Drew Marine

IMO 2020 - 0.5% sulfur initiative

Regulations 14 (*1,*2) and 18 of MARPOL Annex VI

2020 Bunker

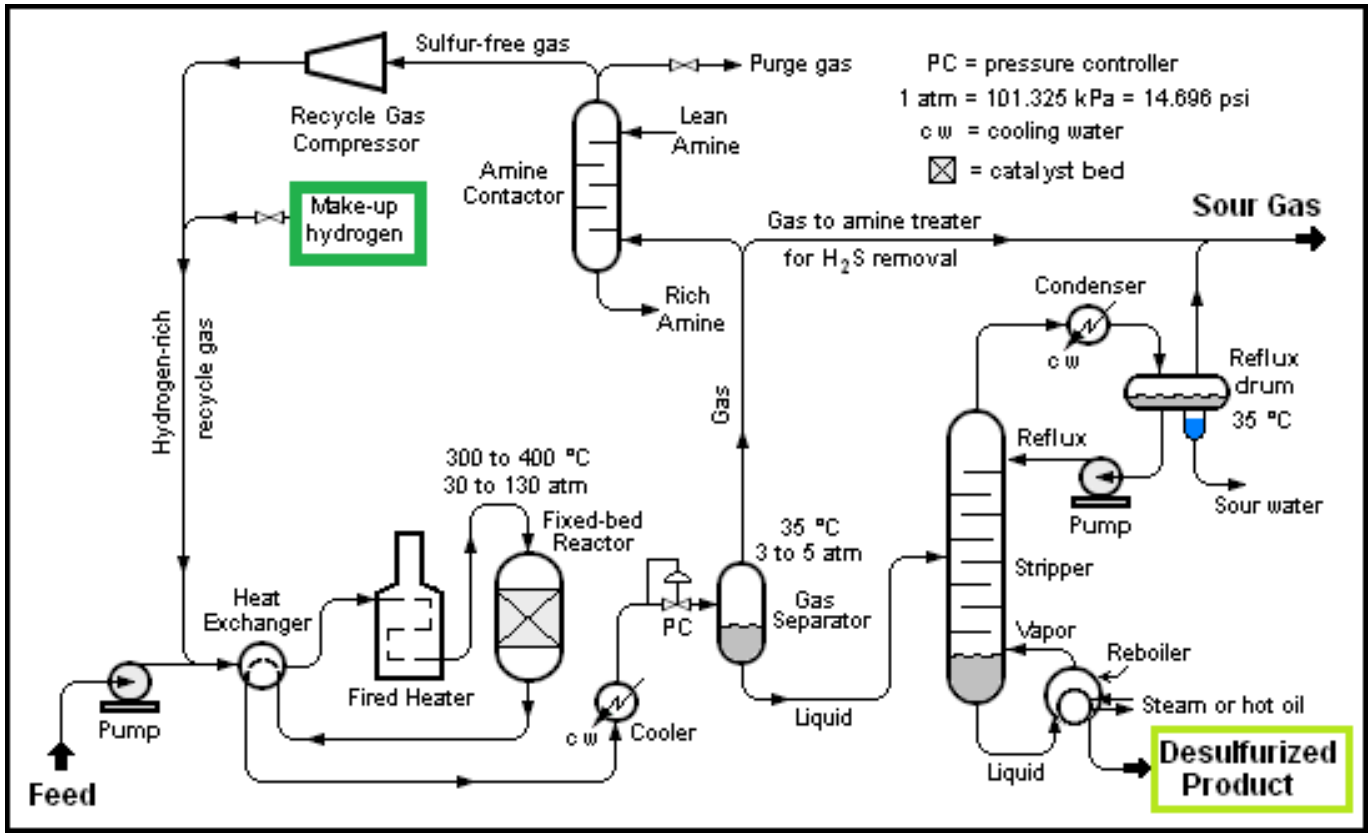
Worldwide

- **≤0.5% Low sulfur FO**
- **≤3.5% sulfur HFO + Scrubber Open loop**

ECA

- **≤0.1% sulfur MGO**
- **≤0.1% sulfur alternative fuel**
- **≤3.5% sulfur HFO + Scrubber Close loop**

De-Sulfur process



Drew Marine

VLSFO

- Quality of VLSFO
- Classification & IMO potential safety implication
- Engine Maker recommendation
- Fuel Treatment

NK Class simulation of fuel after 2020

Table 2.3 Possible fuel oil types used after January 1, 2020

	Sulphur contents limit	possible fuel oil for use
Outside ECAs	0.50%	Marine fuel oil of 0.5% or less sulphur content (*VLSFO-DM, VLSFO-RM*) HSHFO, if ship installs and uses a SOx scrubber
Inside ECAs	0.10%	Marine fuel oil of 0.1% or less sulphur content (*ULSFO-DM, ULSFO-RM*) HSHFO, if ship installs and uses a SOx scrubber

Table 2.4 Regional variation in properties of compliant fuel oils expected in 2020 (amended from the original table from the reference document [2])

Region	Viscosity at 50 °C, (cSt)	Density at 15 °C, (kg/m^3)	CCAI	Flash point, (°C)
Africa	10	911	828	97
Asia	110.7	926	801	111
North America	14.7	925	833	110
Latin America	52.1	911	797	97
Middle East	180	934	803	118
Europe	17.2	908	813	94
Russia	66.4	932	814	116

The ASTM D-975 standard distillate fuels available in North America, There are currently three standards for sulfur content in No. 2 Diesel, S15, S500 (0.05%) and S5000 (0.5%)

Blended VLSFO - S 0.5%

IMO Number	: 9439618	B.D.N Number	: 13-0010734		
Sample Type	: VLSFO	Density @ 15 Deg C	: 961.9	kg/m3	
Bunker Port	: Jiang Yin - China	Viscosity @ 50 Deg C	: 364.20	mm2/s	
Bunker Date	: 29-May-2019	Flash Point	: 120	Deg C	
Supplier	: China Marine Bunker	Sulphur	: 0.43	%	
Supplying Barge	: Tong Ran Gong 19	Water	: 0.10	%	
Quantity	: 294.89 MT				

			TEST RESULT	ISO SPECS	
Density @ 15 Deg C	kg/m3	ISO 12185	960.4	991.0	Max
KV 50	mm2/s	ISO 3104	325.30	380.00	Max
KV 100	mm2/s	ISO 3104	31.80	Non-spec	
Flash Point	Deg C	ISO 2719	>70.0	60.0	Min
Pour Point	Deg C	ISO 3016	+12	30	Max
MCR	%m/m	ISO 10370	7.75	18.00	Max
Ash	%m/m	ISO 6245	0.033	0.100	Max
Water	%V/V	ISO 3733	0.05	0.50	Max
Sulphur (Domestic ECA)	%mass	ISO 8754	0.43	0.50	Max
Vanadium	mg/kg	IP 501	4	350	Max
TSP	%m/m	ISO 10307-2	0.02	0.10	Max
AL + SI (7 + 7)	mg/kg	IP 501	14	60	Max
Zinc	mg/kg	IP 501	<1	15	Max
Phosphorus	mg/kg	IP 501	<1	15	Max
Calcium	mg/kg	IP 501	58	30	Max
Sodium	mg/kg	IP 501	5	100	Max
CCAI	-	ISO 8217 Annex F	823	870	Max

<0.5% HFO China – Qinghuangdao

Sample Dispatch Date:	NOT STATED
Lab Receipt Date:	2019-02-28
Courier Used:	DHL
Dispatched From:	NOT STATED
Sample	1
Port	QINHUANGDAO
Sampling Date	2019-02-02
Supplier	NOT STATED
Barge/Inst	YUN HAI YOU 3
Sample Point Type	MANIFOLD
Sampling Method	DRIP
Advised Bunker Details	
Viscosity cSt	169.0
Density @ 15°c kg/l	0.9892
Sulphur	0.45
Quantity MT	65
Seal Number Lab	1990841
Tag Seal Numbers Lab	2330321
Seal Number Vessel	NOT STATED
Seal Number Supplier	NOT STATED
Seal Number MARPOL	NOT STATED

		Required	Tested
Sample		1	Amber
ISO-F Grade(2017)		RMG180	RMG180
K Viscosity at 50oC	cSt	180 Max	138.2
K Viscosity at 100oC calc	cSt		19.0
Density @ 15°c	kg/l	0.9910 Max	0.9726
Water Content	% v/v	0.50 Max	0.25
Ash Content at 550oC	% m/m	0.10 Max	0.016
Micro Carbon Residue	% m/m	18.0 Max	6.62
Total Sediment	% m/m	0.10 Max	< 0.01
Net Specific Energy	MJ/kg		41.24
Gross Specific Energy	MJ/kg		43.63
Sulphur Content	% m/m	3.50 Max	0.33
Pour Point	°C	30 Max	30
Flash Point	°C	60 Min	> 70.0
CCAI	Index	870 Max	845
Silicon	mg/kg		5
Aluminium	mg/kg		2
Vanadium	mg/kg	350 Max	4
Sodium	mg/kg	100 Max	11
Iron	mg/kg		8
Phosphorus	mg/kg	15 Max	1
Lead	mg/kg		< 1
Calcium	mg/kg	30 Max	8
Nickel	mg/kg		15

Europe <0.5% Sulfur

Testing to ISO8217 (2017 edition)				
Parameter	Test method	RESULTS (RMG 380)		Units
Kinematic Viscosity at 50ºC	ISO3104	341,8	380,0	cSt
Density at 15ºC	ISO3675/12185	0,980	0,991	kg/m3
CCAI	Calculation	849	870	-
Sulphur	ISO8754/14596	0,49		%wt
Flash Point	ISO2719	102,0	60,0	Deg C
Hydrogen Sulphide	IP570		2,00	mg/kg
Acid Number	D664	0,05	2,5	mgKOH/g
Total Sediment Existent	ISO10307-1	0,02	0,10	%wt
Total Sediment Accelerated	ISO10307-2B	0,03	0,10	%wt
Carbon Residue: Micro Method	ISO10370	11,88	18,00	%wt
Pour Point (upper)	ISO3016	21	30	Deg C
Water	ISO3733		30	%vol
Ash	ISO6245	0,037	0,100	%wt
Vanadium	IP501 / ISO 14597	28	350	mg/kg
Sodium	IP501	55	100	mg/kg
Aluminium plus Silicon	IP501 / ISO 10478	26	60	mg/kg
ULO		ULO FREE		-

Korea VLSFO

제 품 명 : VLSFO		성적서 번호 :	QA-190924-08598
지시 번호 : -		시료 채취일 :	2019. 9. 19.
고 객 명 : -		제품 출하일 :	2019. 9. 24.

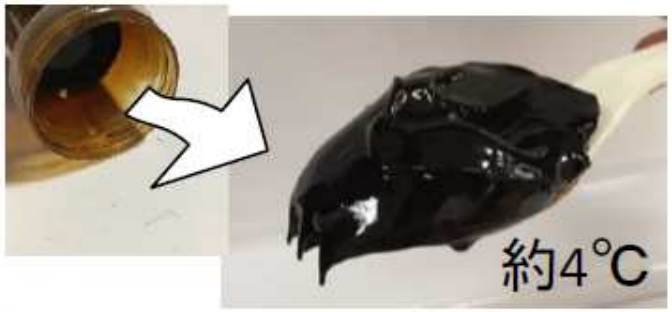
시 험 항 목	시 험 방 법	규 격		결 과
Tank No				MFB5380
Density, (kg/㎥, 15 ℃)	ASTM D 1298	991	max.	899.6
Viscosity, mm^2/s, 50 ℃	ASTM D 445	380	max.	50.9
Flash Point, Procedure B, ℃	ASTM D 93	60	min.	132.0
Sulfur wt %	ASTM D 4294	3.5	max.	0.31
Water vol %	ASTM D 95	0.5	max.	0.05
Ash wt %	ASTM D 482	0.1	max.	0.002
Carbon Residue, wt %	ASTM D 4530	18.0	max.	1.83
CCAI (A)	ISO 8217	870	max.	786
Acid Number, mgKOH/g	ASTM D 664	2.5	max.	0.103
Total Sediment Aged, wt %	ISO 10307-2	0.1	max.	0.01
Pour Point ℃	ASTM D 5950	30	max.	23
Vanadium ,mg/kg	IP 501	350	max.	3
Sodium , mg/kg	IP 501	100	max.	6
Aluminum+ Silicon, mg/kg	IP 501	60	max.	3
ULO, mg/kg Zinc	IP 501	15	max.	1
Calcium	IP 501	30	max.	1
Phosphorus	IP 501	15	max.	1
Gross Calorific Value, kcal/kg	ASTM D 240	Report		10,734
Net Calorific Value, kcal/kg	ASTM D 240	Report		10,106

Singapore VLSFO

Sample	1
Port	SINGAPORE
Sampling Date	2019-10-21
Supplier	SHELL
Barge/Inst	ISSELIA
Sample Point Type	MANIFOLD
Sampling Method	DRIP
Advised Bunker Details	
Viscosity cSt	209.7
Density @ 15°c kg/l	0.9789
Sulphur	0.43
Quantity MT	5840.000
Seal Number Lab	2182068
Tag Seal Numbers Lab	2587051
Seal Number Vessel	2587052
Seal Number Supplier	NOT STATED
Seal Number MARPOL	857452/047872

Sample		1	Amber
ISO-F Grade(2005)		RMG380VLS	RMG380
K Viscosity at 50oC	cSt	380 Max	205.2
K Viscosity at 100oC calc	cSt		24.0
Density @ 15°c	kg/l	0.9910 Max	0.9775
Water Content	% v/v	0.50 Max	0.25
Ash Content at 550oC	% m/m	0.15 Max	0.040
Micro Carbon Residue	% m/m	18.0 Max	9.16
Total Sediment	% m/m	0.10 Max	0.03
Net Specific Energy	MJ/kg		41.12
Gross Specific Energy	MJ/kg		43.50
Sulphur Content	% m/m	0.50 Max	0.45
Pour Point	°C	30 Max	< 6
Flash Point	°C	60 Min	> 70.0
CCAI	Index		845
Silicon	mg/kg		28
Aluminium	mg/kg		21
Vanadium	mg/kg	300 Max	4
Sodium	mg/kg		46
Iron	mg/kg		17
Phosphorus	mg/kg	15 Max	2
Lead	mg/kg		< 1
Calcium	mg/kg	30 Max	20
Nickel	mg/kg		16
Zinc	mg/kg	15 Max	< 1

Japan VLSFO (Wax + Asphaltene)



動粘度(50℃)が24.5cSt程度のサンプル
LSC重油を約4℃まで冷やしたもの

フィルターに詰まっていたゲル状のスラッジ

- **LSC heavy oil has a low kinematic viscosity and is smooth like heavy oil A. At first glance, it may seem unnecessary to heat, but be aware that, like conventional HSC heavy oil, heating is an essential fuel oil.**
- **When the fuel oil temperature is near the pour point (30° C or lower) or even lower, wax may precipitate and clog up as a lump.**
- **If the sludge becomes liquid when heated, it can be determined as wax sludge, so increase the heating of the fuel oil**

Fuel Standard: ISO 8217 - 2017

MARINE RESIDUAL FUELS

Limit	Parameter	RMA 10	RMB 30	RMD 80	RME 180	RMG 180	RMG 380	RMG 500	RMG 700	RMK 380	RMK 500	RMK 700
Max.	Viscosity at 50°C (mm²/s)	10.00	30.00	80.00	180.0	180.0	380.0	500.0	700.0	380.0	500.0	700.0
Max.	Density at 15°C (kg/m³)	920.0	960.0	975.0	991.0	991.0				1010.0		
Max.	Micro Carbon Residue (% m/m)	2.50	10.00	14.00	15.00	18.00				20.00		
Max.	Aluminium + Silicon (mg/kg)	25	40		50	60						
Max.	Sodium (mg/kg)	50	100		50	100						
Max.	Ash (% m/m)	0.040	0.070			0.100				0.150		
Max.	Vanadium (mg/kg)	50	150			350				450		
Max.	CCAI	850	860			870						
Max.	Water (% V/V)	0.30	0.50									
Max.	Pour point (upper) in Summer (°C)	6	30									
Max.	Pour point (upper) in Winter (°C)	0	30									
Min.	Flash point (°C)	60.0										
Max.	Sulphur (% m/m)	To comply with statutory requirements as defined by purchaser										
Max.	Total Sediment, aged (% m/m)	0.10										
Max.	Acid Number (mgKOH/g)	2.5										
	Used lubricating oils (ULO): Calcium and Zinc; or Calcium and Phosphorus (mg/kg)	The fuel shall be free from ULO, and shall be considered to contain ULO when either one of the following conditions is met: Calcium > 30 and zinc > 15; or Calcium > 30 and phosphorus > 15.										
Max.	Hydrogen sulphide (mg/kg)	2.00										

NK Class simulation of fuel after 2020

Table 2.5 Characteristics of paraffin-rich fuel oil and Polycyclic-aromatic-rich fuel oil

	Paraffin-rich	Polycyclic-aromatic-rich
Typical molecular structure	 Icosane (an alkene whose number of carbon atoms is 20)	 Naphthalene
Ignition and combustion quality	Good	Poor
Cold flow properties	Poor	Good
Compatibility	Poor if these two types are mixed	

5 fuel properties which need potential safety implication

1. Compatibility
2. Low viscosity
3. Cold Flow Property
4. Cat-fines
5. Ignition and combustion quality

IMO - Guidance

INTERNATIONAL MARITIME ORGANIZATION

4 ALBERT EMBANKMENT
LONDON SE1 7SR
Telephone: +44 (0)20 7735 7611 Fax: +44 (0)20 7587 3210

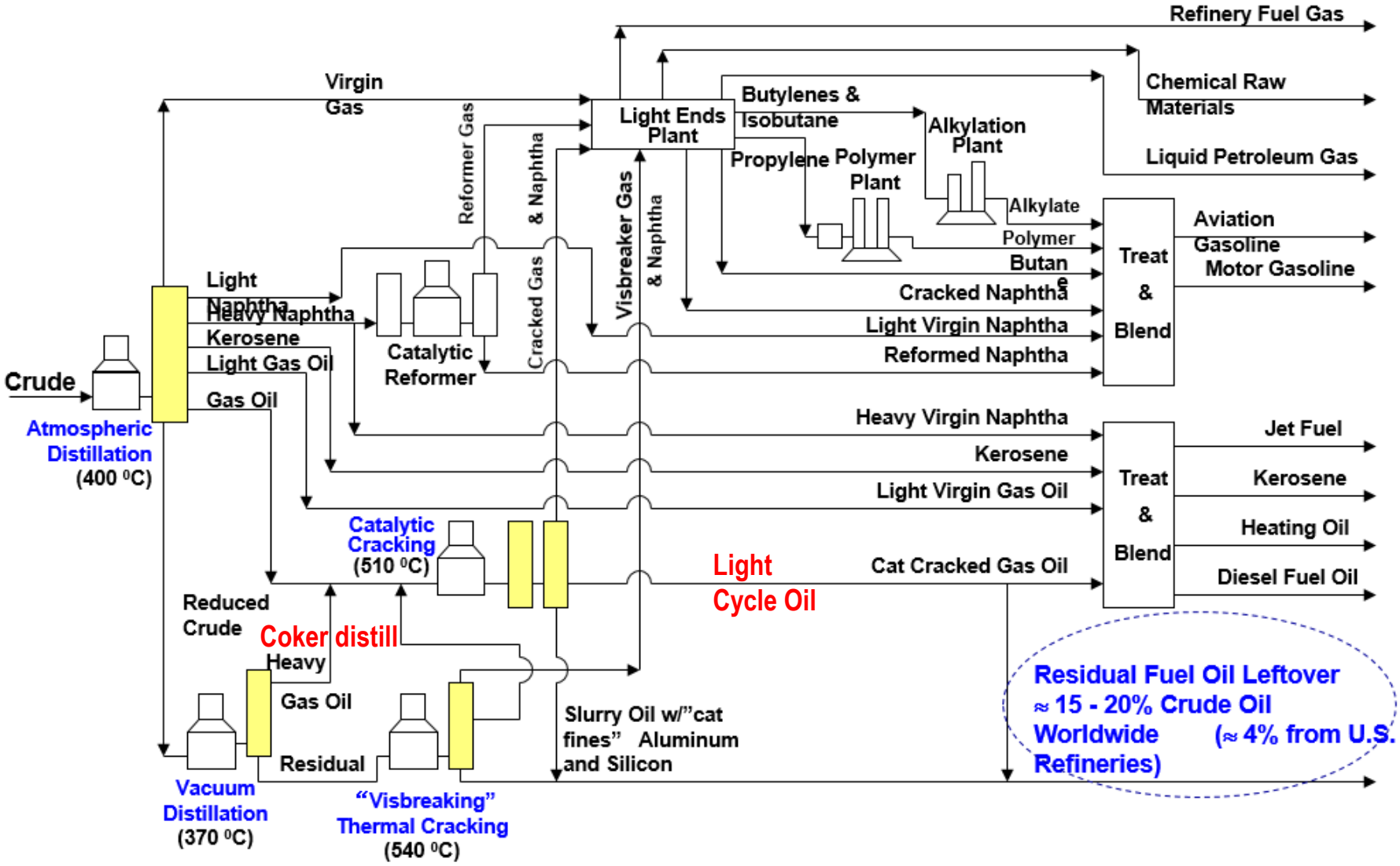
MEPC.1/Circ.878
9 November 2018

GUIDANCE ON THE DEVELOPMENT OF A SHIP IMPLEMENTATION PLAN FOR THE CONSISTENT IMPLEMENTATION OF THE 0.50% SULPHUR LIMIT UNDER MARPOL ANNEX VI

22 Following consideration, the Meeting identified further potential safety implications as follows:

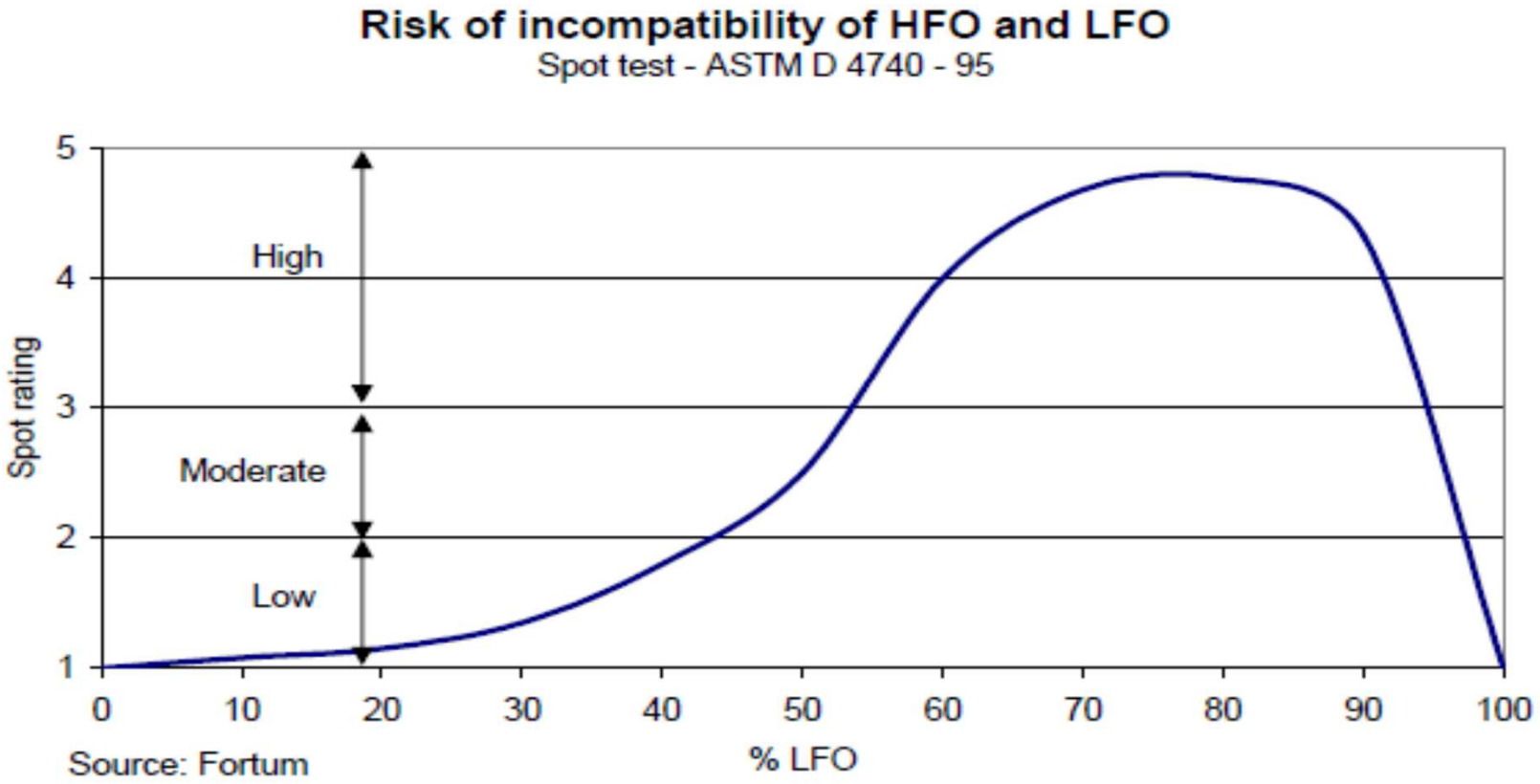
.1 stability of blended fuel oil;
.2 compatibility, including new tests and metrics appropriate for future fuels;
.3 cold flow properties;
.4 acid number;
.5 flash point;
.6 ignition quality; and
.7 cat fines.

Advanced oil refinery



Fuel incompatibility

When two different fuels are mixed there is a risk of incompatibility, which may cause clogging of fuel filters and separators and sticking of fuel injection pumps asphaltene deposits on plunger and barrel)



MAN Comment and Recommendation

- These hybrids/ULSFOs often have a high paraffinic content and high pour points and as such a high viscosity.
- Hybrids/ULSFOs with viscosity similar to DMA up to RME180, which requires a completely different preheating and cooling of the fuel oil to keep the viscosity in the required range between 2.3 to 14.0 cSt before engine.
- Increased incompatibility of these new hybrids/ULSFOs among each other and with HFO
- There are hybrids/ULSFOs containing a high amount of abrasive catfines, even exceeding the average catfines content known from HFO.
- The compatibility of fuels, especially by using hybrids/ULSFOs, has to be determined according to work card 000.05 for spot test ASTM D4740 (visual analyze of fuel mixture 50:50)
- Valve seat lubrication is required to prevent excessive wear. The nozzle cooling water is typically not required for these hybrid fuels.

FO Compatibility Tester

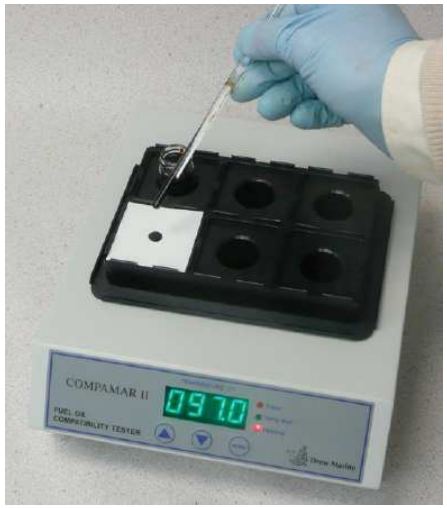
- FO COMPATIBILITY TESTER uses a dry heating bath to heat the oil in test vials and to dry the test paper to determine fuel oil compatibility and stability
- 6 compartments allow simultaneous heating and drying of multiple fuel oil samples.
- Provides indication and degree of sludge formation tendency of all fuels bunkered

Supply scope:

Sample vials, capped x 72
Glove x 20
Safety Glass x 1
Cleaner x 1
Sample beaker x 3
Glass rod stirrer x 2
Filter Paper 50 x 50mm sheets
Sample syringe 30ml (20)
Bottle clip holder x 1

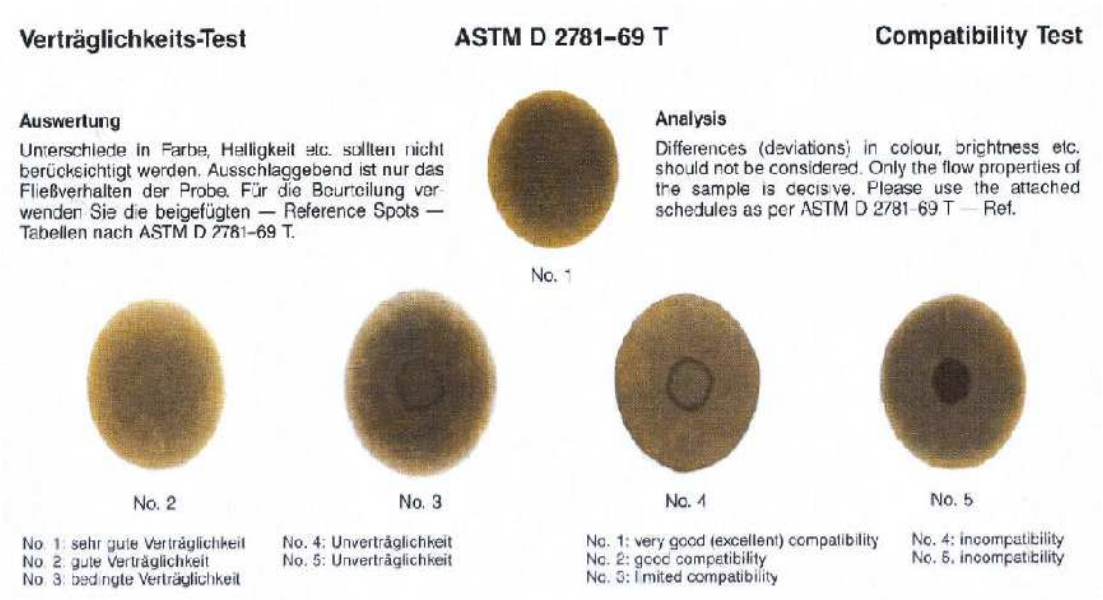
FO Compatibility Tester

- **Stability**
  - 10ml sample
  - Heat 10 minutes. Fuel sample and test paper
  - Stir sample 20 second. 2nd drop sample on test paper
  - Heat test paper 20 minutes
  - Compare test paper

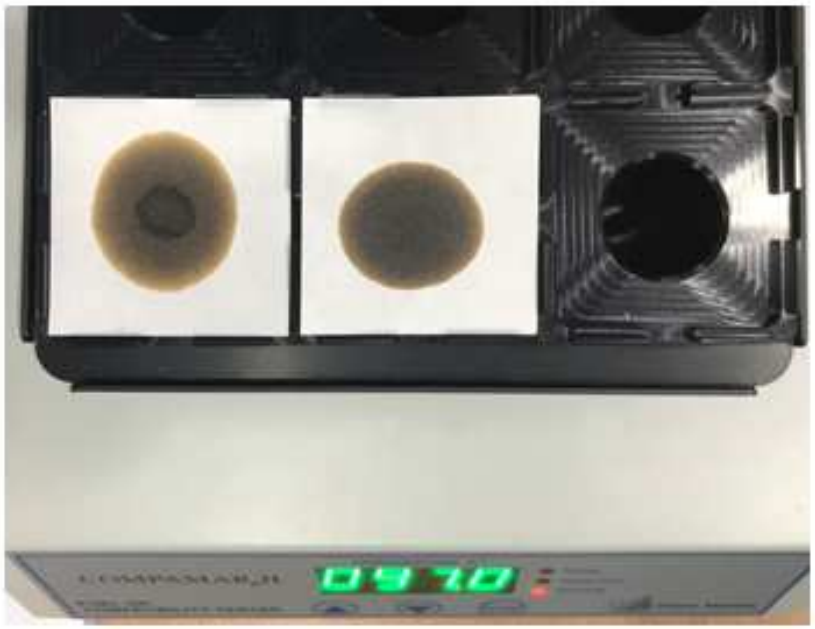


Caution: Do not heat distill fuel

- **Compatibility**
  - 2 samples, 10ml each
  - Heat 5 minutes. Mix 2 samples
  - Heat 10 minutes fuel sample and test paper
  - Stir sample 20 second. 2nd drop sample on test paper
  - Heat test paper 20 minutes
  - Compare test paper



FO Compatibility Tester

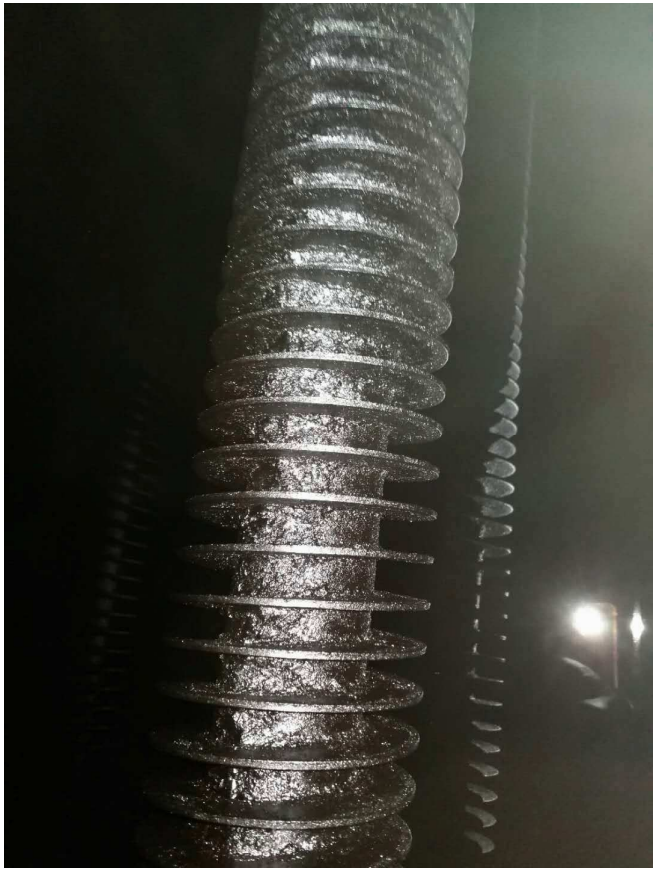


- Mixing HFO 380 with LSMGO to lower sulfur level <0.5%
- Spot model 4 indicate stability problem
- Add AMERGY 222 into sample. It improve from spot 4 to spot 1.

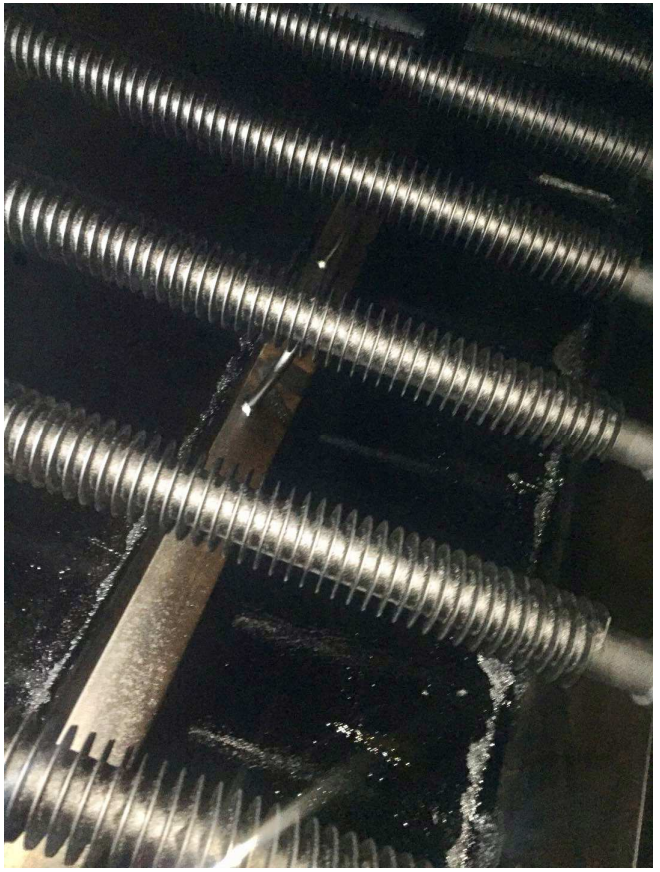
Recommendation – Improve compatibility

- **Quality of 0.5% LSFO may vary by ports and bunker suppliers.**
- **Vessel should keep 5-10 pail of AMERGY 222 to overcome fuel compatibility problem.**
- **Noted:**
  - Do not dose AMERGY 222 into loaded bunker tank when sludge problem in system. FUEL and AMERGY 222 are not able to mix homogeneously.
  - AMERGY 222 should dose to SETTLING TANK by filter of Transfer pump.
- **Homogenizer improve fuel stability and compatibility.**

Fuel storage tank Heater clean by AMERGY 222



Before clean



After clean

AMERGY 222 – REGULAR USERS

MV XIN BEI LUN (Built: 2005)




MV XIN Dan Dong (Built: 2006)

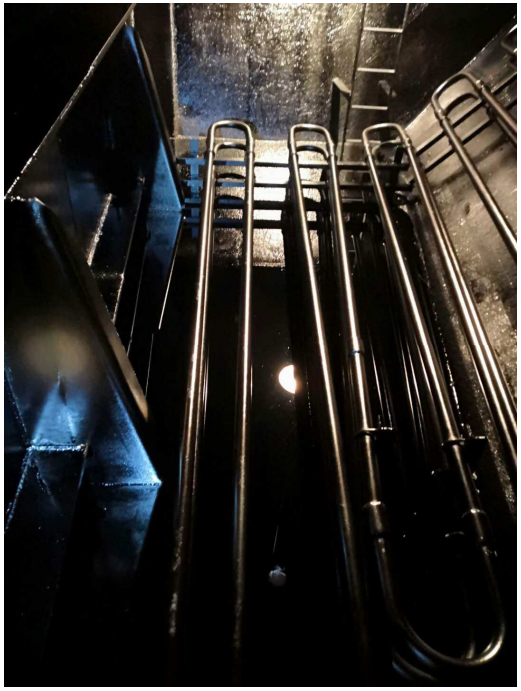


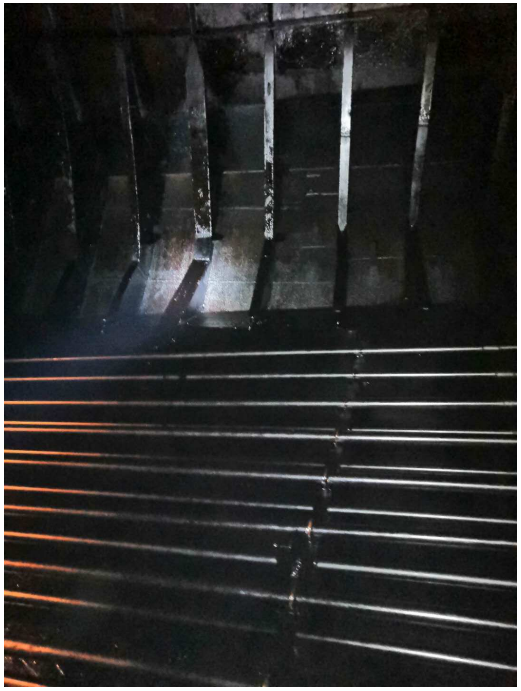

4250 TEU Container

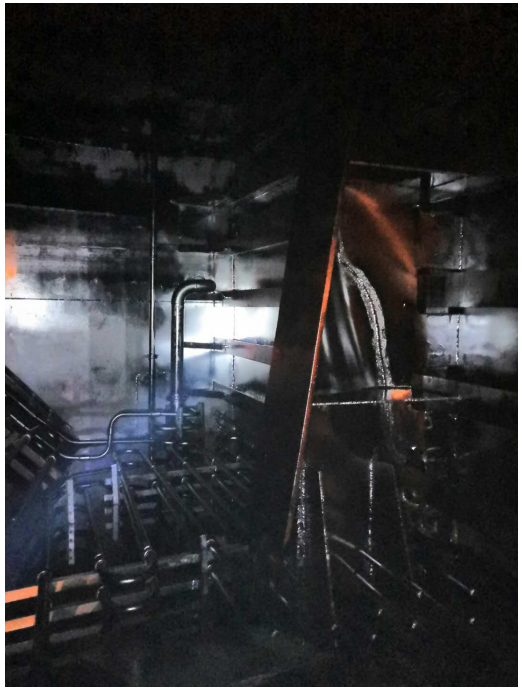
Vessel: MV PENGHU SW. Built: 2011. 37,168 DWT. Bulker

Procedure	藥水反應間隔	Date 執行日期
NO.1 FOT (S) 駁空	Time	2019.01.18 /10:00
Move ↓		
NO.1 FOT (S) 投入藥水	24	2019.01.19 /09:30
Dosing ↓ (40L)	48HR	
駁滿NO.1 FOT (S) (80%)	FO pump in	2019.01.21 /17:20
↓ (350 m³)		
開啟NO.1 FOT (S) 加熱	Heating	2019.01.21 /17:20
↓	96HR	
NO.1 (P) FOT 駁空	FO Pump out	2019.01.21 /17:20
↓		
NO.1 (P) FOT 投入藥水	Dosing	2019.01.21 /17:20
↓ (40L)	48HR	
BUNKER FO 200M/T加入 NO.1 FOT (P) 並開啟加熱	Pump in 200MT & Heat	2019.01.25/2100
↓ 200 m³	96HR	
NO.1 FOT (S)燃油駁到 NO.1 FOT (P)到達艙容 80%並開啟加熱	Move FO from 1S to 80% 1P	2019.02.03/0800-2230
↓ 150m³		
NO.1 FOT (S) 剩餘燃油駁入NO.5 FOT (S)	Empty 1S to 5S	2019.02.04/0800-1730
↓	96HR	
將NO.1 FOT (P) 燃油駁入 NO.1 FOT (S)並開啟加熱	Empty 1P to1S	2019.02.09/0800 2019.02.10/1800
↓ 駁空	96HR	
DRY DOCKING		

AMERGY 222 FO TANK CLEAN







AMERGY 222 – Asphaltene disperse

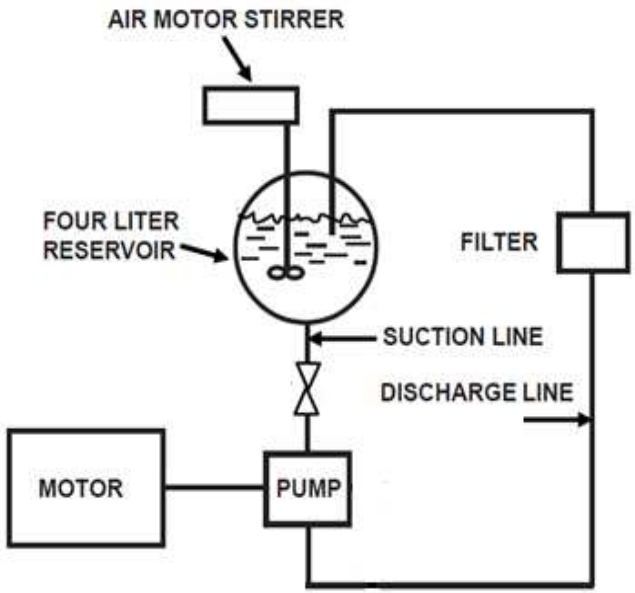


TABLE III

EVALUATIONS WITH 1000 PPM DRY SLUDGE

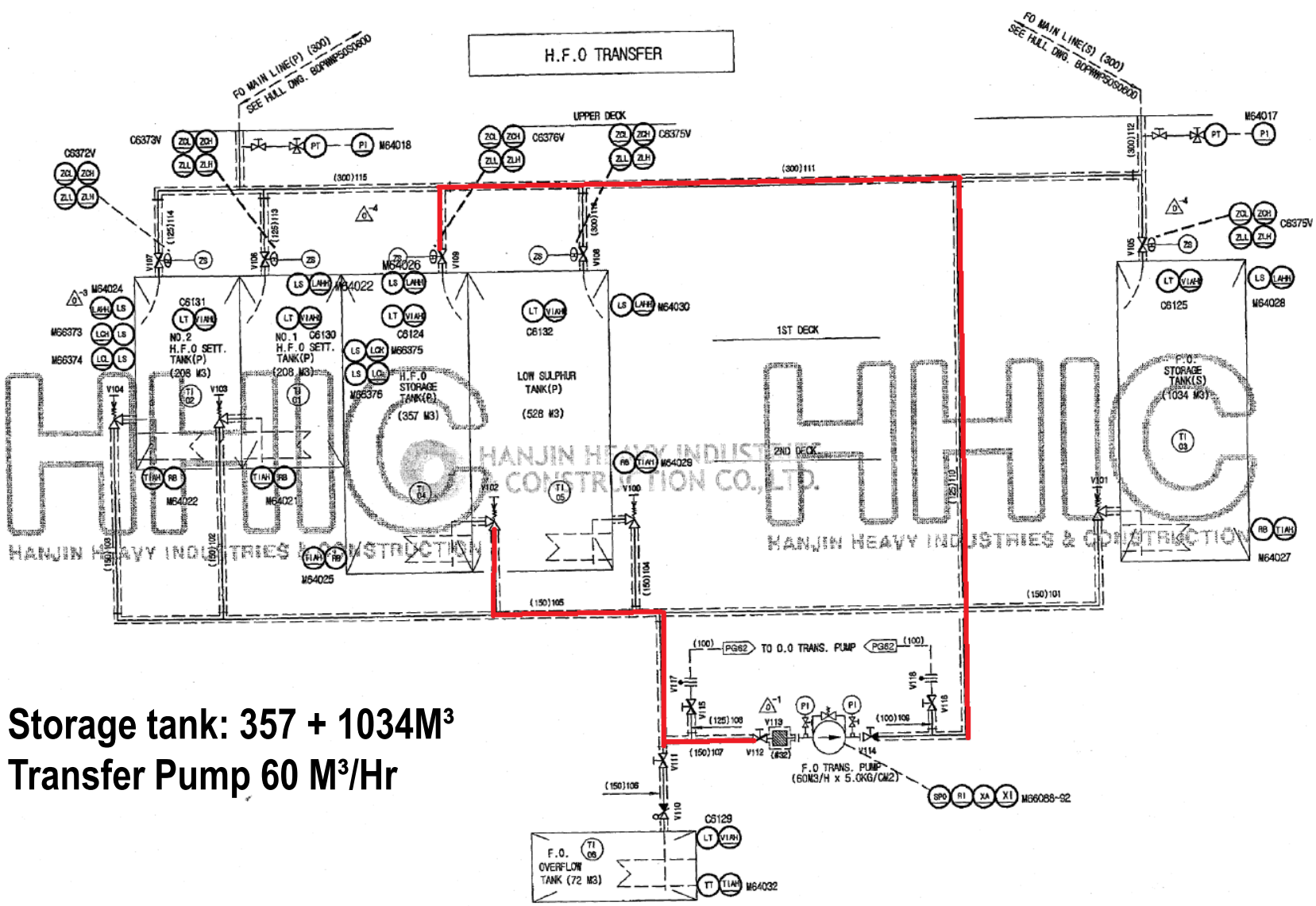
	FLOWRATE (GPH)			
	NO ADDITIVE	AMERGY 222 CONDITIONER DOSAGE 50 PPM	100 PPM	250 PPM
Start				
30 Minutes	53	53	53	53
60 Minutes	34	53	53	53
90 Minutes	24	51	53	53
120 Minutes	18	51	52	53
2.5 Hours	15	48	52	53
3 Hours	15	46	49	53
3.5 Hours	13	46	49	53
4 Hours	12	41	49	53
5 Hours	- -	41	49	53
6 Hours	- -	41	49	53
7 Hours	- -	41	49	53
8 Hours	- -	41	49	53

AMERGY 222 – 2980 vessels

Stability/ Compatibility Spot Number	Dosage Rate
1	1:15,000
2	1:12,500
3	1:10,000
4	1:8,000
5	1:6,000

- **Dose to Fuel Storage before bunkering. Dosage: 1/6,000 - - 1/15,000**
- **After bunkering, never dose to >50% loaded storage tank.**
- **Arranging empty tank to dose AMERGY 222. Transfer HFO into it for proper mixing. Pump HFO between 2 tanks for 2 cycle for sludge disperse**

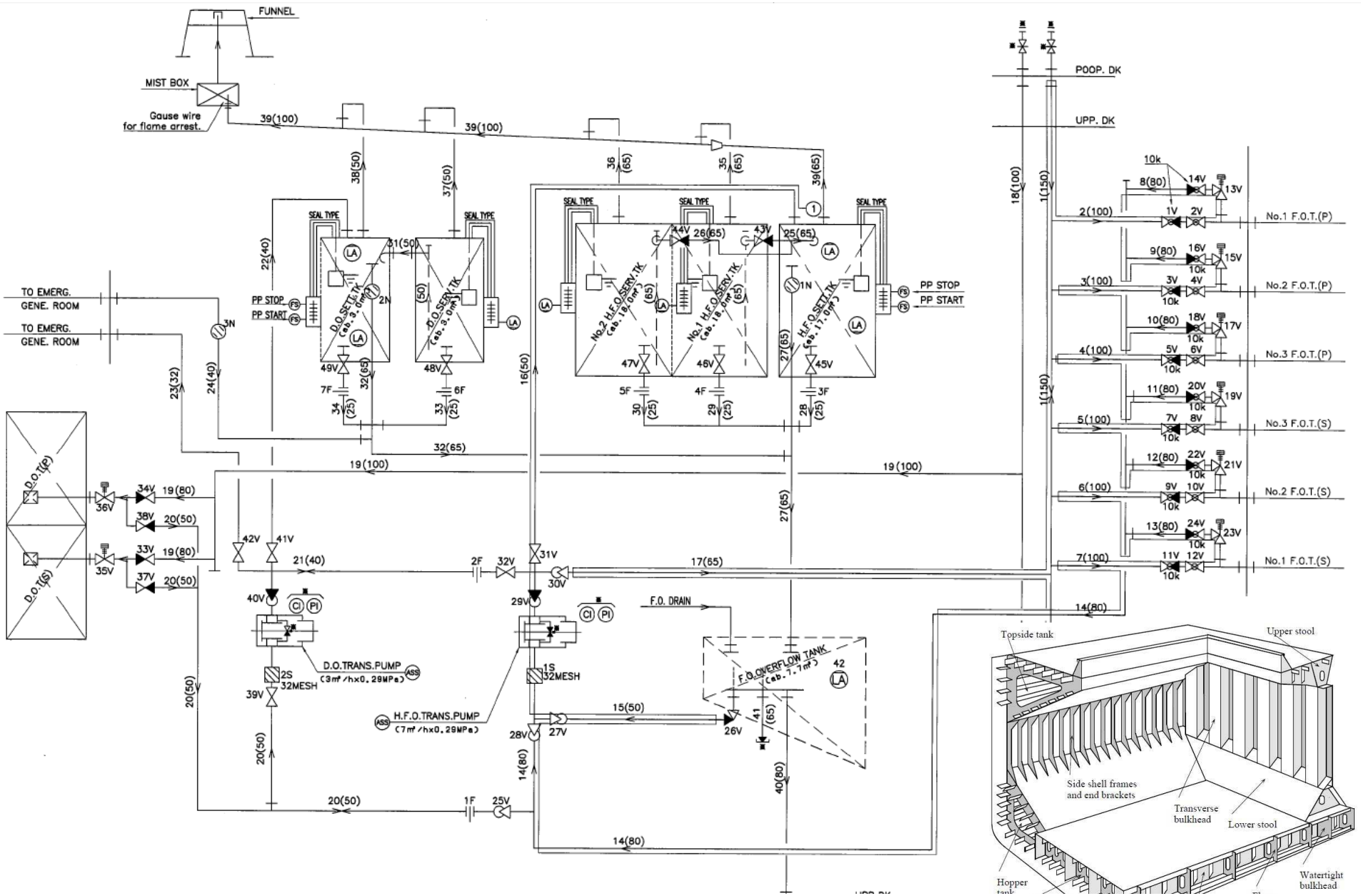
Deep Tank Self Circulation



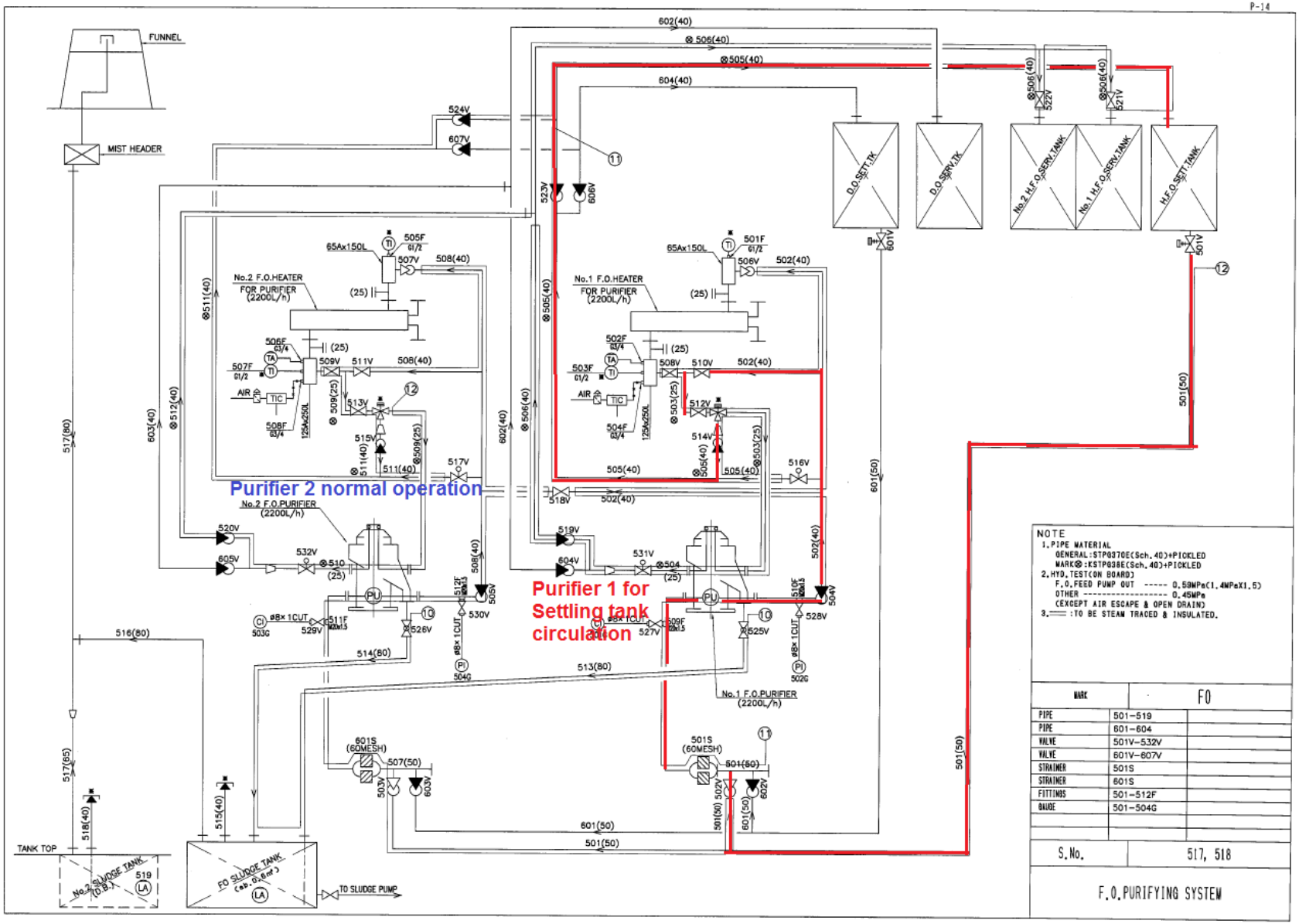
Storage tank: 357 + 1034M³

Transfer Pump 60 M³/Hr

Circulation between 2 HFO Storage Tanks



Settling Circulation by Purifier feed pump



Bio- Fuel Contaminants:

Biofuel typically contains < 0.01% sulfur

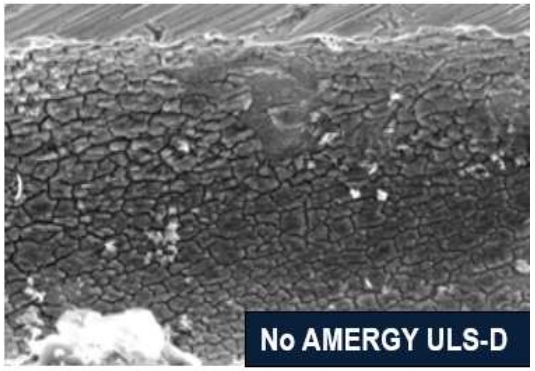
However, in geographies where there is a surplus, excess biofuel comprise a portion of MDO and MGO

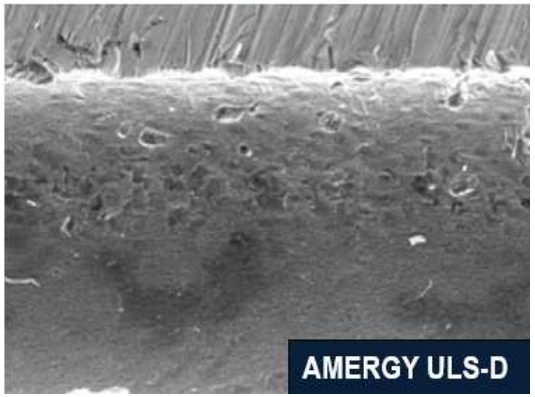
ISO 8217:2012 Marine Fuel Specification stipulates a *de minimis* limit or 0.1%

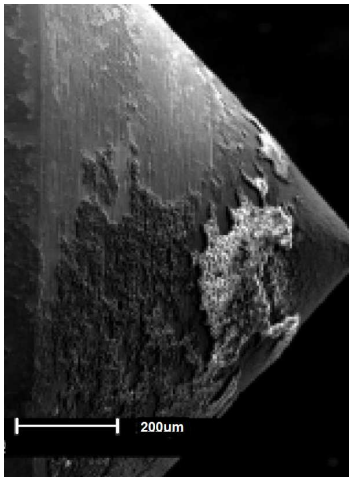
- **tendency to oxidation and long-term storage issues**
- **an affinity to water and risk of microbial growth**
- **degraded low-temperature flow properties**
- **deposition on exposed surfaces, including filter elements**

AMERGY ULS-D

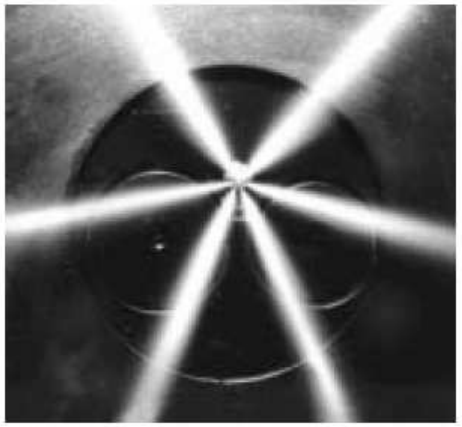
- Eliminates fuel pump plunger and nozzle deposits at the tip
- Prevents the formation of newer internal diesel injector deposits (IDID)
- Clean deposit preventing sticking



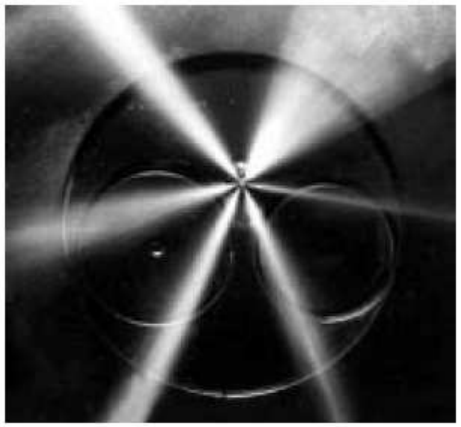




AMERGY ULS-D Injector cleanliness Cleaner



Clean injector – regular spray pattern



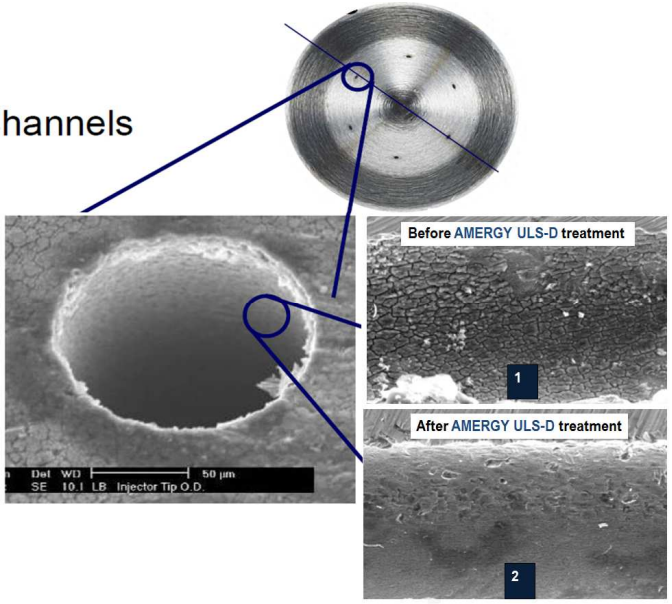
Deposited injector – irregular spray pattern

Untreated fuel

Fuel with deposit control additive

Images of Injector Channels

- Several fuel injectors were removed and sectioned during testing
  - Injector after test with base fuel.
  - Injector after test with **AMERGY ULS-D**
- Internal channels of sectioned injectors were imaged



Drew Marine

ULSFO

- Distillate grade
- Blend grade

Fuel Standard: ISO 8217 - 2017

MARINE DISTILLATE FUELS

Limit	Parameter	DMX	DMA	DFA	DMZ	DFZ	DMB	DFB
Max.	Viscosity at 40°C (mm²/s)	5.500	6.000		6.000		11.00	
Min.	Viscosity at 40°C (mm²/s)	1.400	2.000		3.000		2.000	
Max.	Micro Carbon Residue at 10% Residue (% m/m)	0.30	0.30		0.30		-	
Max.	Density at 15°C (kg/m3)	-	890.0		890.0		900.0	
Max.	Micro Carbon Residue (% m/m)	-	-		-		0.30	
Max.	Sulphur (% m/m)	1.00	1.00		1.00		1.50	
Max.	Water (% V/V)	-	-		-		0.30	
Max.	Total sediment by hot filtration (% m/m)	-	-		-		0.10	
Max.	Ash (% m/m)	0.010	0.010		0.010		0.010	
Min.	Flash point (°C)	43.0	60.0		60.0		60.0	
Max.	Pour point in Winter (°C)	-	-6		-6		0	
Max.	Pour point in Summer (°C)	-	0		0		6	
Max.	Cloud point in Winter (°C)	-16	Report		Report		-	
Max.	Cloud point in Summer (°C)	-16	-		-		-	
Max.	Cold filter plugging point in Winter (°C)	-	Report		Report		-	
Max.	Cold filter plugging point in Summer (°C)	-	-		-		-	
Min.	Calculated Cetane Index	45	40		40		35	
Max.	Acid Number (mgKOH/g)	0.5	0.5		0.5		0.5	
Max.	Oxidation stability (g/m³)	25	25		25		25	
Max.	Fatty acid methyl ester (FAME)	-	-	7.0	-	7.0	-	7.0
Max.	Lubricity, corrected wear scar diameter (wsd 1.4 at 60°C) (um)	520	520		520		520	
Max.	Hydrogen sulphide (mg/kg)	2.00	2.00		2.00		2.00	
	Appearance	Clear & Bright					-	

ABS – Lubricity, Compatibility, Poor Ignition & FCC

ABS Fuel Switching Advisory Notice

Incompatibility of Fuels: Mixing two types of fuels can lead to risk of incompatibility between the two fuels, particularly when mixing heavy fuel and low sulfur distillate fuels. If incompatibility does occur, it may result in clogging of fuel filters and separators and sticking of fuel injection pumps, all of which can lead to loss of power or even shut down of the propulsion plant, putting the ship at risk. Compatibility problems can be caused by differences in the mixed fuels' stability reserves. HFO fuels typically have high aromatic levels and contain asphaltenes. If the stability level of the HFO is low there can be difficulties when mixing with more paraffinic, low sulfur fuels and as a consequence the asphaltenes can precipitate out of the blend as heavy sludge, causing clogging Compatibility test kits are available that can be used when bunkering both HFO and low sulfur fuel.

Lack of Lubricity: Low sulfur fuels, particularly ULSD fuel, can have low lubricity. The reason for this is that sulfur in chemical combination with other components of fuel oil has a lubricating effect. Lack of lubricity can further promote sticking and seizing of fuel pumps caused by low viscosity. The ISO 12156-1 standard offers a test method for fuel lubricity and fuel suppliers can be requested to carry out this test. If the test results are outside commonly used limits, i.e. 460 to 520 microns, fuel suppliers can be requested to add a lubricity additive. Consideration must be given,

Low Sulfur Heavy Fuel Oils: Where sulfur levels are required to be 1 to 1.5 percent low sulfur heavy fuels (LSHFO) may be available in some areas. In the past these were commonly made from low sulfur crude oils, but it is possible for refineries to install desulfurization units to achieve the low sulfur content. These units are expensive and this method may not achieve wide use. If LSHFO is created by a desulfurization unit, fuel aromaticity may be decreased which can result in lower stability reserves and lower fuel stability. A consequence of this happening is increased fuel incompatibility problems when mixing with regular HFO during fuel changeover. The low sulfur processing can also lead to additional quality problems such as ignition and combustion difficulties and increased catalytic fines levels. In addition, when LSHFO is carried on board for use in an ECA, it is required by MARPOL Annex VI be stored and purified separately from regular HFO. This can require piping changes to the fuel transfer and purification system.

The more complex refining of low sulfur fuel, including the desulfurization process, can lead to fuels with poor ignition and combustion characteristics. This particularly affects medium and high speed diesel engines which are more sensitive to this quality. Studies are underway to understand this phenomenon better.

LSMGO – poor ignition & lubricity

(4) Ignition delay and defective combustion

Today's low sulphur fuels tend to have low viscosity and low carbon residue contents. In the production process of such fuel oils, a large quantity of high aromatic Clarified Oil (CLO) as cutter stock is likely to be used. High aromatic fuel oils tend to have poor ignition and combustion properties, and this may cause combustion problems leading to an abnormal wear of piston rings/cylinder liners.

In cases where a sign of abnormal condition such as high exhaust gas temperature, etc. is observed, the following measures may be effective onboard ships:

- Reducing the engine output
- Lowering the cylinder cooling water temperature
- Temporarily increasing the cylinder oil
- Raising the scavenging air temperature
- Advancing the fuel injection timing
- Enhancing fuel cleaning
- Mixing with normal fuel
- Adding combustion promoter

irective

ClassNK
Technical Information

No. TEC-0797
Date 28 December 2009

ation No. TEC-0687 dated 14 December 2006, ships
equired to use marine fuels with the sulphur content
C directive 2005/33/EC.

(5) Low viscosity and low lubricity.

Low lubricity of gas oils is acknowledged as the most problematic issue relating to properties of low sulphur fuels. Examples of troubles caused by the low lubricity of fuel oils include, but not limited to, abnormal wear of plungers/barrels of, or oil leaking from fuel injection pumps of generator diesel engines. In general, fuel oil lubricity is considered to be derived from oil film forming ability due to the oil's viscosity and lubricity of sulphurs in the fuel oil.

Although the viscosity of MGO is extremely lower than that of other kinds of fuel (1.5 cSt at 40 °C for DMA grade of ISO 8217), such a low viscosity range is not generally taken into account at design stages of equipment with a slide member, such as fuel injection pumps, etc.

In order to prevent troubles caused by low lubricity of fuel oils, installing a fuel oil cooler and/or using additives for improvement of the fuel oil lubricity may be effective.

ons of machinery have been pointed out.
uels in Diesel Engines and Boilers" is

onsidered for establishment of measures
g by ClassNK.

anagement companies are requested to
on of the machinery can be maintained

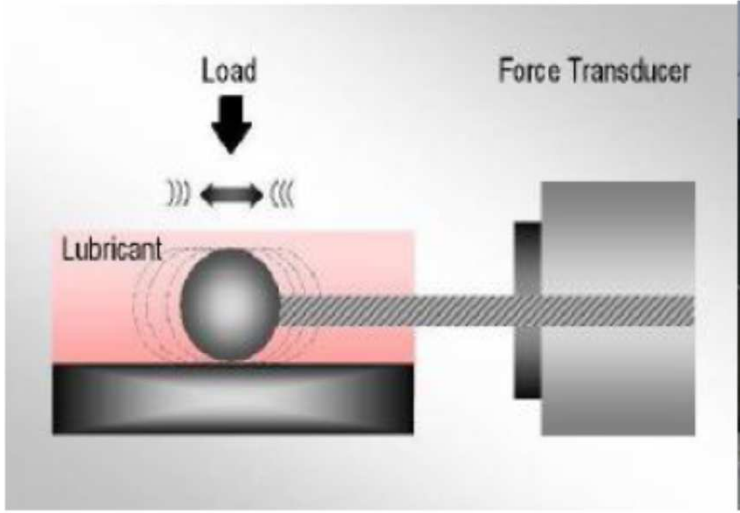
Minimum Viscosity

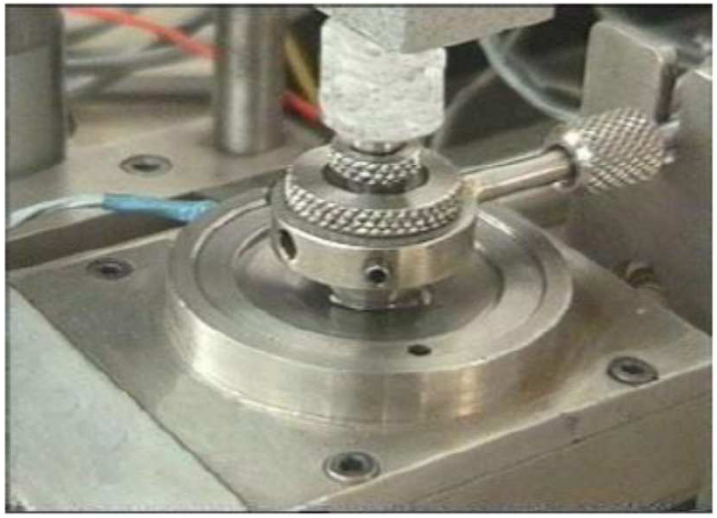
Typical minimum viscosity levels for various engine types are listed below. Engine makers should be consulted for limits applicable to any specific engine as the minimum viscosity limits do vary between engine makers and engine types from the same maker.

- Slow Speed Diesel Engines (cross head type with rated speed of less than 400 rpm): 2 cSt is typical minimum fuel viscosity.
- Medium Speed Diesel Engines (trunk piston type with rated speed of 400 rpm to less than 1400 rpm): 1.8 to 3.0 cSt is minimum viscosity depending on make and type.

- **Vapor lock by over heating**
- **Poor lubrication**
  - **Excessive wear**
  - **Sticking**
- **Balance problem by different fuel injection**
- **Carbon deposit on leaking nozzle.**

ASTM6079-99





HFRR is capable of rubbing a steel ball loaded with 200 g mass against a stationary steel disk completely submerged in a test fuel at 60 C. The apparatus uses a 1-mm stroke length at a frequency of 50 Hz for 75 min. After 75 minutes of test time, the ball is removed from the vibrator arm and cleaned. The dimension of the major and minor axes of the wear scar are measured under a microscope and recorded as HFRR wear scar diameter

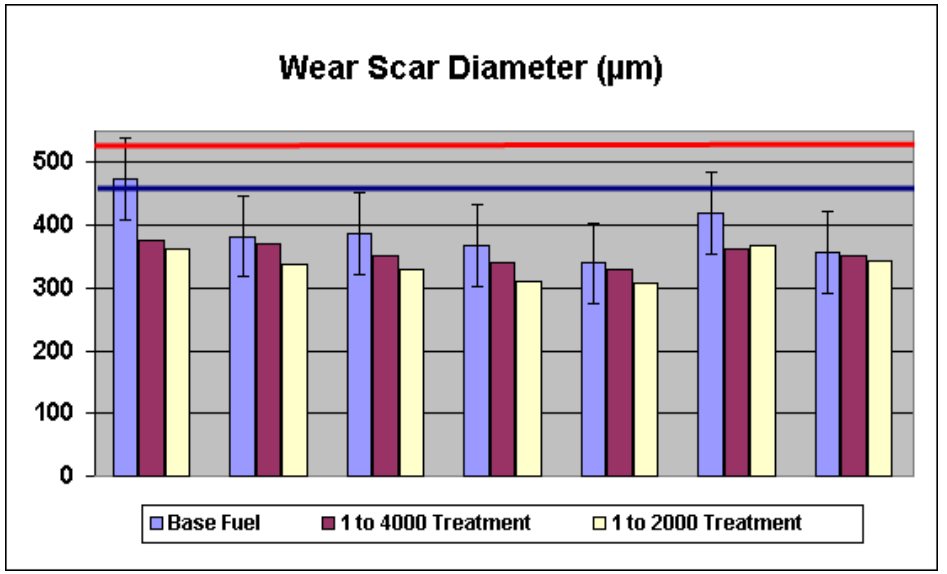
AMERGY® XLS

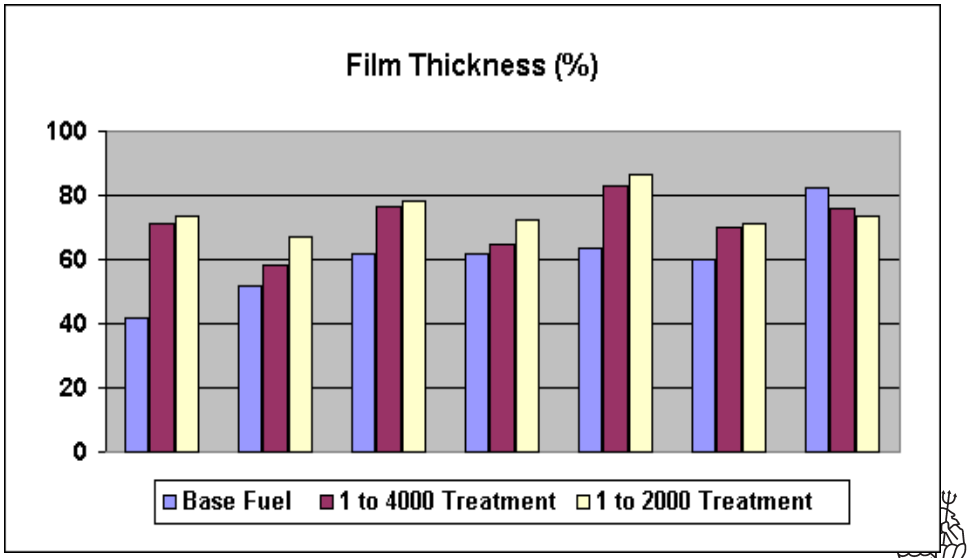
HFRR results show the following:

AMERGY® XLS

- Reduced Wear Scar Diameter (WSD)
- Increased Film Thickness

Reduced WSD and increase in Film Thickness shows that AMERGY XLS restores lubricity in marine fuels





AMERGY XLS – 2850 vessels

Customized treatment for low sulfur fuels

- **Lubricity agent**
  - prevents injection equipment seizures
  - prolongs life of injection equipment.
- **Stabilizing and anti-oxidation agents**
  - improves long term storage of low sulfur fuel oils
  - protects premium fuel from destabilizing
- **Detergent for cleaner injectors**
  - reduces likelihood for carbonized deposits
- Dosage rate of 1:5000

THREE-IN-ONE TREATMENT!

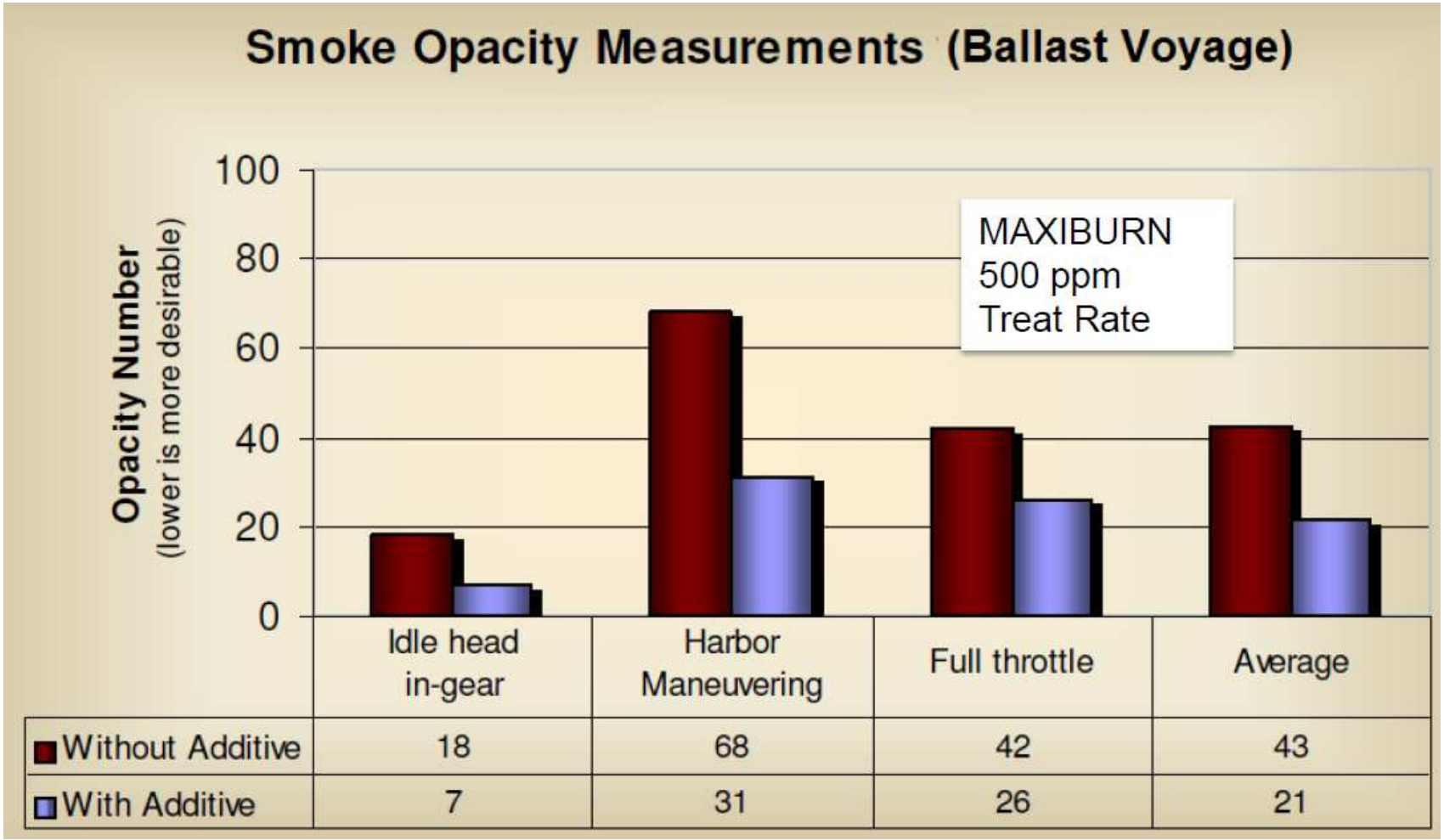
Ignition Quality problem - LSMGO

Advised Bunker Details

Viscosity cSt	3.739
Density @ 15°c kg/l	0.8667
Sulphur	0.087
Quantity MT	109.224
Seal Number Lab	1510996
Tag Seal Numbers Lab	1804606
Seal Number Vessel	NOT STATED
Seal Number Supplier	NOT STATED
Seal Number MARPOL	256062 / 2400258 / 065910

		Required	Tested
Sample		1	Red
ISO-F Grade(2010/12)		DMAULS	--------
K Viscosity at 40oC	cSt	2.0 Min / 6.0 Max	3.366
Density @ 15°c	kg/l	0.8900 Max	0.9071
Water Content	% v/v	-	< 0.02
Ash Content at 550oC	% m/m	0.01 Max	< 0.010
Total Sediment Existent	% m/m		< 0.01
Net Specific Energy	MJ/kg		42.01
Gross Specific Energy	MJ/kg		44.62
Colour	n/a		Brown
Appearance			Clear
Sulphur Content	% m/m	0.087 Max	0.17
Pour Point	°C	0 Max	< -9
CFPP	°C		< -9
Flash Point	°C	60 Min	> 70.0
MCR 10%	% m/m	0.30 Max	0.33
Cetane Index	Index	40 Min	35

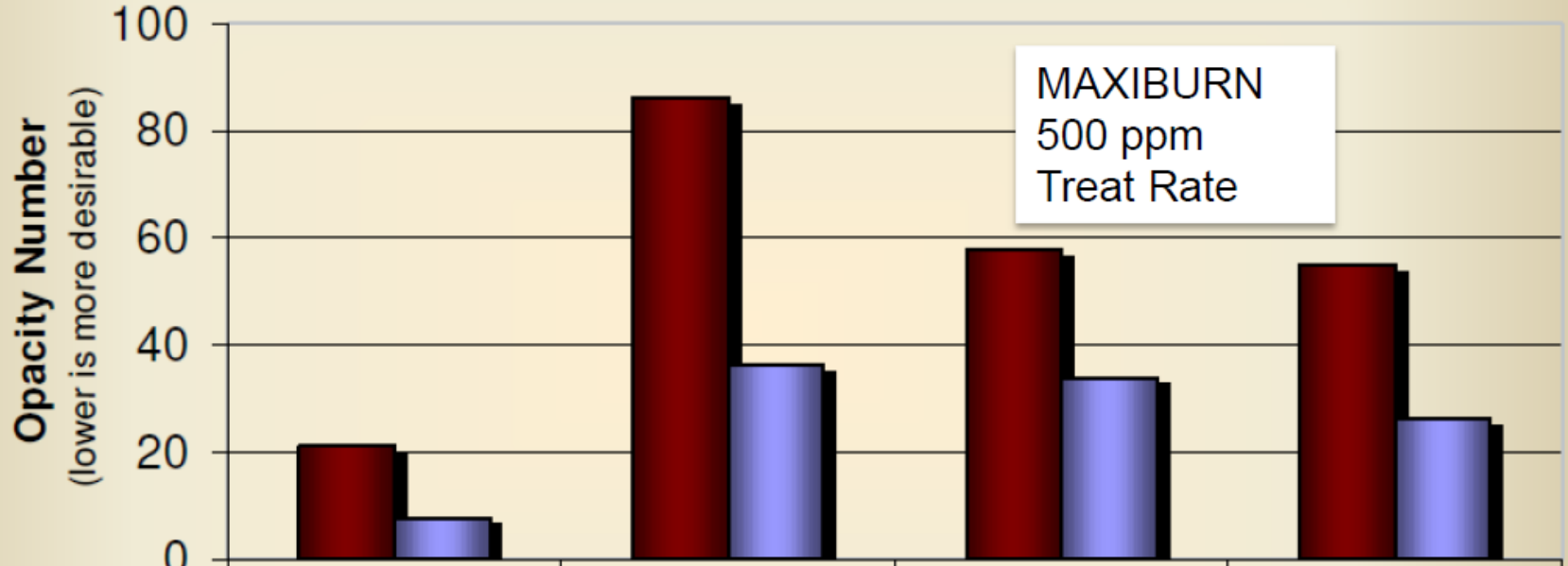
MAXIBURN – Improve Port Maneuvering



	Idle head in-gear	Harbor Maneuvering	Full throttle	Average
Without Additive	18	68	42	43
With Additive	7	31	26	21

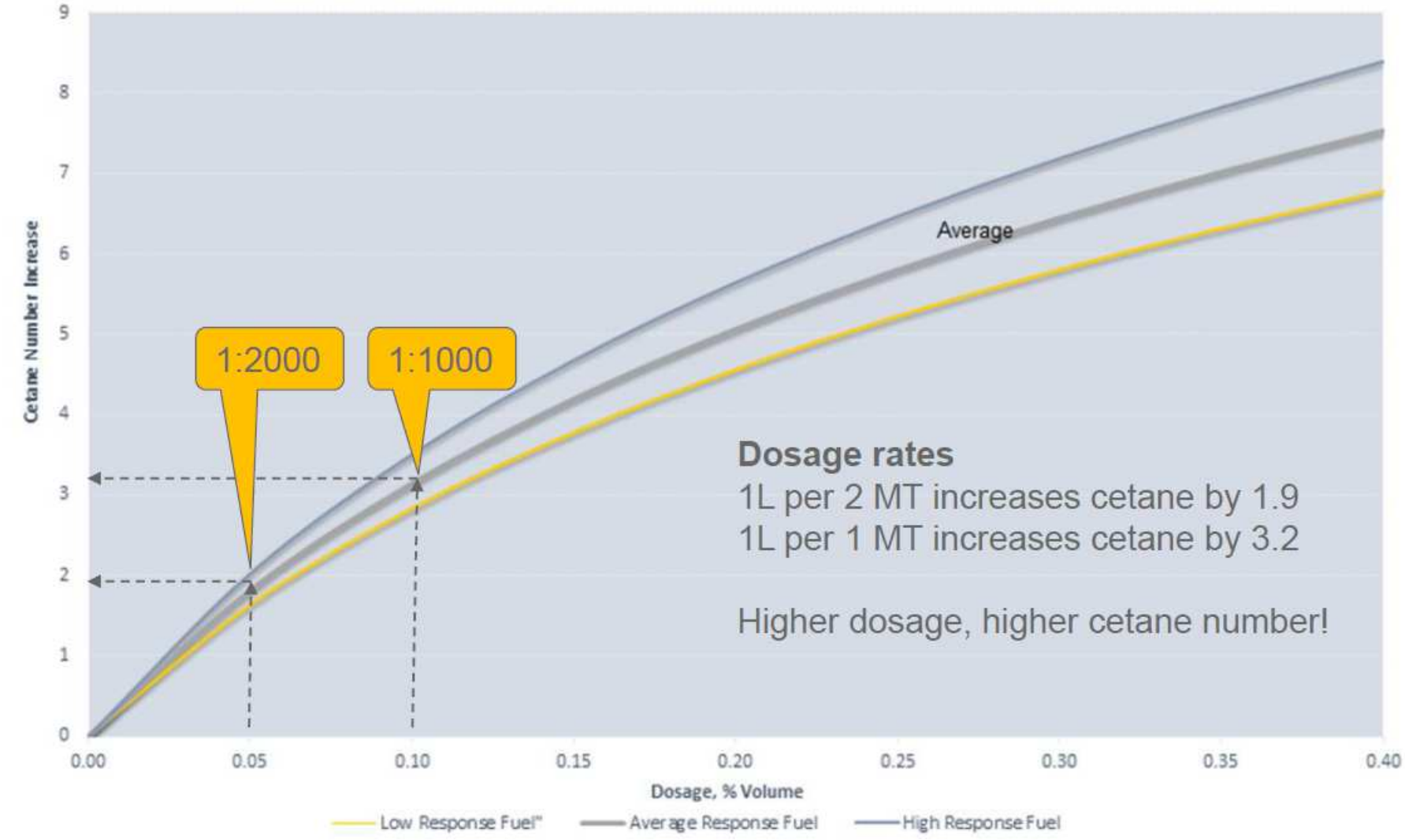
MAXIBURN –Reduces Smoke by 50%

Smoke Opacity Measurements (Fully Loaded)



	Idle head in-gear	Harbor Maneuvering	Full throttle	Average
Without Additive	21	86	58	55
With Additive	8	36	34	26

MAXIBURN –Increases Cetane Numb



MAXIBURN - Improve ignition and combustion

- organometallic combustion & ignition improver
- Premium blend of stabilizers, dispersants, detergents, organometallic combustion improvers, cetane improvers, and corrosion inhibitors
  - Stabilizes fuel in storage by reducing oxidation and destabilization
  - Disperses any water contamination
  - Detergents clean filters, injectors, and cylinder liners
  - Inhibitors prevent corrosion from fuel contaminants
  - Cetane improvers shorten ignition delay and increase performance at low loads
  - Combustion improvers minimize unburned carbon formation
- Improves overall combustion
  - Reduces smoke opacity (~ 35% to 62%)
  - Reduces fuel consumption (~ 2.4% to 4.4%)

LSFO 0.1% – alternate fuels

Source: Lloyds

Characteristics	Unit	Limit	HDME 50 (EXXONMOBIL)	Fuel Oil (Chemoil)	DMB (Chemoil)	Fuel Oil (Chemoil)2	ULSFO (Shell)	SK ULSFO (SK Energy)	BP 0.1 RMD (BP)	Eco Marine Fuel (Lukoil)
Kinematic viscosity at 50 °C	mm2/s	min/max	25 to 45	16.84	10.5	26.3	10-60	30~40	6-13	65
Density at 15 °C	kg/m3	max	895 to 915	0.8589	0.885	0.896	790-910	0.928	850-890	0.91
Cetane index	—	min			40				—	
CCAI	—		795 to 810			795	800	790~800	760-820	860
Sulphur	mass %	max	0.1	0.084	0.085	<0.1	<0.1	<0.1	0.10	0.095
Flash point	°C	min	70	>60	70	>60	>60	70	60	60
Hydrogen sulfide	mg/kg	max	1		0.1		<2		2	2
Acid number	mg KOH/g	max	0.1		0.1	2.35	<0.5		2.5	2.5
Total sediment existent	mass %	max	0.01	0.01	0.05	0	0.01-0.05	0.02	—	
Total sediment aged	mass %	max	0.01	0.01		0.01	0.01-0.05	0.02	0.07	0.1
Oxidation stability	g/m3	max	0.01						—	
Carbon residue: micro method	mass %	max	0.3	<0.10	0.1	3.8	2	6	4	14
Cloud point	°C	max	—							
Pour point (upper) W	°C	max	9 to 15	-20	-4	-6	18	20~25	+27	20
S	°C	max	9 to 15							
Appearance	—	—	brown/ green - opaque	Not Clear and bright	ɔt Clear and brig	Not Clear and bright		Black	—	
Water	volume %	max	0.05		0.05		0.05	0.2	0.3	0.1
Ash	mass %	max	0.01	0.003	0.005	0.06	0.01	0.05	0.04	0.07
Lubricity, (wsd 1,4) at 60 °C	µm	max	320		310				—	
Vanadium	mg/kg	max	1			<1	2	0.7	50	2
Sodium	mg/kg	max	1	4		1	10	2	50	2
Al & Si	mg/kg	max	3	<3		<10	12-20	10~20	25	17
Calcium	mg/kg	max	1	13		175	free of ULO	5		free of ULO
Phosphorus				7		<1	free of ULO			free of ULO
Zinc	mg/kg	max	1	2		<1	free of ULO	1		free of ULO

SHELL ULSFO – Blended distill fuel - S 0.1%

- Avoid mixing with other fuel whenever possible.
- Shell ULSFO should be tested for compatibility with previously bunkered fuel (e.g. using ASTM D4740 spot test) in the ratio that it is likely to mix in the fuel system.
- Bunker storage tanks should be completely empty and free of sludge where possible. Unpumpable fuel oil should less than 0.5 % of Shell ULSFO to be bunkered
- When being stored for long periods or in cold climates the temperature of the fuel should not drop below its pour point.
- FCC and sludge from previous bunker fuels may build-up in the bottom of tanks. Shell ULSFO has a cleaning effect on tanks and so cleaning the storage, settling and service tanks prior to using Shell ULSFO is recommended.

Accident

Manhattan Bridge. Credit: Kees Torn/Wikimedia Commons Credit: Kees Torn/Wikimedia Commons

30 June 2017

Users of low sulphur marine gas oil are being advised to monitor it closely when used in cold temperatures following a fatal boiler furnace explosion on board a container ship in January 2017.

The ship's engine room oiler, 35-year-old Celso Banas from the Philippines, died of multiple injuries during the explosion on the Japan-registered Manhattan Bridge.

The second engineer suffered severe burn injuries to his face and right arm, which required a skin graft.

At the time of the incident, the ship was berthed alongside a container terminal in Felixstowe.

Accident by Wax in LSMGO

Boiler explosion highlights MGO challenges

A safety bulletin from the UK Marine Accident Investigation Branch (MAIB) concerning a fatal explosion on the *Manhattan Bridge* highlights the challenges of low-sulphur distillate fuel.

One engineer was killed and another badly injured in January, when an auxiliary boiler on the containership blew up. The bulletin noted that the vessel, which was berthing alongside a container terminal in Felixstowe, had been operating on marine gas oil (MGO) for several days prior to the incident, having switched from heavy fuel oil when it entered the North Sea ECA.

An examination of the boiler fuel system by the burner unit manufacturer identified the build-up of waxy deposits in the supply filter, sufficient to restrict the fuel flow. The formation of waxy deposits at low temperatures has been attributed to the increased paraffin content in some MGO. The bulletin noted that 'industry reports indicate an increased incidence of boiler and marine diesel engine performance problems in colder waters following the implementation of the more stringent sulphur emissions limit [in 2015]'.

Inspection after the boiler explosion revealed waxy deposits in the unit's fuel line filter

The MAIB also noted that the rules under which the bunkered MGO was sampled did not include the cloud point (CP) test measuring the temperature at which crystals visibly begin to form, or the cold filter plugging point (CFPP) test measuring the lowest temperature at which fuel of a given volume, drawn by vacuum through a standardised filter (45 micron) within a specified time (60 seconds), continues to flow.

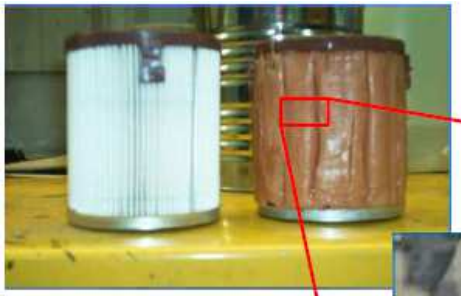
MAIB noted that these tests were only included under the 2017 version of the ISO 8217, which was introduced in March. The MGO loaded at Rotterdam in November 2016 was declared under the 2005 version of the standard. There was thus no way for the crew to know that the MGO, which later was shown to have a CFPP of 14°C, would lead to wax formation if not properly heated in the 4°C ambient air temperature at Felixstowe.

"It is essential that vessel operators carefully consider anticipated ambient air and sea temperatures that will be experienced during the voyage when purchasing low-sulphur MGO bunkers," the bulletin concluded. Monitoring of MGO's visual appearance, inspections of fuel filters, checking fuel system pressures and maintaining of tanks and pipework above CP and CFPP temperatures would control the risk, the MAIB noted.

Recommendation – improve cold flow property

- It says the marine gas oil loaded on the Manhattan Bridge was only subjected to the PP test, as per regulations at the time.
- The MAIB is recommending that when operating in cold climates, the risk of waxy residue developing in the vessel's fuel lines can be controlled by:
  - Closely monitoring the visual appearance of low sulphur MGO bunkers for signs of wax precipitation.
  - Conducting regular fuel filter inspections and close monitoring of fuel system pressures.
  - Maintaining the temperature of the low sulphur MGO in the vessel's tanks and pipework above the CP and CFPP temperatures to avoid the possibility of filter blocking.
- It says the addition of cold-flow improver chemicals to the low sulphur MGO in the vessel's storage tanks should only be considered as a last resort under the strict guidance of an additive supplier.

LSFO pour point



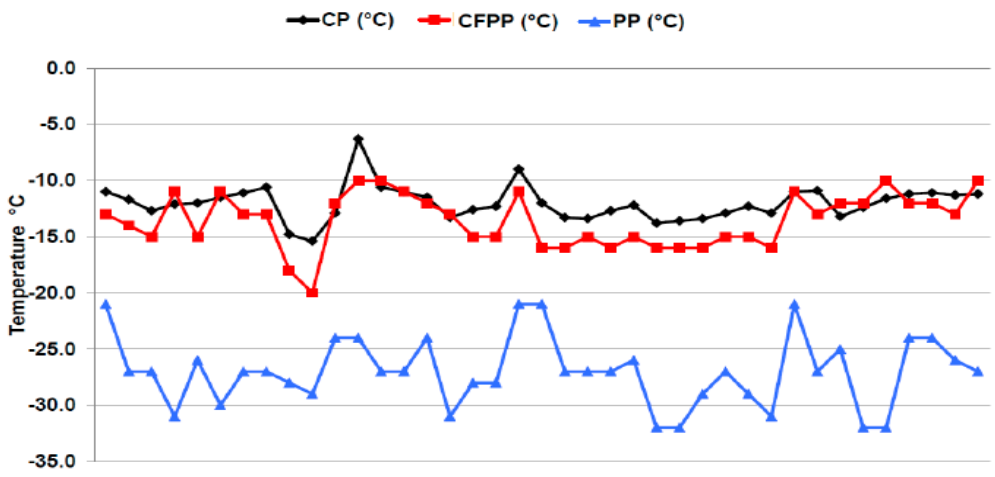
Fuel Filter
New vs. Choked

Objective: Maintain fuel flow through the filters and to engine

Fuel Filter Porosity

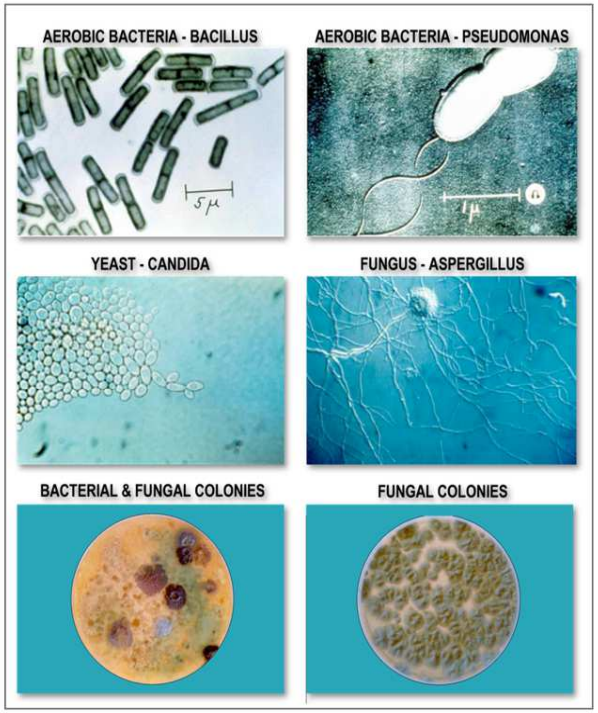
AMERGY PPD

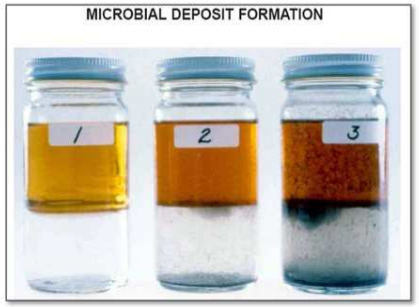
- AMERGY PPD pour point depressant is a low temperature flow improver for marine distillate fuels, including marine gas oil (MGO) and ultra-low sulfur diesel (ULSD) fuel.
- AMERGY PPD modifies the crystallization of the wax or paraffin normally found in distillate fuels when subjected to low storage temperatures

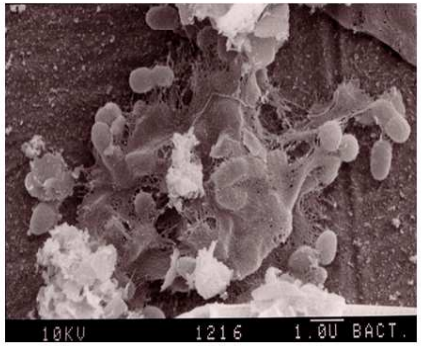


AMERGY PPD Dosage Rate	Stability, Spot Number		
Cloud Point, °C	1	2 or 3	4 or 5
CP ≤ -16.0	No treatment necessary		
-16.0 < CP ≤ -12.0	1:20,000	1:15,000	1:10,000
-12.0 < CP ≤ -8.0	1:15,000	1:10,000	1:5,000
-8.0 < CP ≤ -4.0	1:10,000	1:5,000	1:2,500
-4.0 < CP ≤ 0.0	1:5,000	1:2,500	1:1,000
0.0 < CP ≤ +4.0	1:2,500	1:1,000	1:500
+4.0 < CP ≤ +8.0	1:1,000	1:500	1:500
> +8.0	1:500	1:500	1:500

AMERSTAT® 25







FAME – hydrophilic, naturally attracts water

Water – naturally attracts microbes

Microbes

- Thrive @fuel-water interface
- Create biofilm
- Consume oil, "breathe" sulfate, oxidize iron (steel)
- Create waste (as sludge), generate H_2S, corrode tank/pipe surfaces

- **Protects from all types of microbial growth for all marine fuel oil grades**
- **Unparalleled dosage treatment rates**
  Initial: 1 to 12500
  Maintenance: 1 to 25000
- **Kills sulfate reducing bacteria (SRB) to prevent H_2S production, Minimizes metal corrosion, Maintains cleaner fuel storage tanks and fuel filters**

Proposal – ECA ULSFO (S ≤ 0.1%)

- **ECA S 0.1% - AMERGY XLS**
  - Improve lubricity preventing excessive wear on pumps & nozzles
  - Preventing compatibility problem during fuel exchange
  - Mitigate nozzle carbon deposit by leaking fuel.
  - Improve oxidation problem.
- **Harbor Maneuvering – AMERGY XLS + MAXIBURN**
  - Prevent starting problem by increase cetane number.
  - Improve smoke conditions.
  - Prevent acid corrosion problem
- **Cold climate – AMERGY PPD + AMERGY XLS**
  - **Prevent wax problem by reduce CFFP and Pour point.**
  - **Prevent fire hazard by heating LSMGO**
- **LSMGO long term storage - AMERSTAT 25 + AMERGY XLS**

Proposal – VLSFO (S ≤ 0.5%)

- **FO Compatibility & Stability Tester**
- **Improve Compatibility and Stability – AMERGY 222**
  - Preventing excessive sludge problem
  - Kept stable performance of purifiers and filter
  - Reduce Asphaltene clustering in Service system
  - Improve combustion
- **Improve Pour Point – AMERGY 222 + AMERGY PPD**
  - Heating is recommended to improve pour point.
  - Use additional AMERGY PPD, if heating not enough.
- **Keep performance of fuel atomization equipment – AMERGY ULS-D**
  - Clean internal deposit of HP pumps and Nozzles
  - 1 pails to Settling tank in every 2 weeks.

Drew Marine