SHIP SUPPLIER INDUSTRY OFFSHORE

LIMAN MARINE SERVICES

AN INTRODUCTION

Mechanical Heavy Fuel Treatment Systems

LMS

Our proprietary Heavy Fuel Treatment and Asphaltene Micro De-Agglomeration Processing System was developed and successfully tested in large heavy fuel marine diesel engines over a number of years. Our equipment micronizes HFO via liquid shear, ultrasonic waves and acceleration power reducing fuel droplet size while breaking down asphaltene molecular chain agglomerations to a 3 micron consistency. This enables asphaltene separator pass-through and combustion enhancing engine efficiency, reducing NOx and particulate emissions. Micro De-Agglomeration of 80% of asphaltene agglomerations for useable fuel improves fuel efficiency and reduces sludge disposal costs and logistics. Based on tried and true engineering concepts, the proprietary and innovative design produces unmatched economic benefits.

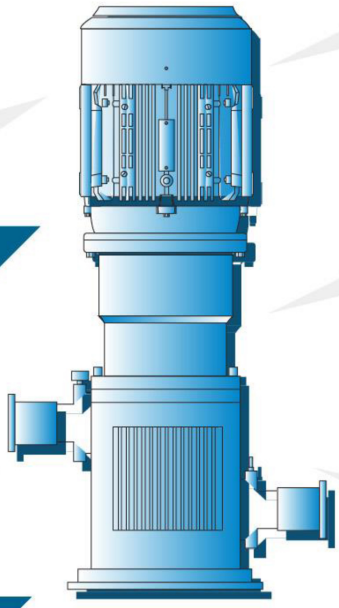
WHAT IS IT?

The proprietary Heavy Fuel Micronization and Asphaltene Micro De-Agglomeration Systems are easily and inexpensively installed in-line, are high speed and an intricately designed proprietary stator/rotor system with state-of-the-art Siemens co-designed software controls and sensors, to produce extreme shearing forces that process fuel and asphaltene agglomerations to approximately three microns.

- Fuel, including asphaltene agglomerations, flows over the rotor at high speed.
- The arrangement, location and alignment of every single blade is based upon a highly complex proprietary design.
- Powerful liquid shear forces are created, micronizing the fuel and breaking up the asphaltene agglomerations.
- Organic substances are treated.
- Inorganic substances like cat fines pass through unaltered.
- There is no physical grinding, no metallic contact.
- The rotor is made from 99.99% pure aluminium - no electro-static issues.
- The surface has a special finish that approximates a diamond coating.
- Wear is virtually eliminated.
- Magnetic coupler driven so no metal on metal contact or seals to replace.

WHAT DOES IT DO?

The system has produced the following benefits in our installed vessel base:



UP TO
90%
LESS PARTICULATES

65% TO 90% LESS PARTICULATES
IN FLUE STACK

15%
REDUCTION IN NOx

NOx REDUCTION

25%
LESS MAINTENANCE

REDUCED MAINTENANCE TIME & COST

>2%
CONSUMPTION IMPROVEMENT

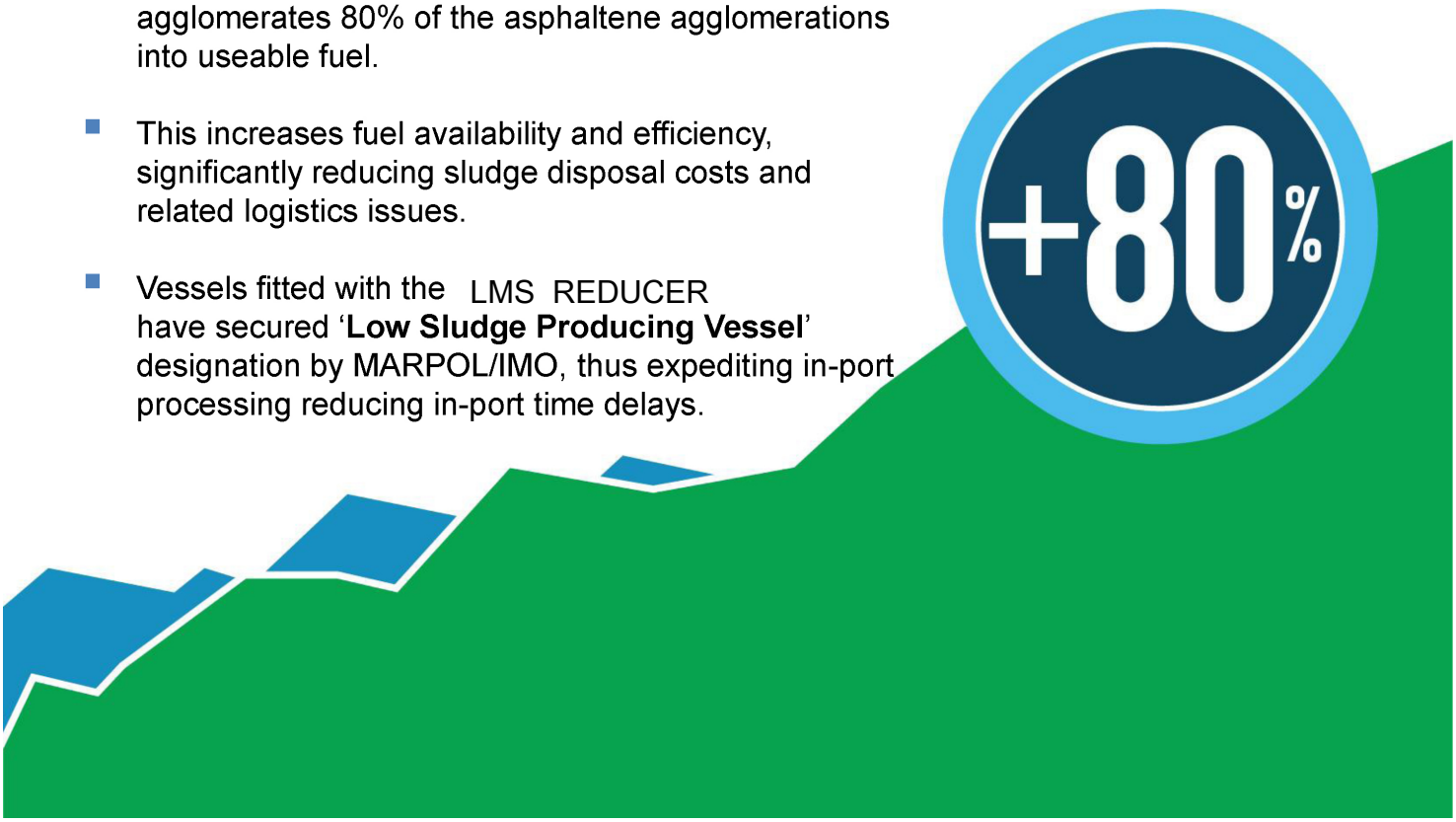
FUEL CONSUMPTION
IMPROVEMENT

80%
LESS SLUDGE

ASPHALTENE AGGLOMERATIONS
CONVERTED TO USEABLE FUEL WITH
REDUCED DISPOSAL COSTS.

ASPHALTENES REPROCESSING & RECOVERY

- The LMS REDUCER micro de-agglomerates 80% of the asphaltene agglomerations into useable fuel.
- This increases fuel availability and efficiency, significantly reducing sludge disposal costs and related logistics issues.
- Vessels fitted with the LMS REDUCER have secured '**Low Sludge Producing Vessel**' designation by MARPOL/IMO, thus expediting in-port processing reducing in-port time delays.

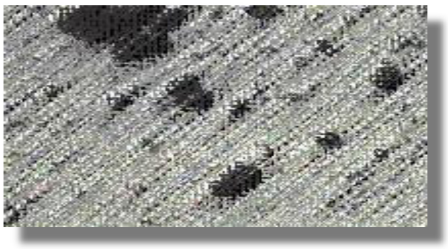


SUMMARY

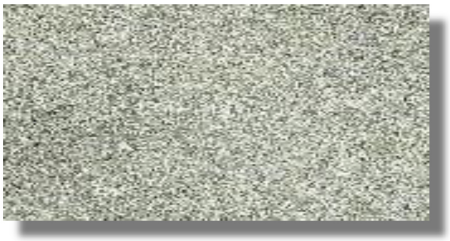
IRREGULAR FUEL MOLECULAR STRUCTURE AND ASPHALTENE AGGLOMERATION NEGATIVELY IMPACTS EFFICIENCY, PRODUCTIVITY AND PROFITABILITY.

- Fuel exists as droplets, not individual molecules.
- Asphaltenes: Dynamically and constantly formed tar-like particles in HFO which are usually discarded as sludge even though they have a high calorific value.
- Fuel droplets typically vary in size in the range of 70 – 120 microns in diameter before treatment.
- After treatment, droplets are reduced to a uniform size of less that 3 micron diameter creating a multiple increase in fuel surface area enhancing oxygenation and thus improving combustion.
- Aggregate fuel droplet surface area can be increased by as much as 20 to 40 times.

HEAVY FUEL UNDER A 10 MICRON SCALED MICROGRAPH



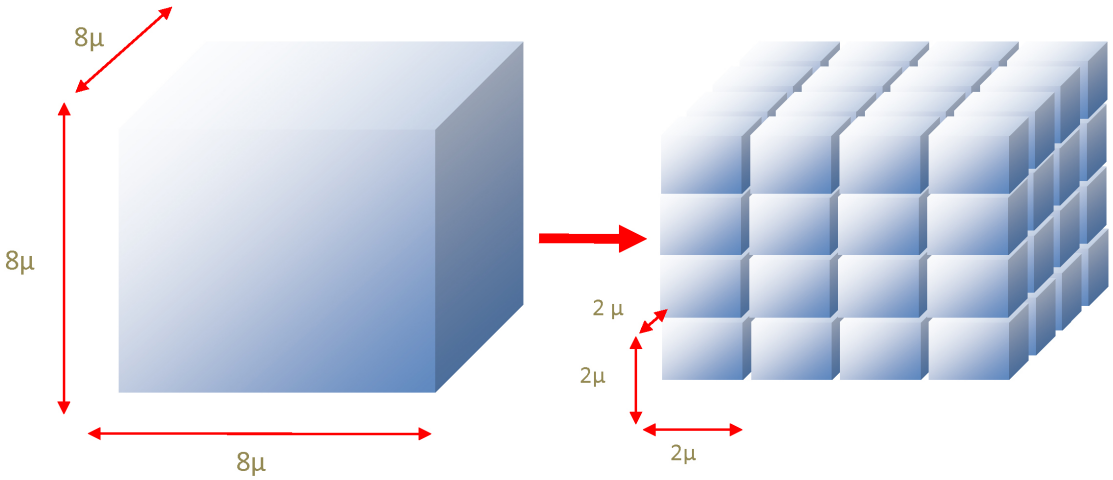
BEFORE TREATMENT



AFTER TREATMENT

HOW DOES IT DO IT?

The effect of reducing droplet size on surface area



1) Greater surface area
2) Better distribution of vapour in cylinder
3) More contact with oxygen
4) Improved carburetion
5) Better combustion
6) Reduced sludge

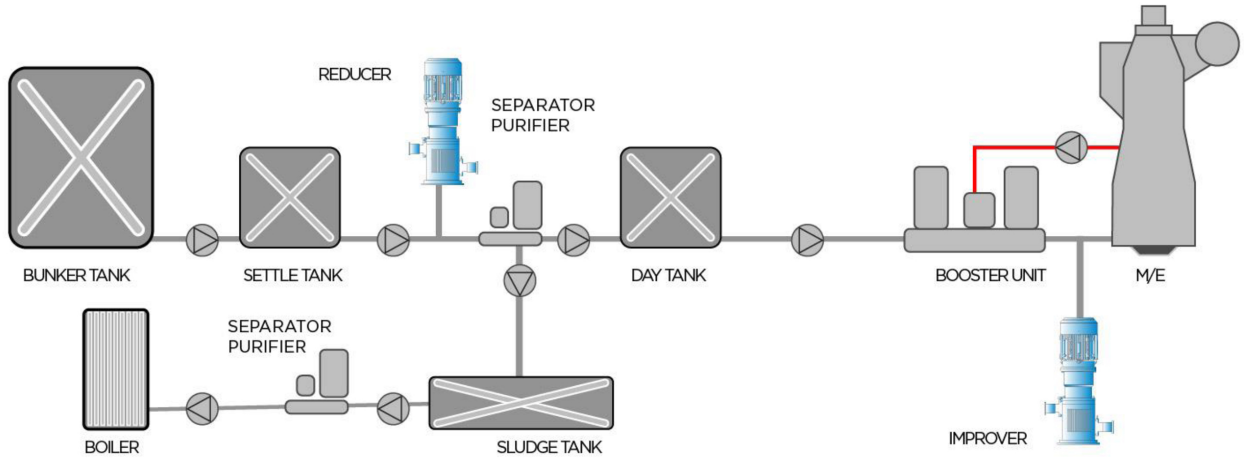
SURFACE AREA= 8µ x 8µ x 6 = 384µ²

SURFACE AREA = 2µ x 2µ x 6 = 24µ²

TOTAL S.A. = 24µ² x 64 = 1.536 µ²

HOW DOES IT DO IT?

Option 1

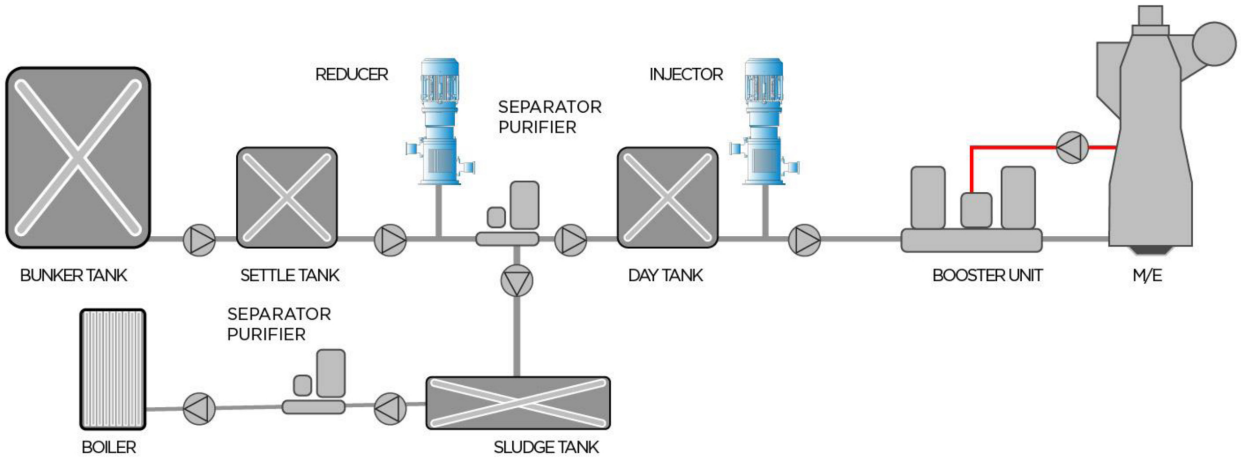


- **REDUCER**
  Installed between the settling tank and the separator/purifier where it converts asphaltene agglomerations to burnable fuel, thereby reducing sludge and improving separator performance.

- **IMPROVER**
  Installed before the fuel rail, reduces fuel droplet size, enhancing oxygenation and combustion, therefore improving fuel efficiency. It also processes remaining asphaltenes, thereby improving MEP while decreasing particulates & NOx.

HOW DOES IT DO IT?

Option 2



- **REDUCER**
  Installed between the settling tank and the separator/purifier where it converts asphaltene agglomerations into burnable fuel, reducing sludge and improving separator performance.

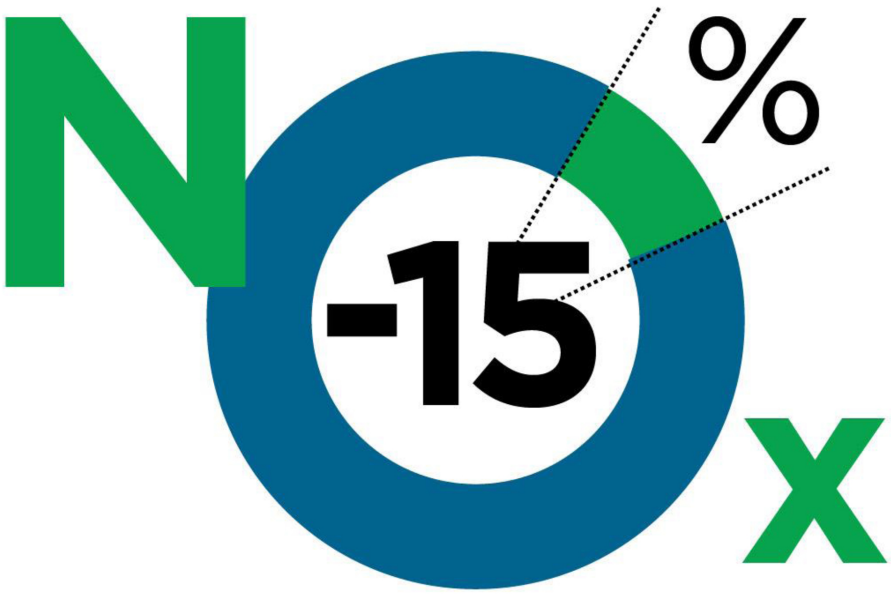
- **INJECTOR**
  Installed between the day tank and booster unit. It reduces fuel droplet size and injects and emulsifies water to further increase available surface area for oxygenation and combustion, enhancing efficiency and performance. It also processes remaining asphaltenes, thereby improving MEP while decreasing particulates & NOx.

PARTICULATE REDUCTION

Both LMS Systems micronize Heavy Fuel Oil droplets to three microns enhancing oxygenation and creating more efficient and complete combustion which reduces stack particulate emissions.

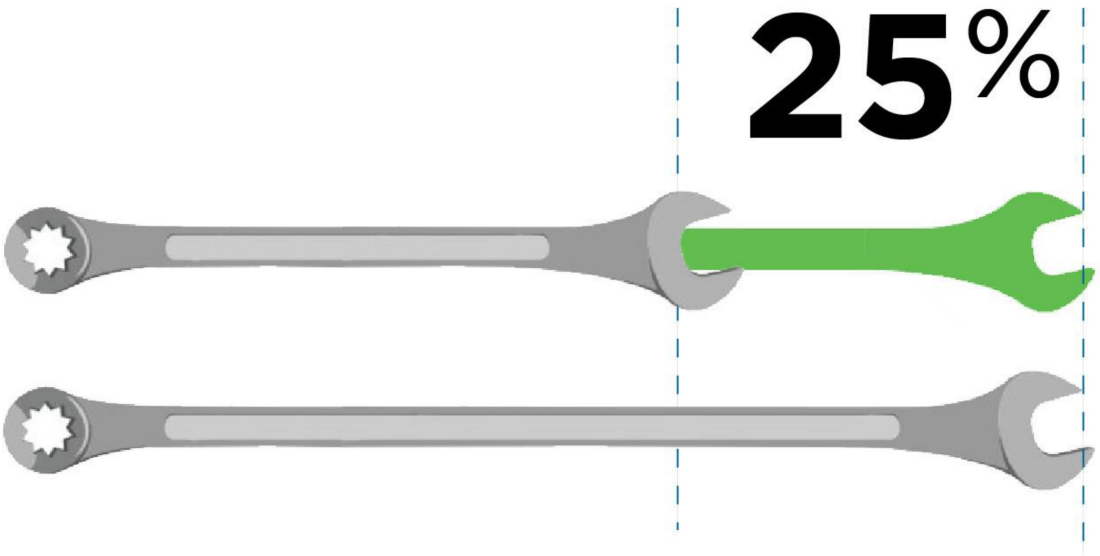
REDUCTION IN NOx

The enhanced combustion efficiency created by the LMS IMPROVER or INJECTOR reduces NOx emissions by 15%.



REDUCED MAINTENANCE

Improved combustion efficiency created by the LMS IMPROVER or INJECTOR keeps the engine cleaner, reduces filter expenses, overall maintenance and overhaul expenses by up to 25%.



REDUCED FUEL CONSUMPTION

>2%

LESS FUEL CONSUMPTION

The combination of converting 80% of asphaltene agglomerations into useable fuel coupled with improved fuel combustion efficiency through increased oxygenation, generates well in excess of 2% fuel savings, and in some applications from 4% to 6%.

ECONOMIC BENEFITS

Seven years of development and successful onboard operations demonstrates that the LMS System materially enhances performance, reduces NOx and particulates, and improves overall efficiency of heavy fuel oil fired engines, generating economic benefits in ten areas as follows:

10

These ten areas produce significant operational cost reductions and economic benefits.

ECONOMIC BENEFITS

LMS REDUCER:

1. Micro de-agglomerates asphaltene agglomerations to three microns thereby enabling separator pass-through and combustion thereby converting approximately 80% of asphaltene agglomerations into useable fuel.

2. Reduces sludge creation and handling and disposal costs by approximately 80%.

3. Installation can often enable vessels to secure '***Low Sludge Producer***' certification by MARPOL/IMO leading to fee/tax and scheduling benefits and savings.

ECONOMIC BENEFITS

LMS IMPROVER:

4. Reduces fuel droplet size, thereby enhancing oxygenation and combustion efficiency, and reduces NOx emissions by up to 15%, and particulates reduction by up to 65%, thereby sharply reducing pollution emission fees/taxes.

5. Has been shown to improve fuel consumption efficiency by at least 2%, and often significantly more when combined with the LMS REDUCER.

LMS INJECTOR:

6. Reduces fuel droplet size, emulsifies water and fuel, and thereby enhances oxygenation and combustion efficiency while reducing NOx emissions by up to 20%, and particulates reduction by approximately 90%, effectively reducing pollution emission fees/taxes.

7. Has shown to improve fuel consumption by at least 4% when combined with the LMS REDUCER

ECONOMIC BENEFITS

LMS 'THE SYSTEM'

8. Micronization and homogenization of organic material to three microns enhances separator performance and effectiveness.

9. Reduces main engine and HFO fueled auxiliary generator maintenance, as well as reducing supporting item costs (cleaning, filters etc.) by in excess of 25%.

10. Reduces main engine and HFO fueled auxiliary generator overhaul costs by in excess of 25% due to cleaner engines and auxiliaries.

THE NUMBERS + DATA

MARITIME INDUSTRY EXHIBITS - Additional Background Information:

The following slides contain the referenced test results and data based upon a 24 month trial, and are verified by DNV, GERMANISCHER LLOYD

Items to note:

NO IMPACT ON CAT FINES :

- The units have no impact on cat fines and other inorganic materials including water beyond releasing them from asphaltene agglomeration, facilitating separation.

ORGANIC MATERIAL PROCESSING ONLY:

- The LMS treatment only impacts organic materials such as asphaltene agglomerations.

NOx AND PARTICULATE EMISSIONS REDUCED IN DIESEL ENGINES:

- The following exhibits show the results of LMS Improver and Injector (with water), and the resulting homogenization in heavy fuel diesel engines leading to the reduction of NOx and particulate emissions.

THE NUMBERS + DATA

THE FOLLOWING CHARTS ARE BASED ON TEST DATA EVALUATED AND APPROVED BY M.A.N. & GERMANISCHER LLOYD

Tests #1 and #3 on Cat-Fines performed by FRAS TECHNOLGY and the DNV

TEST 1	Units	437721 1/II Before separator	437722 1/IV After Separator	% Reduction	437726 Sediments after 2 hours
Density @ 15C	kg/m3	1010,9	1011		
Viscosity @ 50C	mm2/s	441	442	-0,2	
Water	%V/V	0,2	0,1	50,0	
Micro Carbon Residue	%m/m	15	15	0,0	
Sulphur	%m/m	2,9	2,9	0,0	
Total Sediment Existent	%m/m	0,06	0,04	33,3	
Total Sediment Potential	%m/m	0,05	0,05	0,0	
Total Sediment Accel,	%m/m	0,04	0,02	50,0	
Ash	%m/m	0,06	0,04	33,3	40,3
Vanadium	mg/kg	150	150	0,0	764
Sodium	mg/kg	29	22	24,1	9031
Aluminium	mg/kg	25	7	72,0	68626
Silicon	mg/kg	26	9	65,4	65534
Iron	mg/kg	32	22	31,3	34997
Nickel	mg/kg	44	46	-4,5	609
Calcium	mg/kg	5	4	20,0	6813
Magnesium	mg/kg	LT 1	LT 1		1333
Lead	mg/kg	LT 1	LT 1		276
Zinc	mg/kg	1	2		1239
Phosphorus	mg/kg	LT 1	LT 1		810
Asphaltene	%m/m	7,6	8,8	-15,8	
Calculated Values					
Net Specific Energy	MJ/kg	39,89	39,94		
CCAI (Ignition Quality)	-	870	870		
Aluminium + Silicon	mg/kg	51	16	68,6	
Test results after runnnig 45 min without homogenizer					

TEST 3	Units	437727 3/I Before homogenizer	437728 3/II Before separator	437729 3/IV After separator	% Reduction	437734 Sediments from bowl after 2 hours	437735 Sediments from top after 2 hours
Density @ 15C	kg/m3	1010,8	1010,7	1010,6			
Viscosity @ 50C	mm2/s	441	441	440	0,2		
Water	%V/V	0,2	0,2	0,2	0,0		
Micro Carbon Residue	%m/m	16	16	16	0,0		
Sulphur	%m/m	2,9	2,9	2,9	0,0		
Total Sediment Existent	%m/m	0,05	0,05	0,03	40,0		
Total Sediment Potential	%m/m	0,02	0,04	0,03	25,0		
Total Sediment Accel,	%m/m	0,02	0,02	0,01	50,0		
Ash	%m/m	0,04	0,05	0,04	20,0	50,6	49,1
Vanadium	mg/kg	142	150	150	0,0	960	943
Sodium	mg/kg	25	25	20	20,0	15403	13596
Aluminium	mg/kg	23	24	6	75,0	82891	79638
Silicon	mg/kg	24	24	7	70,8	77541	68261
Iron	mg/kg	33	31	20	35,5	53215	50868
Nickel	mg/kg	45	46	45	2,2	848	841
Calcium	mg/kg	4	4	4	0,0	9321	8957
Magnesium	mg/kg	LT 1	LT 1	1		1811	1819
Lead	mg/kg	LT 1	LT 1	LT 1		366	366
Zinc	mg/kg	1	1	1		1894	1804
Phosphorus	mg/kg	LT 1	LT 1	LT 1		1110	1024
Asphaltene	%m/m	8,8	8,9	9,3	-4,5		
Calculated Values							
Net Specific Energy	MJ/kg	39,9	39,89	39,9			
CCAI (Ignition Quality)	-	870	870	870			
Aluminium + Silicon	mg/kg	47	48	13	72,9		
Test results after 45 min running homogenizer							

THE NUMBERS + DATA

THE FOLLOWING CHARTS ARE BASED ON TEST DATA EVALUATED AND APPROVED BY M.A.N. & GERMANISCHER LLOYD

Tests #2 and #4 on Cat-Fines performed by FRAS TECHNOLGY and the DNV

TEST 2	Units	437723 2/II Before separator	437724 2/III Heavy liquid outlet	437725 2/IV After separator	% Reduction	437726 Sediments after 2 hours	TEST 4	Units	437730 4/I Before homogenizer	437731 4/II Before separator	437732 4/III Heavy liquid outlet	437733 4/IV After separator	% Reduction	437734 Sediments from bowl after 2 hours	437735 Sediments from top after 2 hours
Density @ 15C	kg/m3	1010,9	1011,7	1010,8			Density @ 15C	kg/m3	1010,8	1010,7	1011,6	1010,6			
Viscosity @ 50C	mm2/s	455	583	453	0,4		Viscosity @ 50C	mm2/s	470	454	572	449	1,1		
Water	%V/V	1,5	9,5	0,8	46,7		Water	%V/V	4,4	4,4	9,7	1,1	-10,0		
Micro Carbon Residue	%m/m	15	14	16	-6,7		Micro Carbon Residue	%m/m	15	16	14	16	0,0		
Sulphur	%m/m	2,9	2,7	2,9	0,0		Sulphur	%m/m	2,8	2,9	2,7	2,9	0,0		
Total Sediment Existent	%m/m	0,05	0,04	0,04	20,0		Total Sediment Existent	%m/m	0,03	0,04	0,01	0,01	75,0		
Total Sediment Potential	%m/m	0,05	0,06	0,03	40,0		Total Sediment Potential	%m/m	0,03	0,04	0,03	0,02	50,0		
Total Sediment Accel.	%m/m	0,07	0,03	0,01	85,7		Total Sediment Accel.	%m/m	0,04	0,04	0,04	0,02	50,0		
Ash	%m/m	0,05	0,07	0,04	20,0	40,3	Ash	%m/m	0,05	0,05	0,11	0,05	0,0	50,6	49,1
Vanadium	mg/kg	144	132	145	-0,7	764	Vanadium	mg/kg	139	149	131	145	2,7	960	943
Sodium	mg/kg	25	112	24	4,0	9031	Sodium	mg/kg	23	26	210	22	15,4	15403	13596
Aluminium	mg/kg	23	14	10	56,5	68626	Aluminium	mg/kg	22	24	16	9	62,5	82891	79638
Silicon	mg/kg	24	14	11	54,2	65534	Silicon	mg/kg	22	24	16	10	58,3	77541	68261
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Magnesium	mg/kg	LT 1	LT 1	LT 1		1333	Magnesium	mg/kg	LT 1	LT 1	LT 1	LT 1		1811	1819
Lead	mg/kg	LT 1	LT 1	LT 1		276	Lead	mg/kg	LT 1	LT 1	LT 1	LT 1		366	366
Zinc	mg/kg	1	1	1		1239	Zinc	mg/kg	1	1	1	1		1894	1804
Phosphorus	mg/kg	LT 1	LT 1	LT 1		810	Phosphorus	mg/kg	LT 1	LT 1	LT 1	LT 1		1110	1024
Asphaltene	%m/m	8,9	8,2	8,8	1,1		Asphaltene	%m/m	7,8	10,8	10,2	9	16,7		
Calculated Values							Calculated Values								
Net Specific Energy	MJ/kg	39,33	35,95	39,64	-0,8		Net Specific Energy	MJ/kg	38,12	39,55	35,85	39,51			
CCAI (Ignition Quality)	-	870	868	870	0,0		CCAI (Ignition Quality)	-	870	870	868	870			
Aluminium + Silicon	mg/kg	47	28	21	55,3		Aluminium + Silicon	mg/kg	44	48	32	19	60,4		
Test results after running 45 min with water injection (app. 40l/h) without homogenizer							Test results after 45 min with water injection (app. 40l/h) and running homogenizer								

THE NUMBERS + DATA

SUMMARY EXTRACT

"Based on our findings using the optical microscope, both samples contain the same particle structures. To inspect the shape and surface structure of such small particles, optical microscopes are not suitable. To investigate the presence and structure of cat fines in particular, Scanning Electron Microscopy was used. By detecting secondary electrons from the specimens, spherical shaped particles composed of Al+Si (i.e. cat-fines) were found in both samples. There is not any difference in the cat-fines between the two samples taken before and after the Reducer".

THE FINDINGS IN THIS DOCUMENT HAVE BEEN REVIEWED AND APPROVED BY DET NORSKE VERITAS (DNV).

Performed by
Tormod Lundberg

FRAS technology

Verified by
Sølve Fjerdingstad

DNV

THE NUMBERS + DATA

LMS - **APPLICATION TO VESSELS**

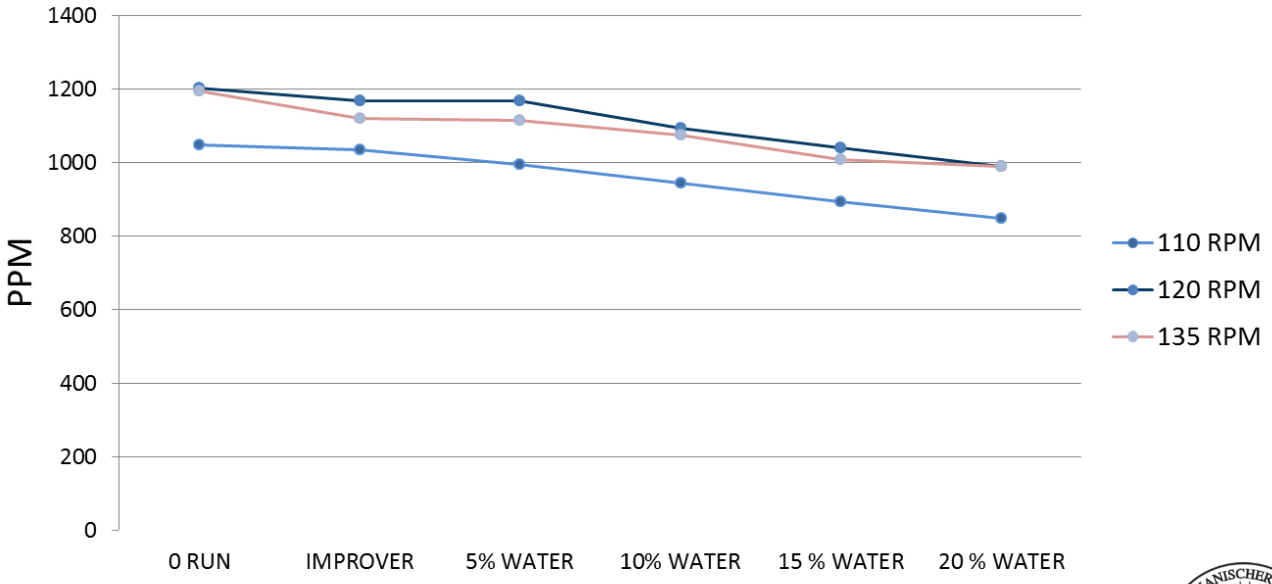
Visible proof on the decrease on Soot (Particulates)

Running in Improver Mode

Running in Injector Mode

THE NUMBERS + DATA

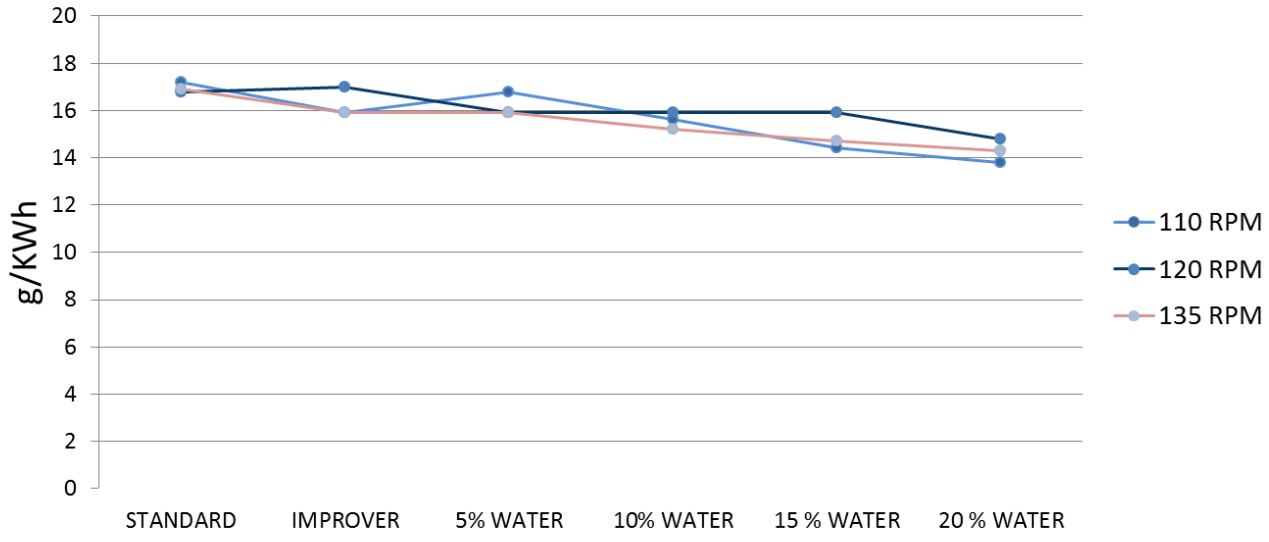
REDUCTION OF AVERAGE NOx



IMO MARPOL ANNEX VI ISO 8178 TEST

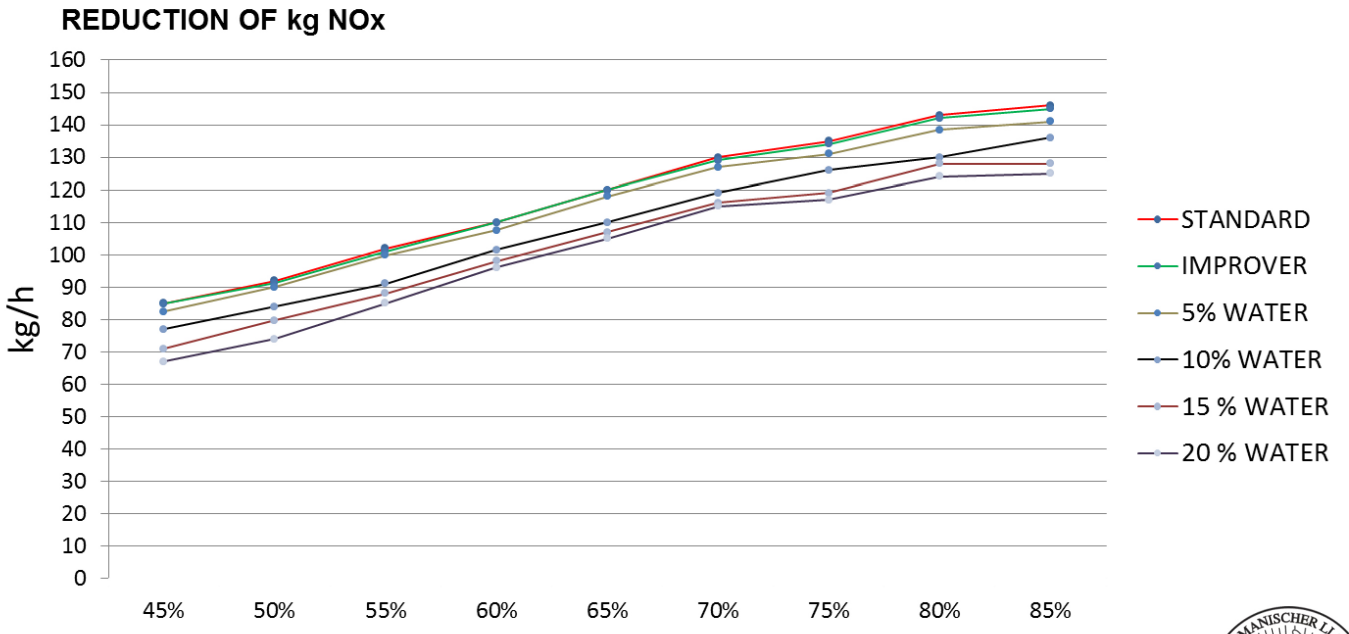
THE NUMBERS + DATA

REDUCTION OF NOx g/KWh



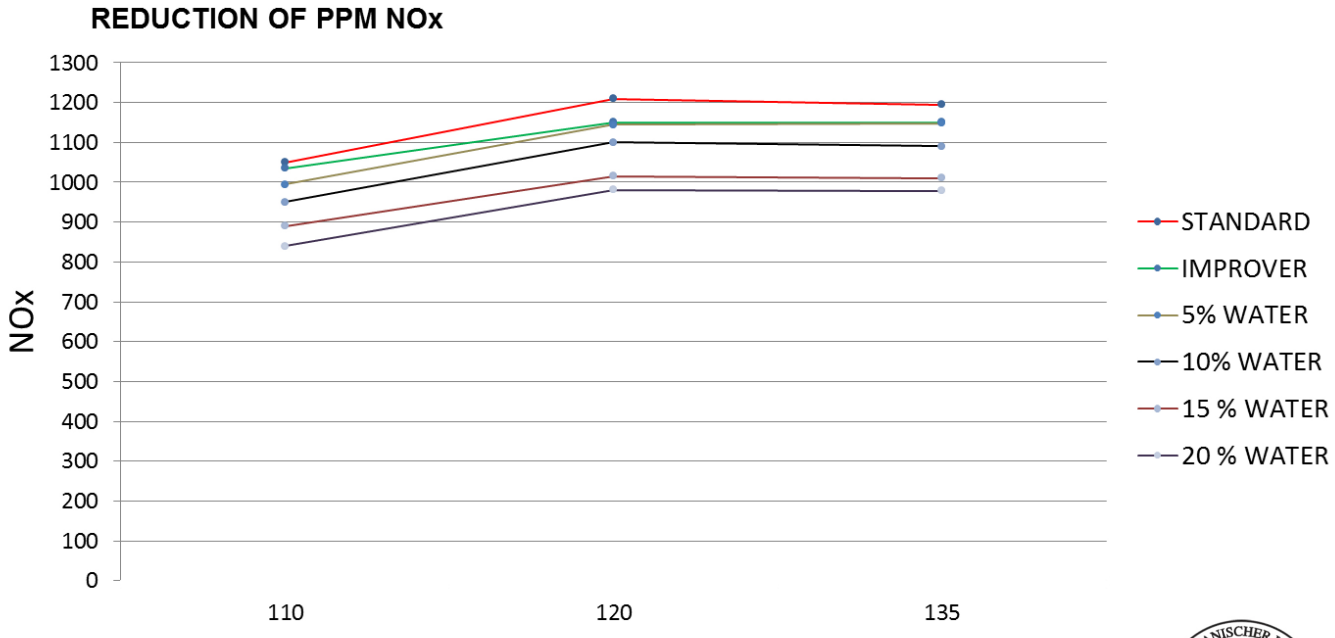
IMO MARPOL ANNEX VI ISO 8178 TEST

THE NUMBERS + DATA



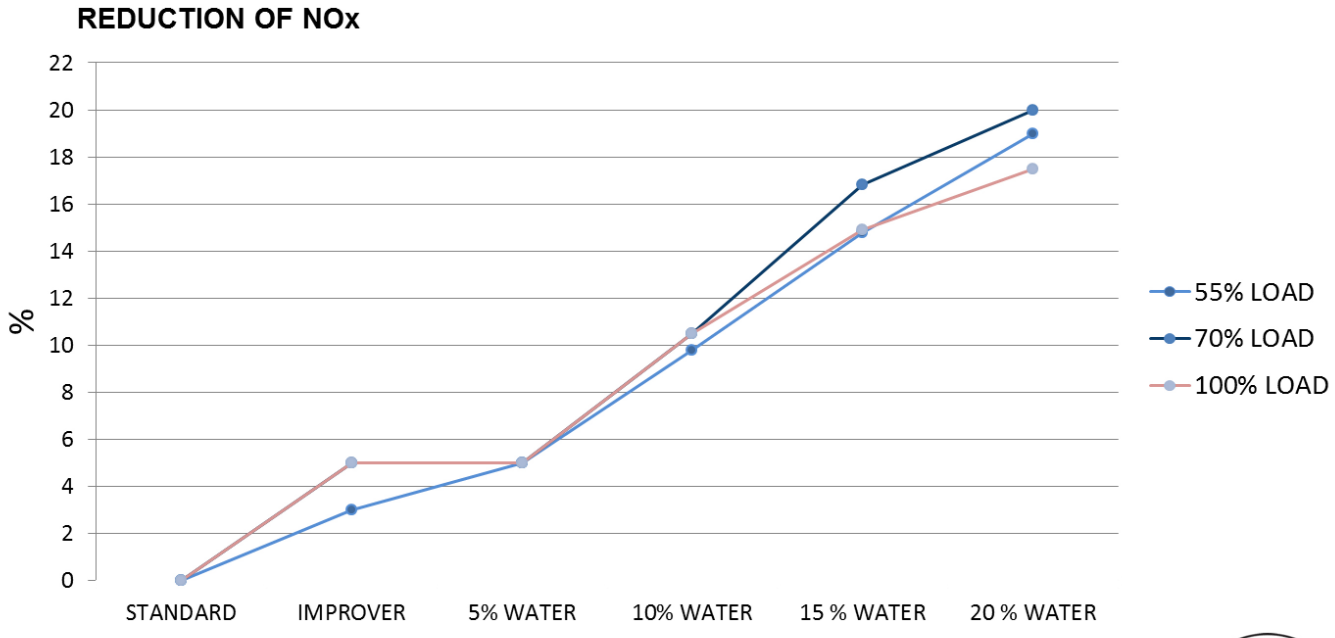
IMO MARPOL ANNEX VI ISO 8178 TEST

THE NUMBERS + DATA



IMO MARPOL ANNEX VI ISO 8178 TEST

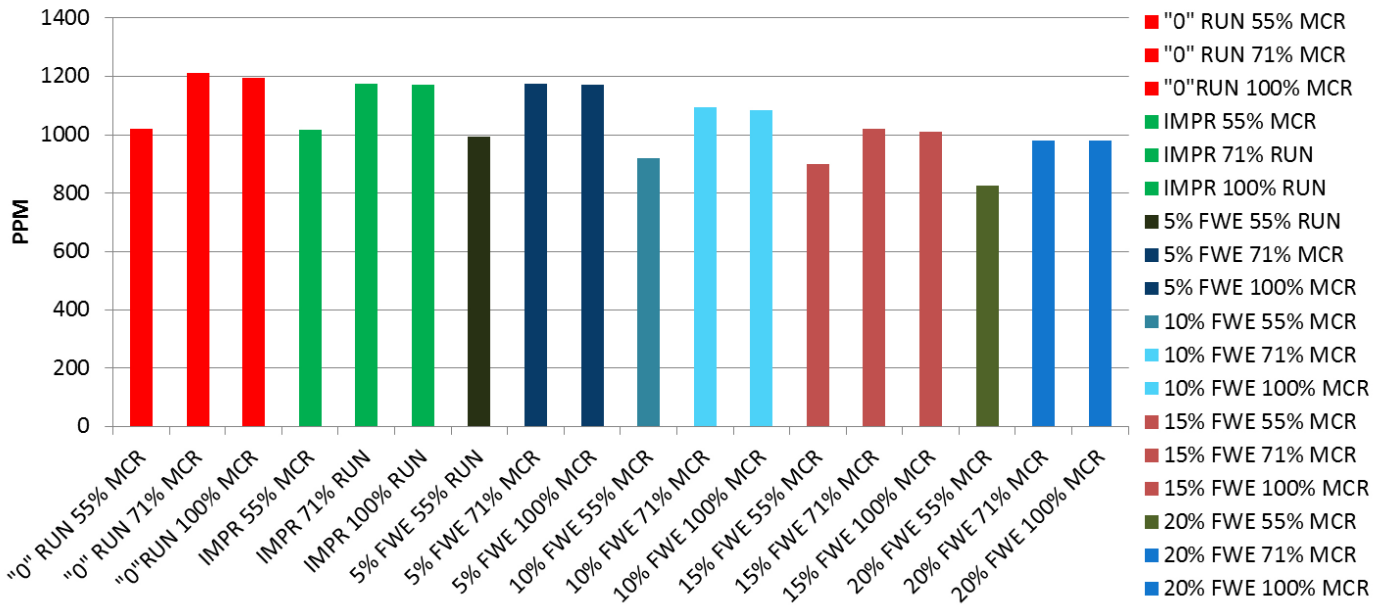
THE NUMBERS + DATA



IMO MARPOL ANNEX VI ISO 8178 TEST

THE NUMBERS + DATA

REDUCTION OF NOx



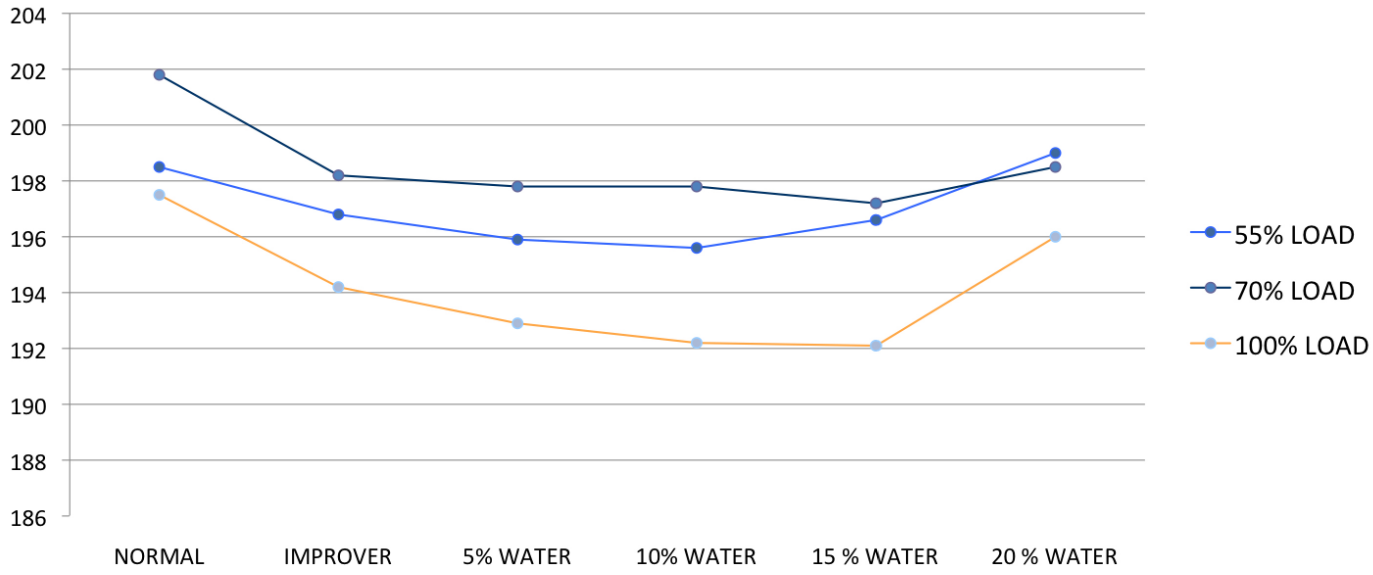
FWE: FUEL WATER EMULSION

IMPR: IMPROVER MODE

IMO MARPOL ANNEX VI ISO 8178 TEST

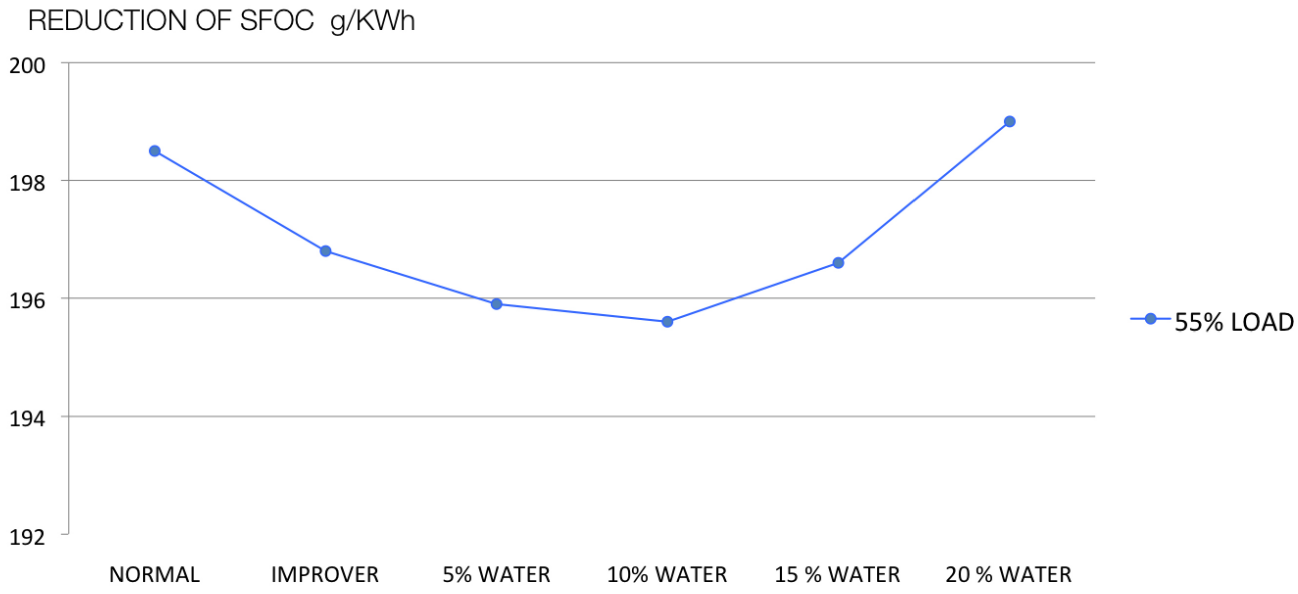
THE NUMBERS + DATA

REDUCTION OF SFOC g/KWh



Specific fuel oil consumption according ISO 3046/1 conditions

THE NUMBERS + DATA



Specific fuel oil consumption according ISO 3046/1 conditions

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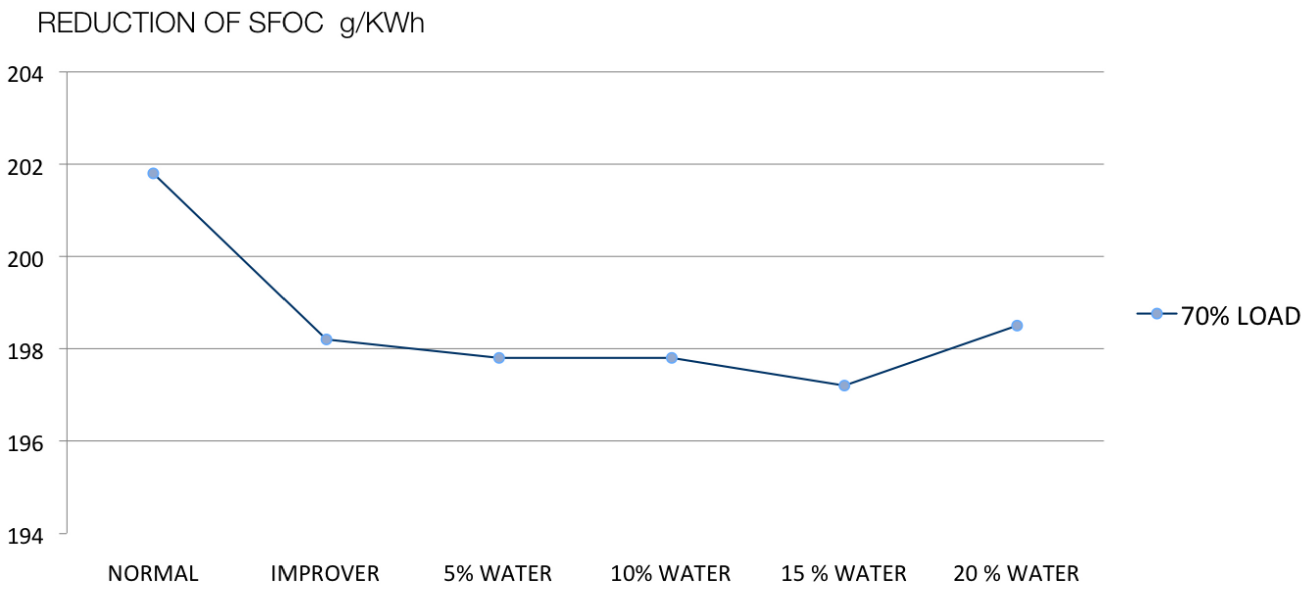
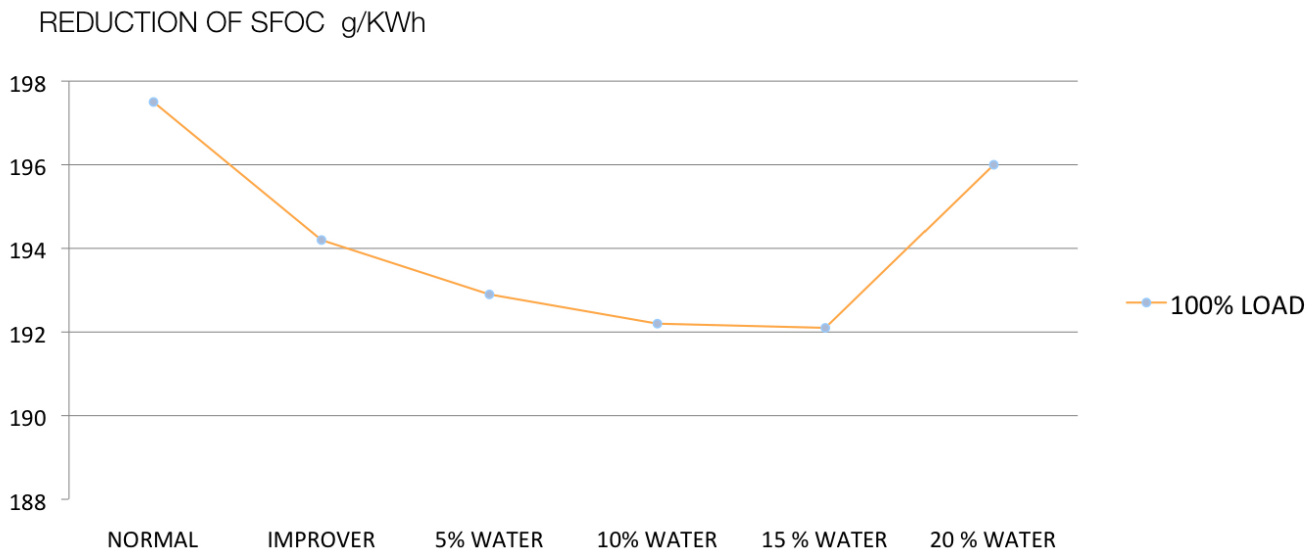


Specific fuel oil consumption according ISO 3046/1 conditions

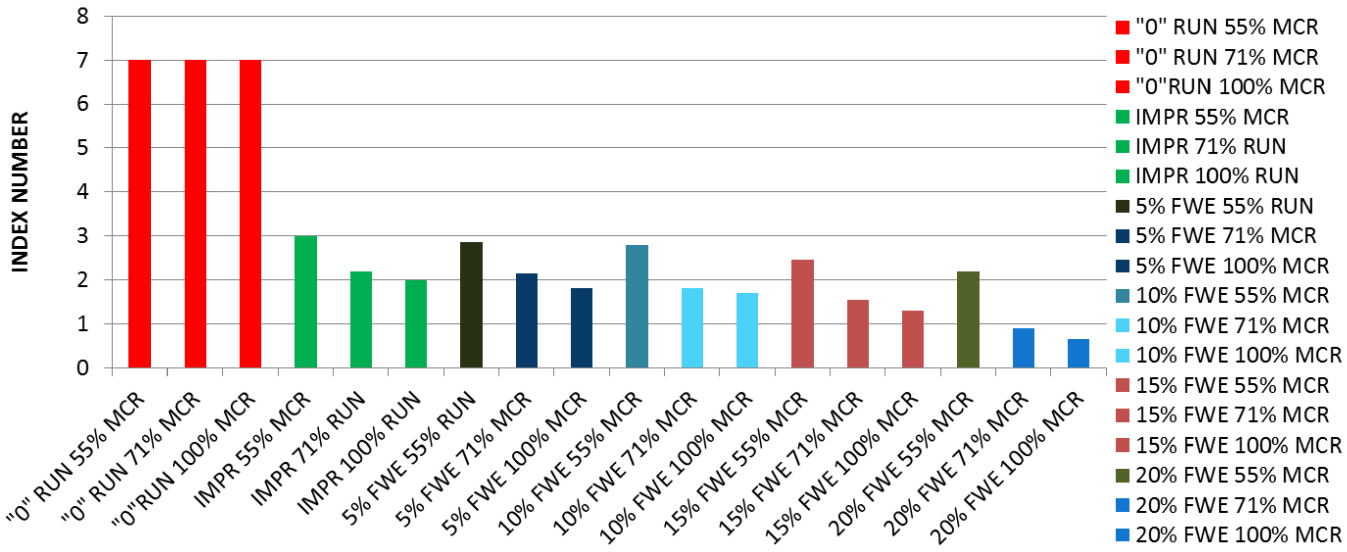
THE NUMBERS + DATA



Specific fuel oil consumption according ISO 3046/1 conditions

THE NUMBERS + DATA

REDUCTION OF PM



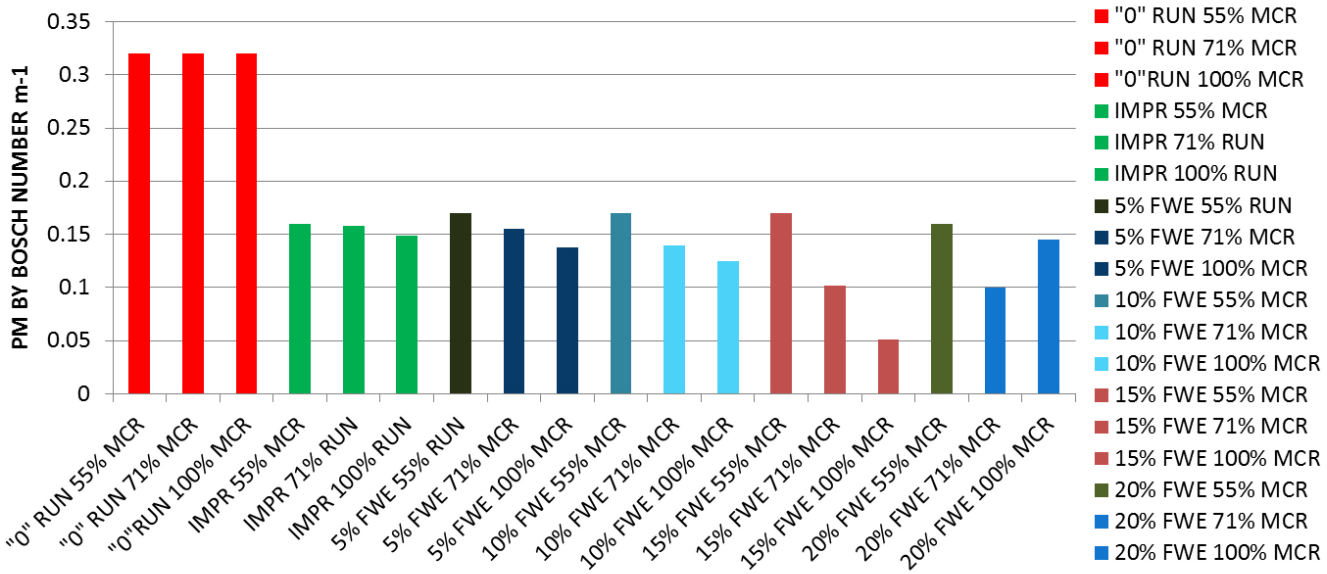
TAKEN WITH SMOKE PUMP TEST KIT WITH SMOKE SCALE INDEX

FWE: FUEL WATER EMULSION

IMPR: IMPROVER MODE

THE NUMBERS + DATA

REDUCTION OF PM BY BOSCH NUMBER

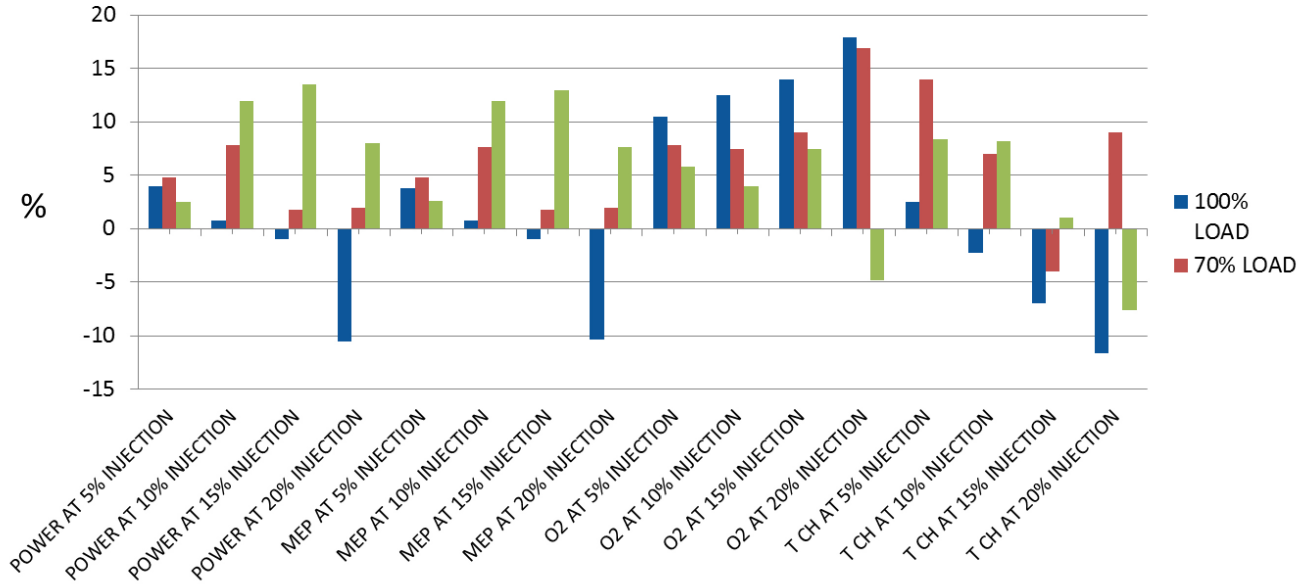


FWE: FUEL WATER EMULSION

IMPR: IMPROVER MODE

THE NUMBERS + DATA

INCREASE WITH THE BLUEFIN FTS INJECTOR



PLEASE NOTE THAT THE FUEL RACK AT FULL LOAD HAS TO BE ADJUSTED AND FIXED BY THE ENGINE BUILDER IF NECESSARY