOU23F001246	510	440	463	557	393	487
HOU23F001433	600	480	553	647	433	527
HOU23F002675	680	570	633	727	523	617

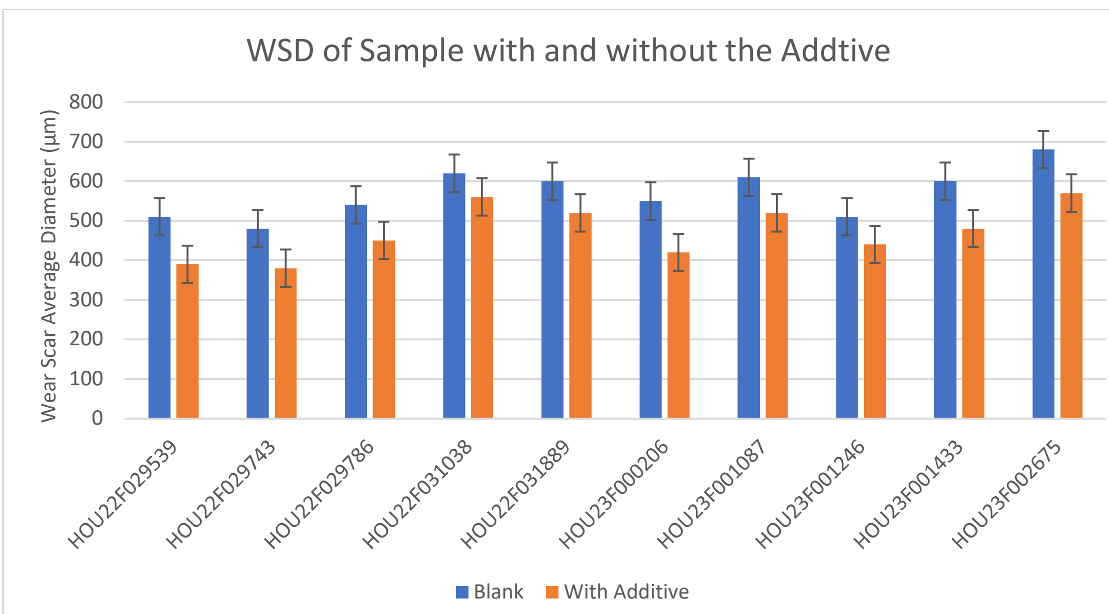

Figure 1: The HFRR WSD comparison for samples with and without the additive.

As depicted in **Figure 1** above, the addition of SulNOx additive led to a significant reduction in the HFRR average WSD for all selected samples. However, the degree of reduction varied depending on the properties of the respective blank samples.

Table 3: Reduction in WSD after Dosing with the Additive

Sample Number	WSD Blank (μm)	WSD Dosed (μm)	Reduction (%)
HOU22F029539	510	390	23.5
HOU22F029743	480	380	20.8
HOU22F029786	540	450	16.7
HOU22F031038	620	560	9.7
HOU22F031889	600	520	13.3
HOU23F000206	550	420	23.6
HOU23F001087	610	520	14.8
HOU23F001246	510	440	13.7
HOU23F001433	600	480	20.0
HOU23F002675	680	570	16.2

The effectiveness of the SulNOx additive in improving lubricity can be quantified by calculating the percentage reduction in WSD results compared to the respective blank samples, as presented in **Table 3**. The minimum reduction in WSD, 9.7%, was observed in sample HOU22F031038, while the most significant reduction of 23.6% was seen in sample HOU23F000206. Overall, the addition of the additive at a concentration of 500 ppm resulted in a notable reduction in WSD of 17.2% across all ten samples, indicating an improvement in lubricity properties.

However, the varying sensitivity of the additive across the samples remains unclear and does not show a solid correlation with the respective blank WSD values. Additionally, the HFRR test only measures one aspect of lubricity, while other factors such as viscosity, thermal stability, and fuel oil composition can also impact the overall fluid performance. Therefore, it is essential to consider HFRR test results in conjunction with other parameters when assessing the efficiency of the additive in enhancing lubricity properties.

CONCLUSION

The test results demonstrate that the SulNOx ECO additive can effectively improve the lubricity of all selected samples as evidenced by the average reduction of 17.2% in the intrinsic HFRR WSD values of the blank samples when the additive was added at a concentration of 500 ppm.

However, it should be noted that this conclusion is based solely on the selected fuel oils and the testing results obtained in our laboratory. Other types of approval or technology validation may require additional tests using a different protocol, which is beyond the scope of this report.

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