Hellenic Engineers Society
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Service Experience of MAN B&W Two-stroke Diesel Engines

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Senior Manager

Low Speed – Operation

Disclaimer

All data provided on the following slides is for information purposes only, explicitly non-binding and subject to changes without further notice.

Service Experience of MAN B&W Two-stroke Diesel Engines

- Total Cost of Ownership for Large Marine Propulsion Engines
- New ECS Software for ME/ME-C Engines
- Operation on Low Sulphur Fuels
- Low Load Operation Update 2011
- Cylinder Condition Update – New Engine Types
- G-type Engines – Short Introduction

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Total Cost of Ownership of Marine Propulsion Engines

Example: Large Bore MAN B&W 2-Stroke Engine

	40% Load Average	80% Load Average
Investment Cost	100%	100%
Operating Cost/year:		
- Fuel	100%	200%
- Cylinder Oil	1.3%	2.6%
- System Oil	0.3%	0.3%
- Overhaul Cost	0.5%	0.5%
- Spare Parts	3.5%	3.5%
Scrapping	?	?

Total Cost of Ownership of Marine Propulsion Engines: Investment Costs

Constant Focus on First-Cost Cost-Down

Example: Low Force Exhaust Valve

Potential First Cost Saving: 200,000 USD for a 12K98ME/ME-C Engine

Total Cost of Ownership of Marine Propulsion Engines: Operating Costs, Fuel

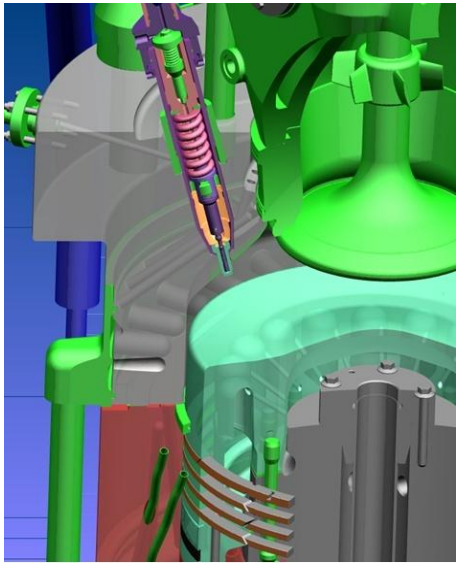
Fuel Costs:

- Extremely Dominating over the Lifetime of a Propulsion Plant
- In Tier 2 version ME-engines have 2-3 g/kWh lower SFOC when comparing to corresponding MC-engines
- Background for introduction of the fuel optimised Tier 2 engines (dot2 engines) with SFOC 1-2 g/kWh lowered
- Reason for increased focus on low load and part load tuning
- Autotuning

However: In many cases the traditional split of costs between ship-owners and charterers limits the optimisation of the propulsion plant (as example WHR systems)

Total Cost of Ownership of Marine Propulsion Engines: Operating Costs, Cylinder Oil

- Combustion Chamber optimised for low SLOC
- Alpha Lubricator with ACC secures minimum SLOC



Recent Service Experience:
MAN B&W 2-stroke engines maintain stable cylinder condition with minimum SLOC at low load both with and without T/C cut out

Total Cost of Ownership of Marine Propulsion Engines: Operating Costs, Overhaul&Spares

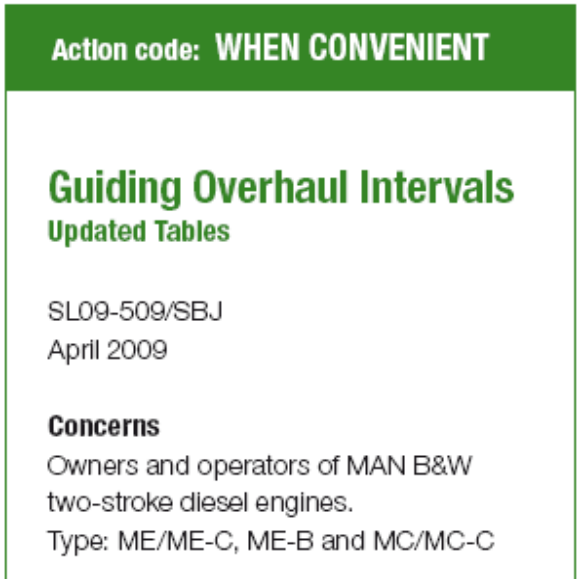
Service Letter SL09-509/SBJ

MAN Diesel

However please note our

SL07-483/HRR concerning

Condition Based Overhaul



Action code: WHEN CONVENIENT

Guiding Overhaul Intervals

Updated Tables

SL09-509/SBJ

April 2009

Concerns

Owners and operators of MAN B&W two-stroke diesel engines.

Type: ME/ME-C, ME-B and MC/MC-C

For Large Bore Engines:

Overhaul intervals for Dry Cargo Vessels can be largely extended in general to more than 32,000 hours

Dock to dock without major overhauls is possible for Tankers

Total Cost of Ownership of Marine Propulsion Engines: Operating Costs, Overhaul&Spares

Service Letter SL09-509/SBJ MAN Diesel

ME/ME-C engines
Guiding overhaul intervals and expected service life

Component	Overhaul interval (hours)	Expected service life (hours)	Remarks
Main hydraulic pump	32,000	Engine lifetime	Check and replace hydrostatic bearings at overhaul. Check and replace cylinder set and piston if required.
Proportional valve for main hydraulic pump		20,000	Replace valve after 20,000 hours
Pressure relief valve for main hydraulic pumps	40,000	Engine lifetime	Replace sealings at overhaul
Exhaust valve actuator	32,000	Engine lifetime	Replace static sealing rings at overhaul.
FIVA valve	32,000	64,000	Check and replace if required
Fuel valve	8,000 - depending on fuel quality	Valve nozzle 16,000 Spindle guide 16,000	Check and replace if required
Fuel oil pressure booster	32,000 - based on engine observations	64,000 Replace or recondition	Change piston rings on hydraulic piston and suction valve at overhaul.

Action code: WHEN CONVENIENT

Guiding Overhaul Intervals
Updated Tables

SL09-509/SBJ
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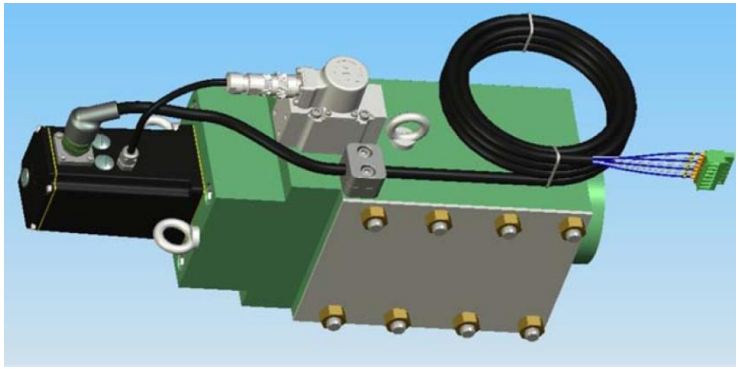
Damage to Pilot Valves on FIVA's During Commissioning Period

Service Test of Bosch Rexroth FIVA:



Ship 1: same unit

-After 20h	3,32 l/min
-After 723h (same cylinder as 20h)	1,27 l/min
-After 743h	3,87 l/min

Ship 2:

-After 2893h	4,60 l/min

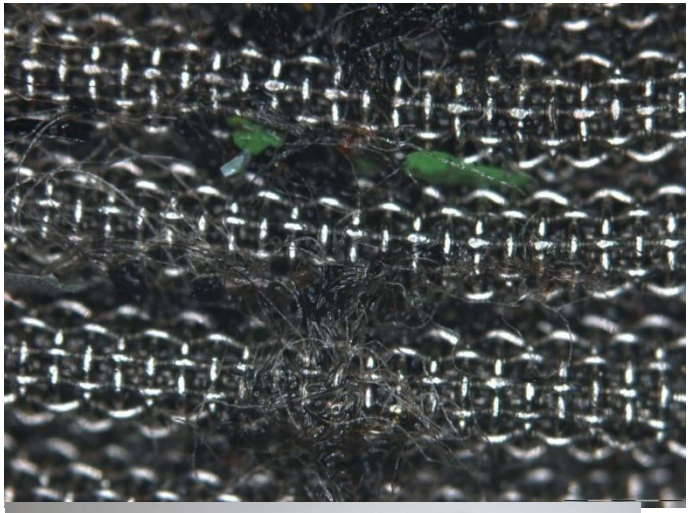
Ship 3:

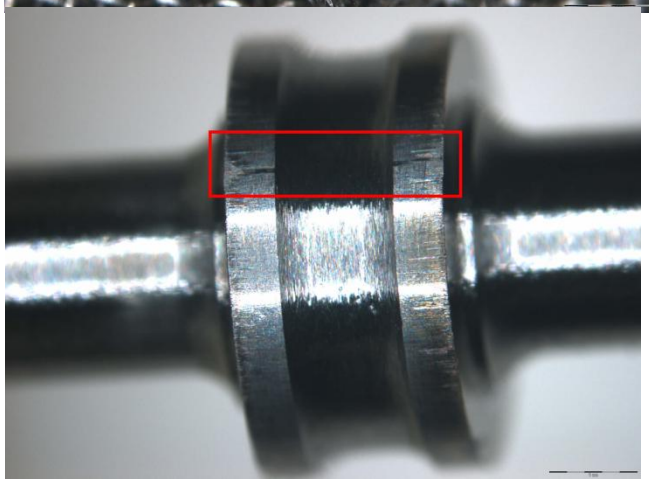
-After 5000h	3,33 l/min

Leakage: delivered with max 1,3 l/min

Damage to Pilot Valves on FIVA's During Commissioning Period

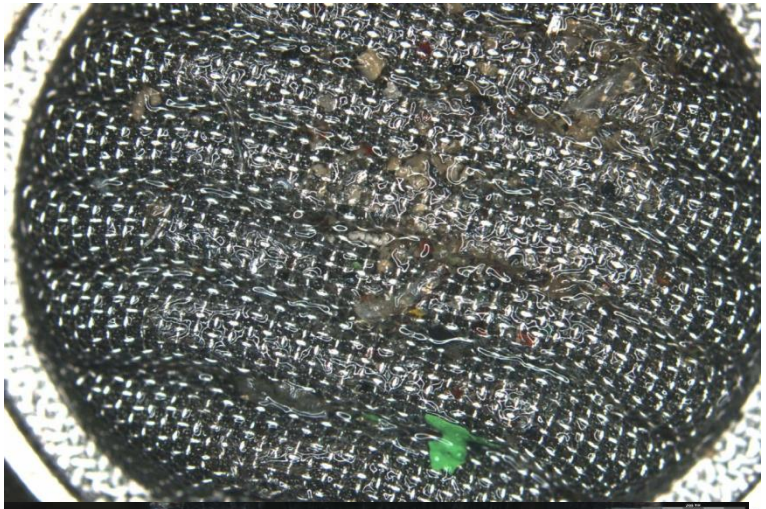
- Ship 1
- Painting,rubber and ??

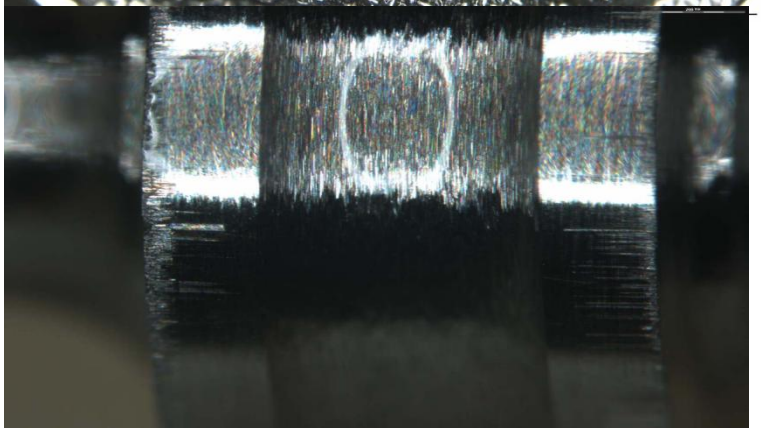




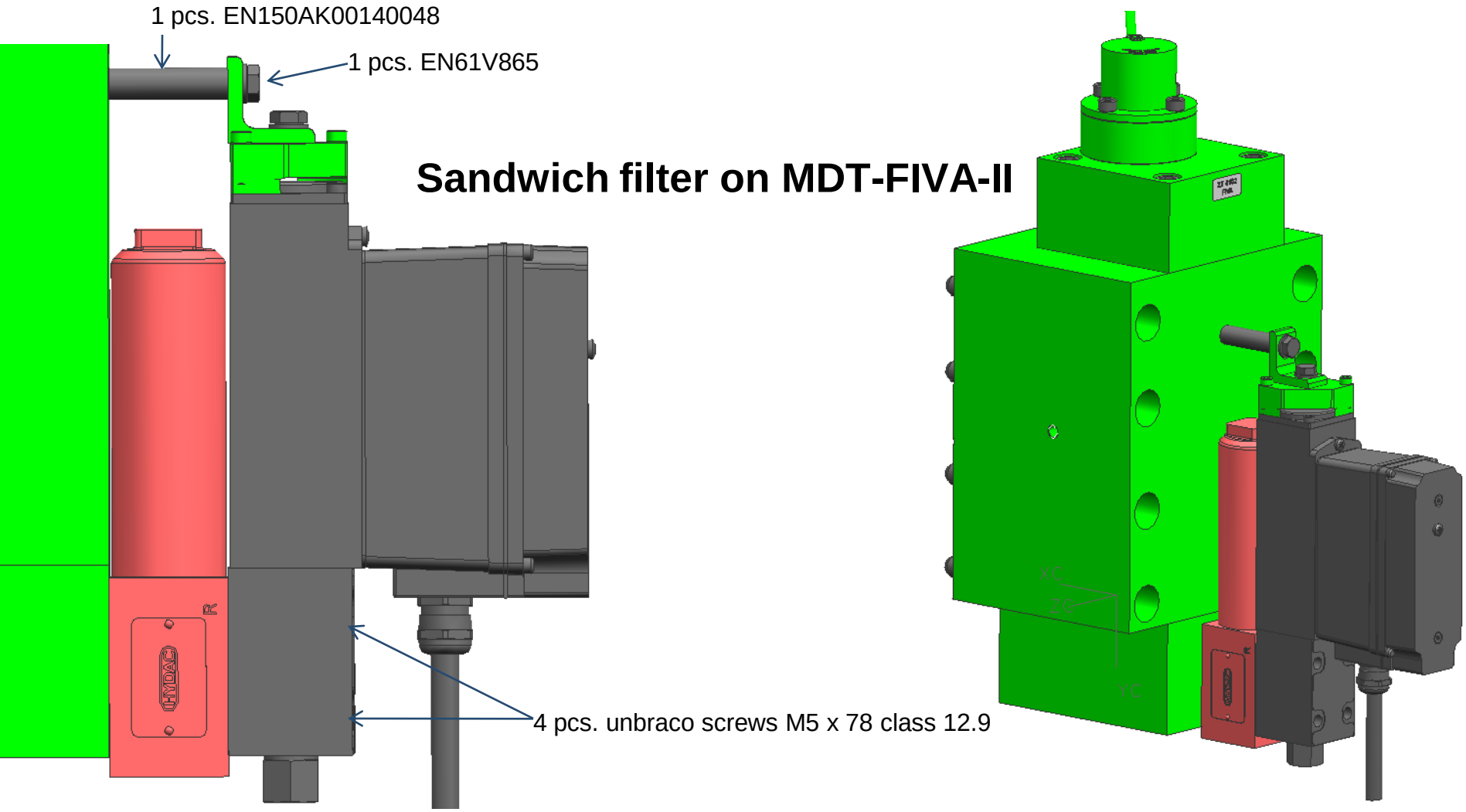
Wear on pilot valve

- Ship 2
- Painting, metal particles and ??





Damage to Pilot Valves on FIVA's During Commisioning Period



Service Experience of MAN B&W Two-stroke Diesel Engines

- Total Cost of Ownership for Large Marine Propulsion Engines
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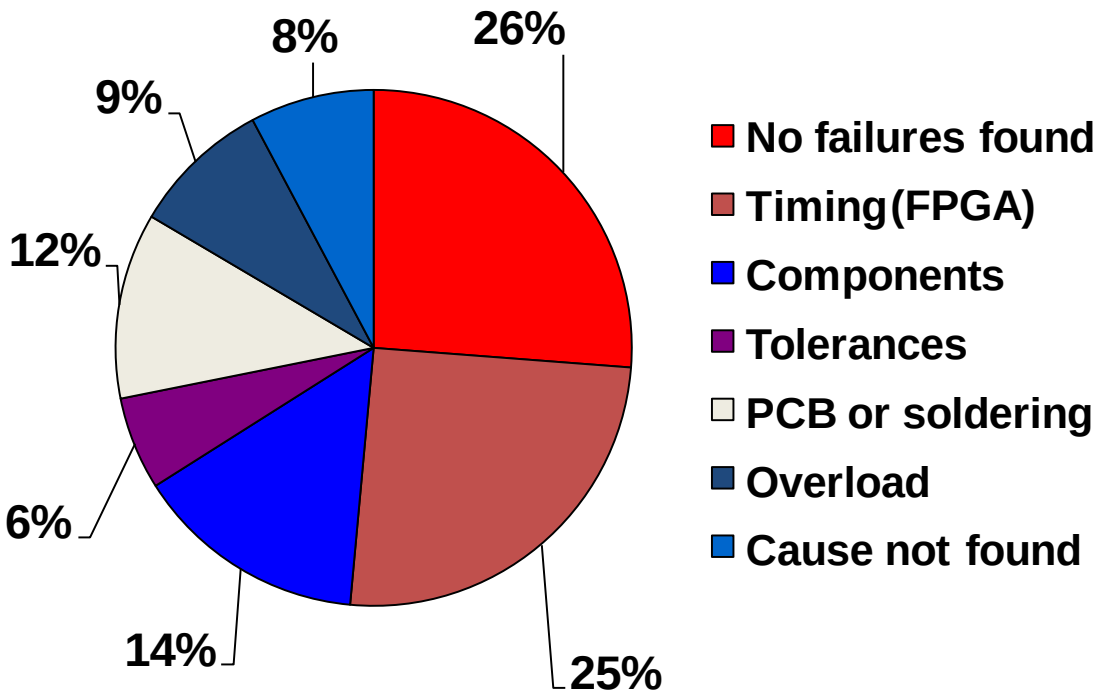
Reliability of Electronics

Multi Purpose Controller (MPC) Failures



ME Engines in Service
Software Improvements

ME-ECS 0905-8 compared to ME-ECS 0510-12

Commissioning Screen for HCU, Tacho and HPS

Trouble Shooting Screens for HCU and HPS

Data logger for HCU and HPS

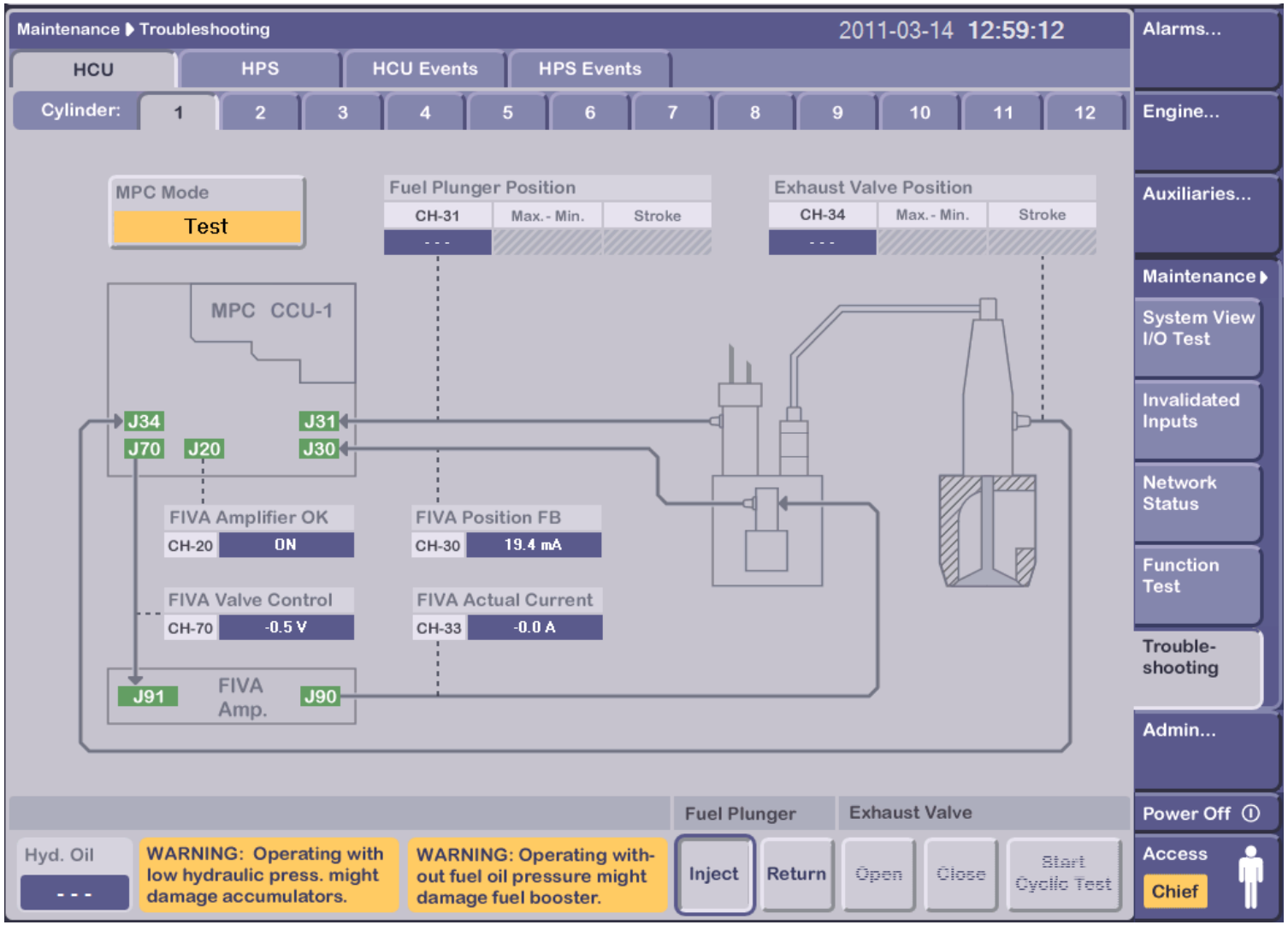
Export of HCU and HPS data logger data to Excel

ECS isolation monitoring and alarms

Electrical noise monitoring and alarm

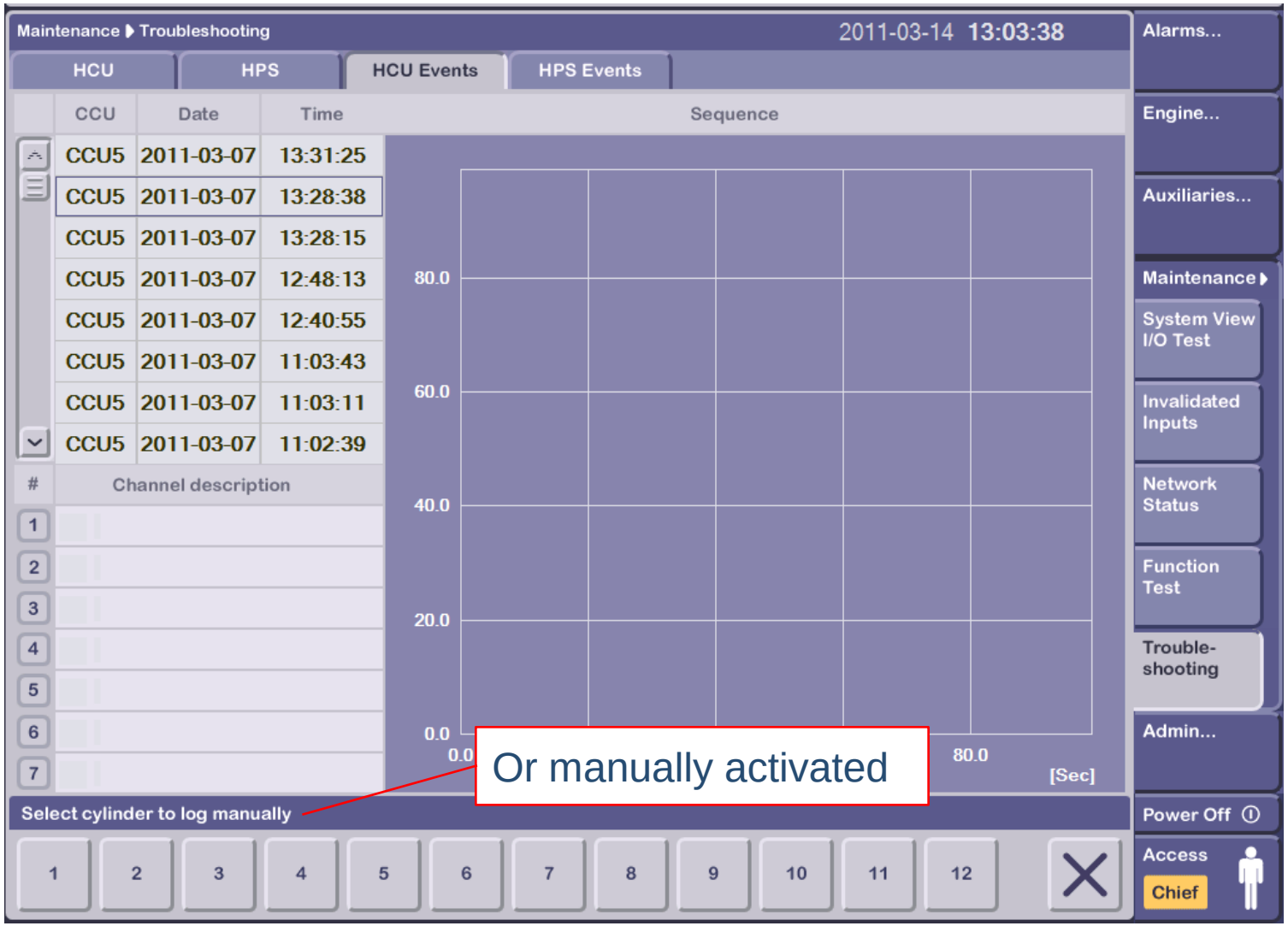
Alarm improvements, grouping of related alarms

Trouble Shooting Screens for HCU



Data Logger for HCU

Data Logger for HCU



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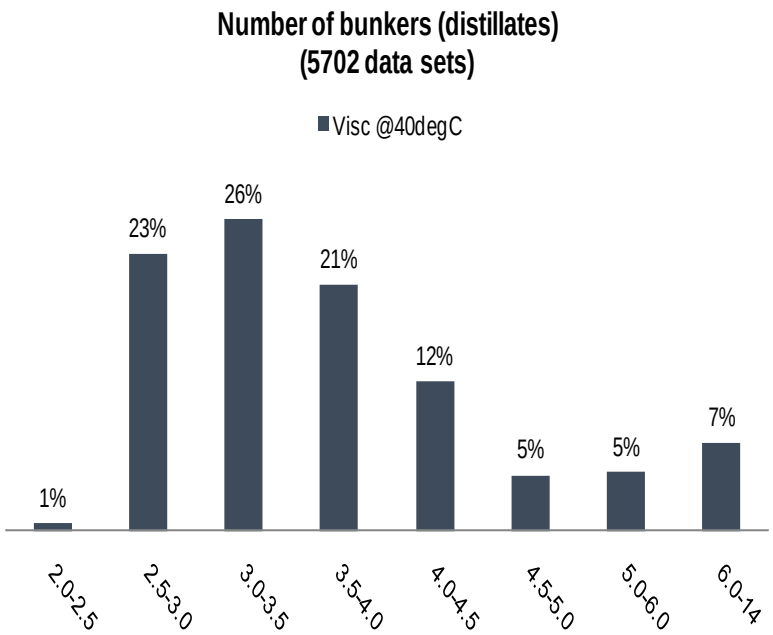
MAN B&W 2-stroke Marine Engines: Controlling SO_x by Burning Clean Fuel

Challenges burning clean fuel:

- Low viscosity of gas oil causing starting difficulties
- Low lubricity causing fuel pump seizures
- High “cat-fines” content especially seen on SECA-fuels
- Cylinder Oils for low or no sulphur fuels

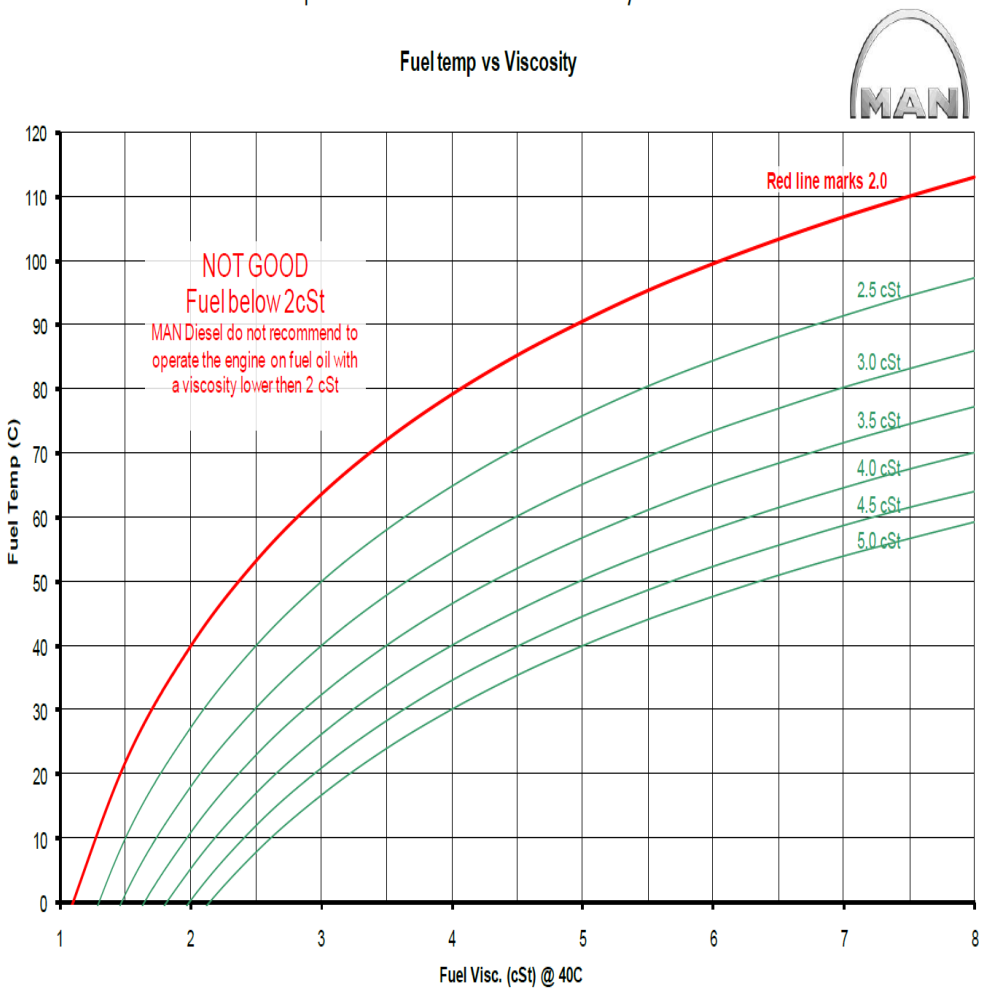
MAN B&W 2-stroke Marine Engines: Controlling SO_x by Burning Clean Fuel

- Majority of distillate fuels has viscosities in the range of 2.5 – 4 cSt.
- Low viscosity may cause starting difficulties and problems operating low load
- Low viscosity may cause pour lubricity causing fuel pump seizures



source reference: DNVPS

Temperature of MGO to ensure viscosity below recommended 2 cSt



MAN B&W 2-stroke Marine Engines: Controlling SO_x by Burning Clean Fuel

Shipboard Experiences with Low Sulfur Distillate Fuel Oil

OSPR

Office of Spill Prevention and Response

Unintended Consequences

PREPARED BY:
Maritime Safety Unit
Jeff Cowan
Mike Coyne

Challenges burning clean fuel:

LOSS OF PROPULSION INCIDENTS

2004 – 2010

(as of Oct 1, 2010)

Port	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
San Francisco	15	11	10	10	12	37	17
Los Angeles / Long Beach	8	12	6	14	14	28	10
San Diego	0	1	3	0	0	0	2
Santa Barbara	0	1	0	0	0	2	1
Humboldt	0	0	1	0	0	0	0
Total per year	23	25	20	24	26	67	30

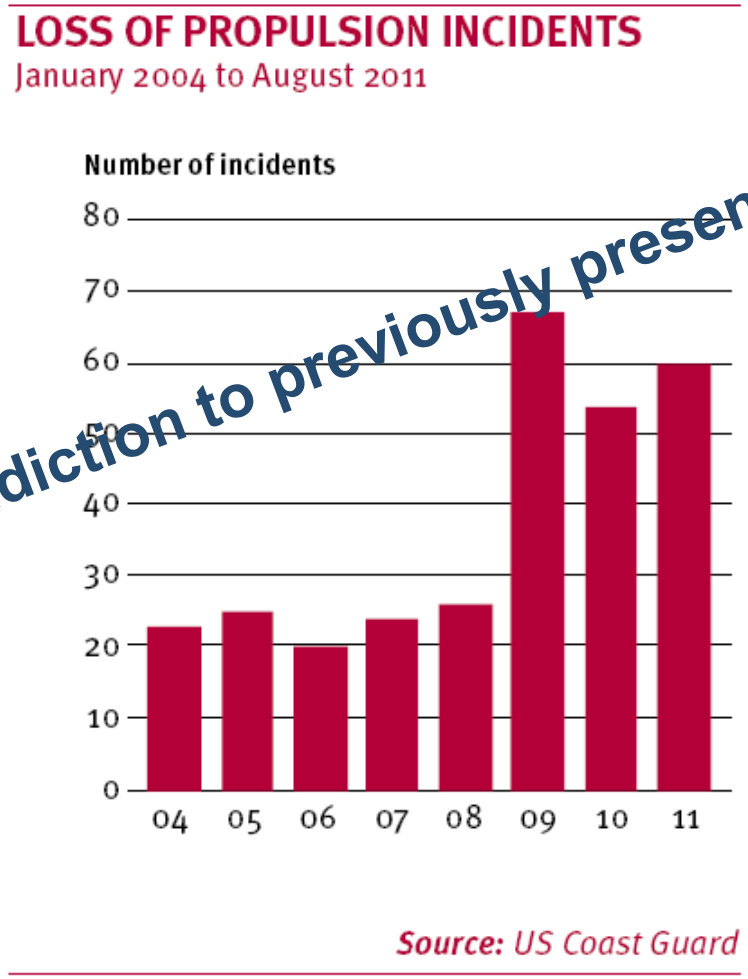
Monthly Totals in 2009

Month	Total LOPs	Fuel Switching Related
Jan – June 2009	21	9
Jul-09	13	6
Aug-09	8	4
Sep-09	9	5
Oct-09	8	3
Nov-09	3	2
Dec-09	5	4
Totals	*67*	*33*

Monthly Totals in 2010

	Total Loss of Propulsion Incidents	Loss of Propulsion - Fuel Switching Related
Jan-10	5	1
Feb-10	3	0
Mar-10	3	2
Apr-10	2	0
May-10	4	0
Jun-10	2	0
Jul-10	3	2
Aug-10	1	0
Sep-10	7	1
Totals	*30*	*6*

MAN B&W 2-stroke Marine Engines: Controlling SO_x by Burning Clean Fuel



Contradiction to previously presented data

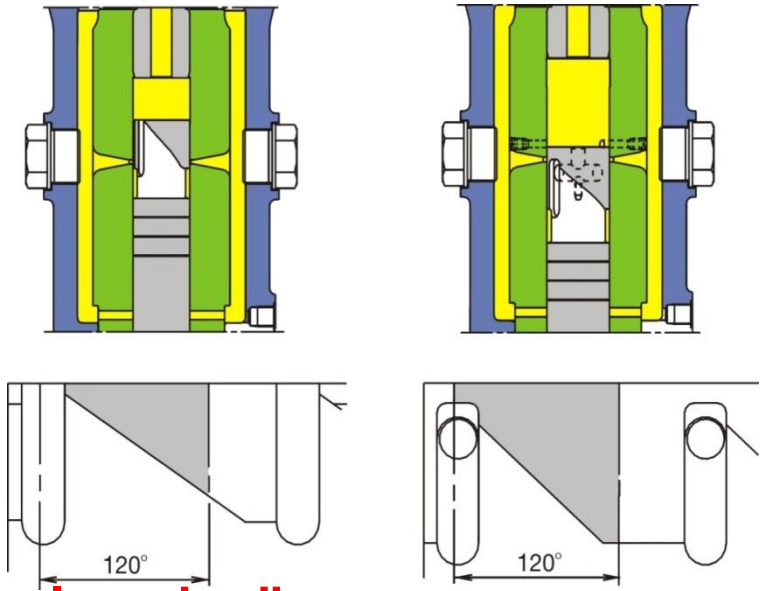
MAN B&W 2-stroke Marine Engines: Controlling SO_x by Burning Clean Fuel

The new CARB rules have lead to an increase in cases of starting difficulties after change over to distillate fuel.

However, such cases is “just” the result of worn fuel pumps, due to neglect of qualified performance check.

Fuel pumps must be overhauled before the index has increased 10% in relation to test bed condition.

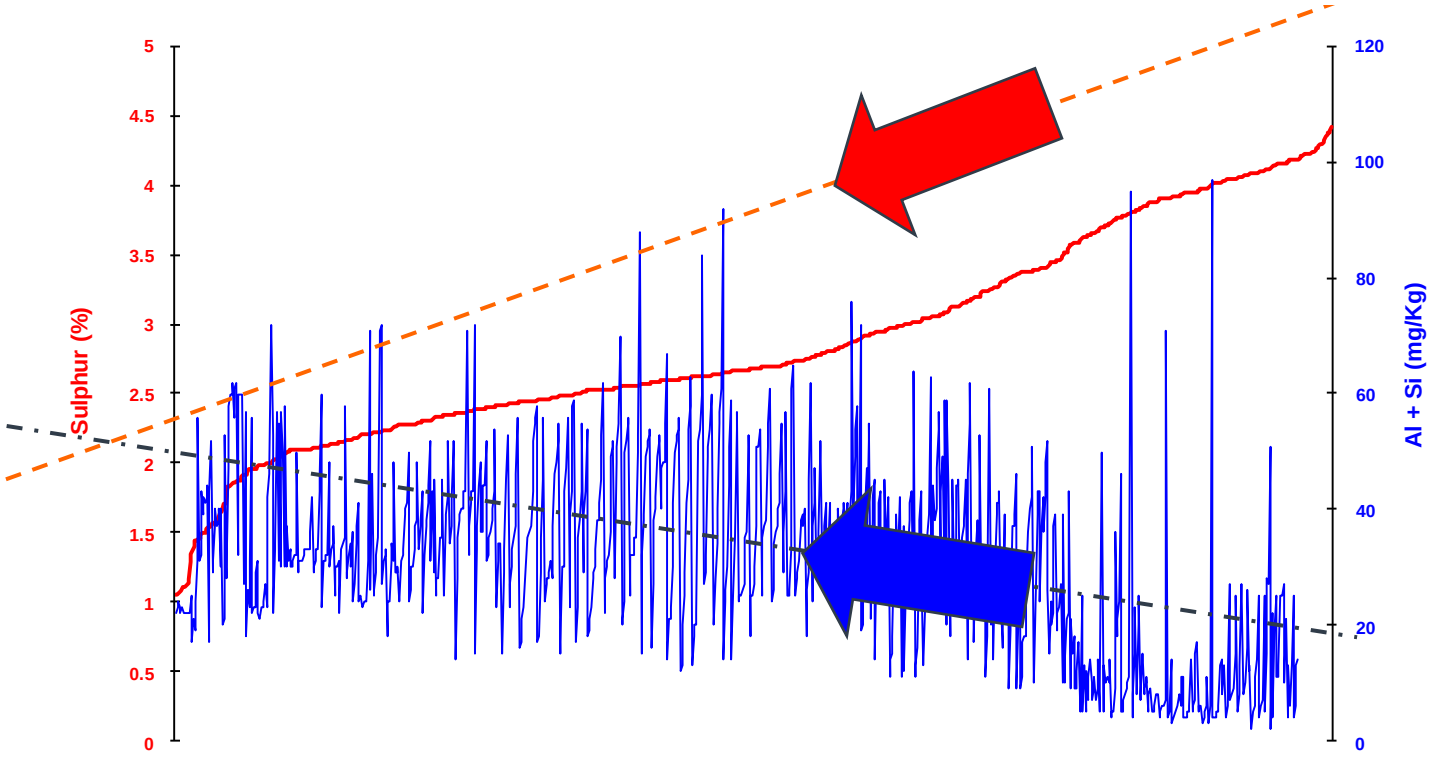
Fuel pump high pressure leakage mainly generated at cut off holes:



MAN Diesel prepares a Service Letter for “re-learning” of performance check to judge fuel pump wear

MAN B&W 2-stroke Marine Engines: Controlling SO_x by Burning Clean Fuel

Challenge of Low sulphur HFO; the lower sulphur the more cat-fines



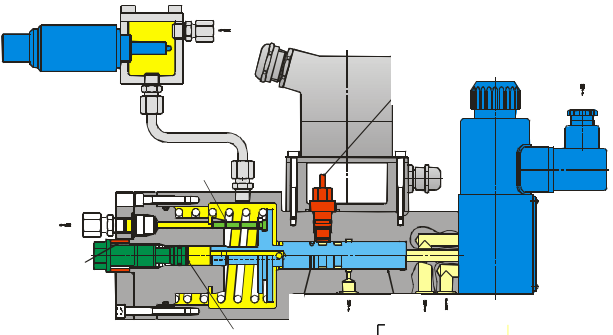
Source: DNVPS database of 1,012 analysis results (from 1 October – 10 November 2007)

MAN B&W 2-stroke Marine Engines: Controlling SO_x by Burning Clean Fuel

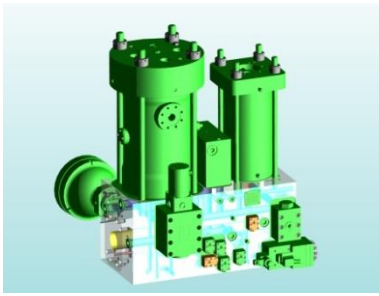
Replica technique:

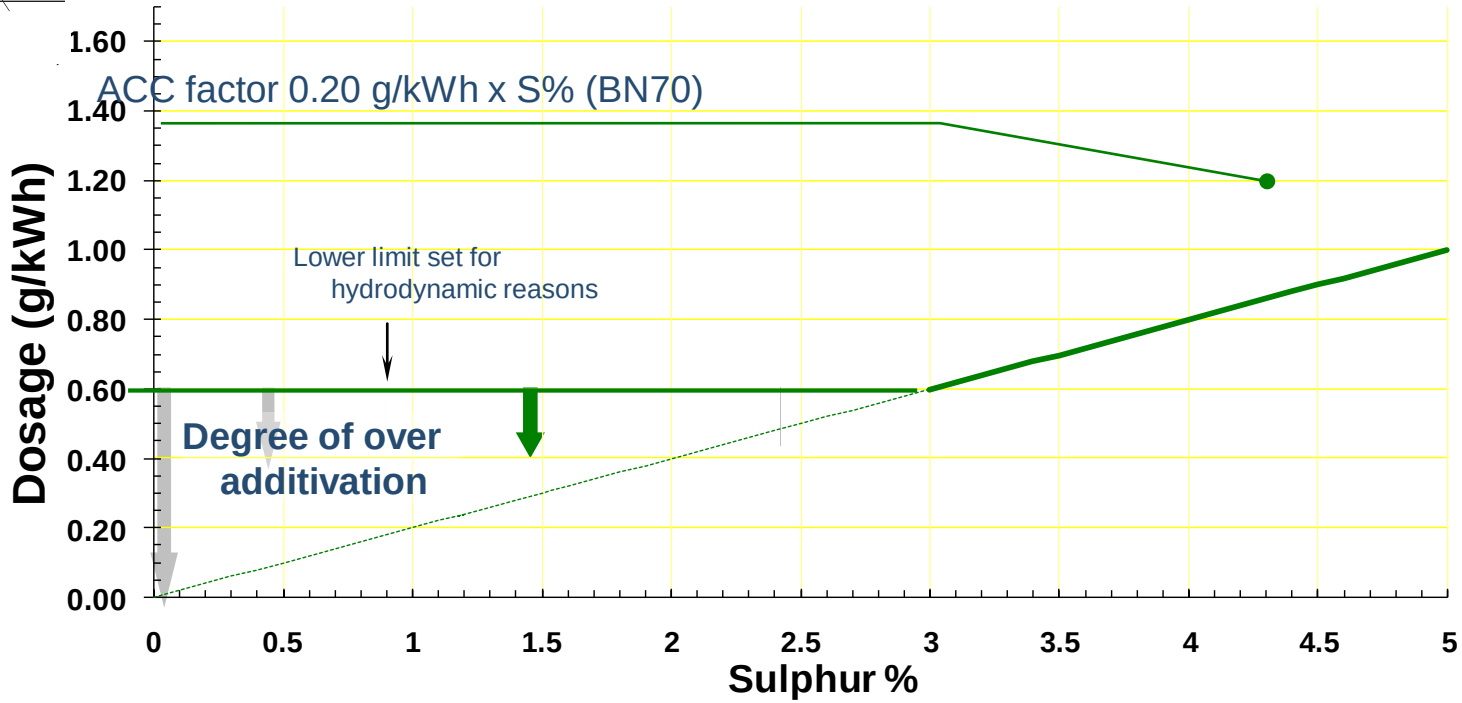
- **The density of cat-fines was found extremely high, with up to 3,000 / cm^2. Acceptable level is below 200 / cm^2 !**
- **The sizes vary from 5µm to 15 µm with a smaller number of ”big” cat-fines in a range of 20 – 25 µm.**
- **This is a result of in-efficiently working centrifuges.**

MAN B&W 2-stroke Marine Engines: Controlling SO_x by Burning Clean Fuel



Sulphur neutralization (additive control)

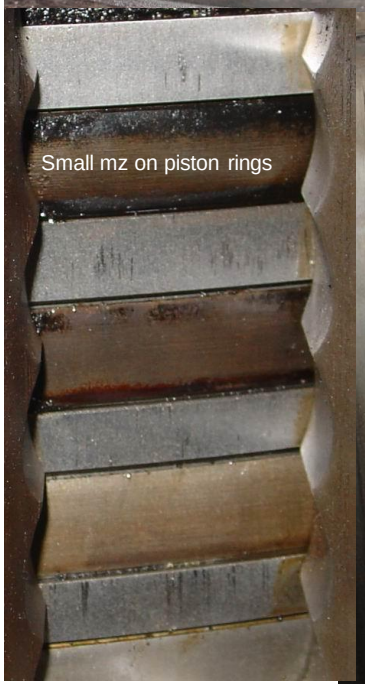


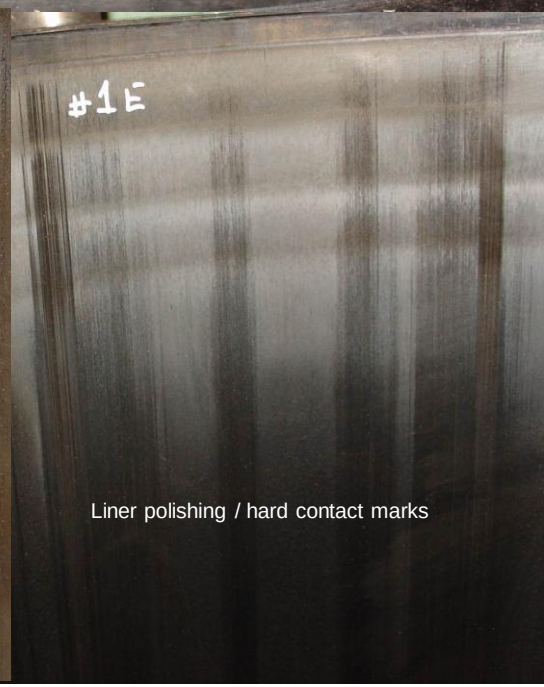


MAN B&W 2-stroke Marine Engines: Controlling SO_x by Burning Clean Fuel

Additive control at low sulphur running:

- How does over-additivation harm the cylinder condition?
- Over-additivation lead to mechanical- and chemical bore polish
- Bore polish lead to micro-seizures and latent risk of scuffing
- Running more then 1 - 2 weeks in SECA area, it is recommended to change to a lower BN cylinder oil (BN40 – 50 cylinder oil)





MAN B&W 2-stroke Marine Engines: Controlling SO_x by Burning Clean Fuel

Extended CARB regulations will require BN12 – 20 Cylinder Oils!

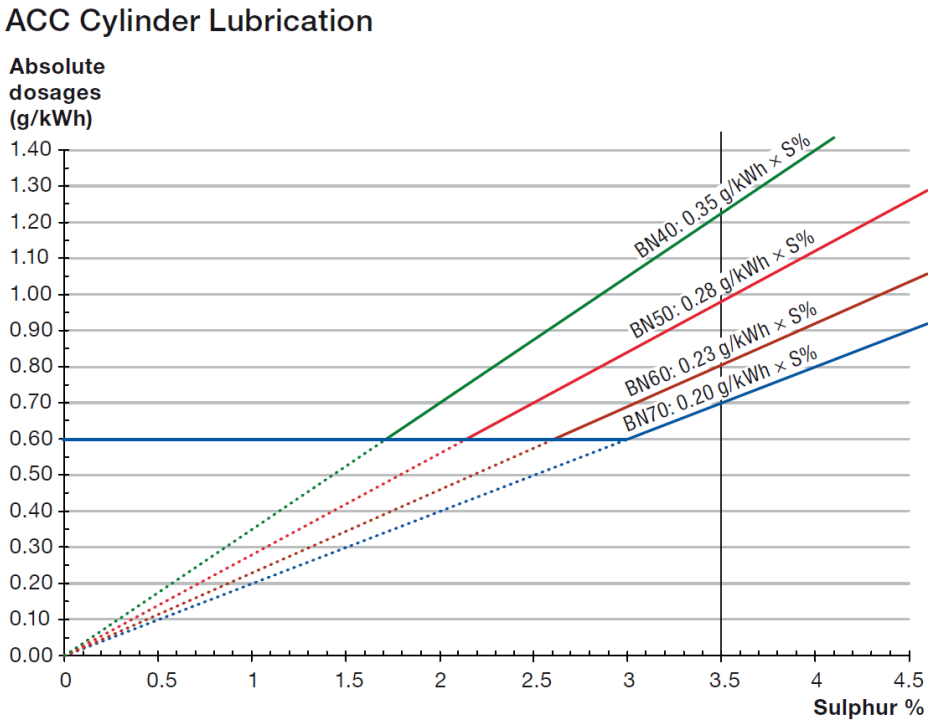


Fig. 1: Recommended cylinder lubrication feed rate as a function of the fuel oil sulphur content for selected lubricating oils (BN40-BN70)

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Low Load Operation

Operation down to 10% Engine Load
Service Experience & Recommendations

Low Load Operation
Service Tests

<u>Low load tests</u>

7K80MC-C	10% load	Sep. 2009	Container ship
9K98ME-C	20-22% load	Mar. 2008	Container ship
12K98MC-C	10% load	Oct. 2009	Container ship

<u>T/C cut out tests</u>

12K98ME	swing gates, ABB T/C	Container ship
10K98MC-C	swing gates, MET T/C	Container ship
12K98MC	blind plates, MET T/C	Container ship
9K90MC-C	blind plates, MAN T/C	Container ship

Low Load Operation
Service Feedback

Two Stroke Low Load Operation Inspection report template (SL09-511)

MAN Diesel

Two Stroke Low Load Ope

The purpose of this report is to de
document the service experience
engine load.
The reports should be used to op
engine load up for cleaning of boi
space, and with regard to cylinde
The report should preferably be r
4 times a month. This could be re

Below items should as minimum

Date of inspection
Vessel name
IMO number
Engine Builder / Number
Engine Type:
Main engine running hours:
Load range [%]:

Pictures, as shown as examples,
should be added.

Inspection area #1: The non-ret
valves in the scavenging air recei
should be photographed.
Comment:

MAN Diesel

Inspection area #3: The drain line from the buffer spaces should be photographed.
Comment:

Inspection area
the top land shou
Comment:

Inspection area #5: The piston crown should be photographed.
Comment:

Inspection area
be photographed
Comment:

Inspection area #7: The exh. valves should be photographed from the exh. gas receiver side
Comment:

Inspection area
exhaust gas boile
Comment:

MAN Diesel

Picture examples from the turbochargers are not available, but in some cases it is possible to have a view of the nozzle ring and maybe the turbine blades from the exh. gas receiver side, through the safety grid. Please supply pictures from this if possible.

Information regarding operation, maintenance and observations during low load operation:

- During low load operation for longer periods, were there any changes in engine load in order to 'clean' the engine and exhaust gas ways?
  Answer: aa
- Was it necessary to increase the maintenance intervals during low load operation? (Cleaning of receivers, turbochargers, boilers ect.)
  Answer: bb
- If temperature indication is available after the boiler this should be reported in order to evaluate acid corrosion in the boiler and funnel.
  Answer: cc
- What was the specific cylinder lube oil consumption and was the level of cylinder lubrication satisfactory?
  Answer: dd
- Are the auxiliary blower running at the stated engine load?
  Answer: ee
- Were any changes made to temperature/viscosity of the HFO?
  Answer: ff
- Were any problems experienced during low load operation?
  Answer: gg
- Based on your experience, do you have any recommendation regarding low load operation?
  Answer: hh

A performance observation at the stated load and a full scavenge port inspection (picture report of all cylinders) would be expedient for the further evaluation; however this must be based on the available time and necessity judged by the crew.

Low Load Operation
Service Feedback

Feedback reports (21)

1)	8S50MC	14% load	Container ship
2)	7L70ME-C	20-30% load	Container ship
3)	7L70ME-C	25-40% load	Container ship
4)	6S70MC-C	30-35% load	Bulk carrier
5)	7S70MC-C7	10% load	Tanker
6)	8K80ME-C	30% load	Container ship
7)	8K80ME-C	23% load	Container ship
8)	8K80ME-C	10% load	Container ship
9)	8K80MC-C	14-20% load	Container ship
10)	8K80MC-C	35% load	Container ship
11)	8K80MC-C	30-50% load	Container ship
12)	7L80MC	30% load	Container ship
13)	7K90MC-C	13-30% load	Container ship
14)	8K90MC-C	20-34% load	Container ship
15)	10K90MC	20-22% load	Container ship
16)	10K90MC	20% load	Container ship
17)	10K90MC	20% load	Container ship
18)	12K90MC	30% load	Container ship
19)	9K98MC-C	12-25% load	Container ship
20)	12K98MC-C	30% load	Container ship
21)	12K98MC	14-21% load	Container ship

Low Load Operation
Service Test

General experience from the tests:

- No significant change in fouling condition of exhaust gas ways
- Slightly increased fouling in scavenge air space
- Apparently too high cylinder oil feed rate at <25% load

Low Load Operation
Service Test

Service test (Sep. 2009):

- Engine: 7K80MC-C (3 years old)
- Test duration: 3 days on 10% load
- No engine load up

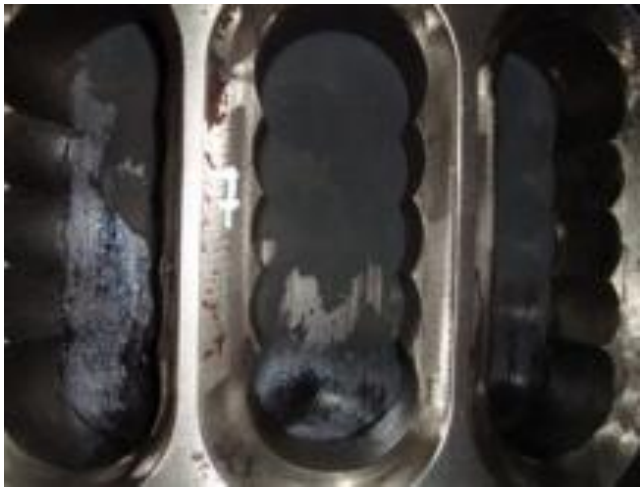
Conclusion

No significant change in fouling condition of exhaust gas ways

Low Load Operation
Service Test

Inspection after 1-day test

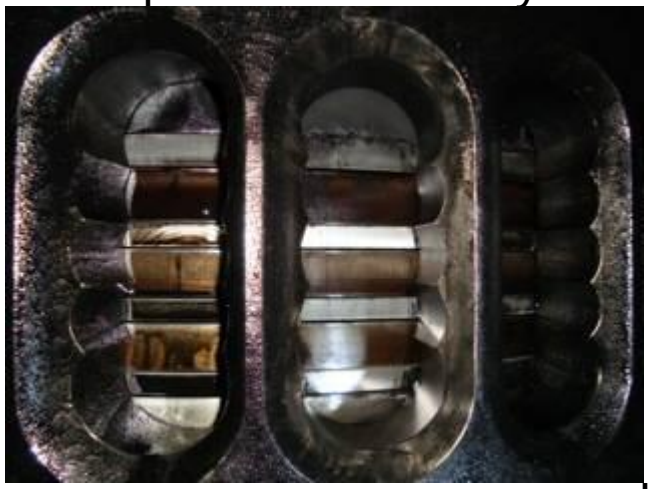
Inspection before test



Inspection after 3-day test

Low Load Operation
Service Test

Inspection after 1-day test



Inspection before test

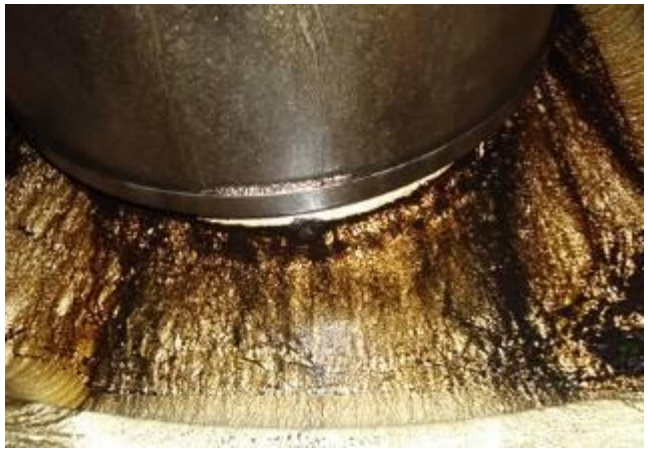
Inspection after 3-day test

Low Load Operation
Service Test

Inspection after 1-day test

Inspection before test

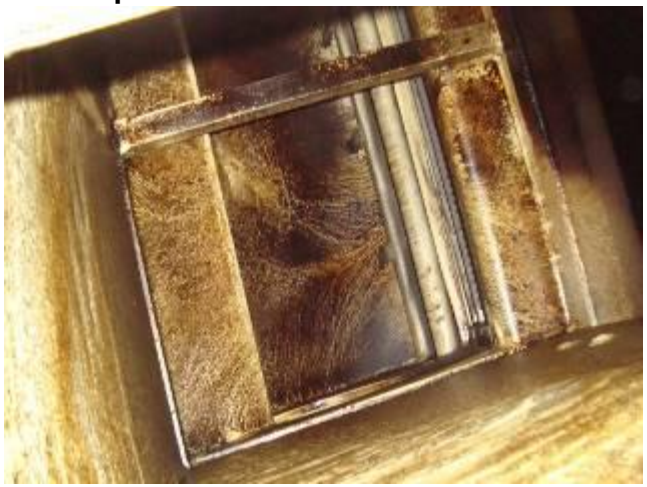
Inspection after 3-day test



Low Load Operation
Service Test

Inspection after 1-day test

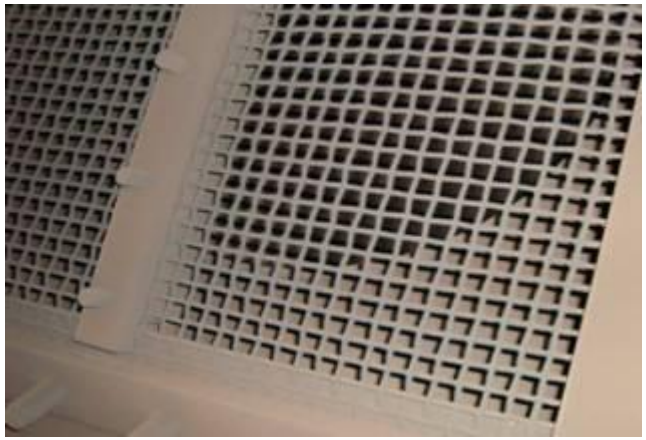
Inspection before test



Inspection after 3-day test

Low Load Operation
Service Test

Inspection after 1-day test



Inspection before test

Inspection after 3-day test

Low Load Operation
Service Test

Inspection after 1-day test

Inspection before test

Inspection after 3-day test

Low Load Operation
Service Feedback

Service feedback report (Oct 2009):

- Engine: 8K90MC-C (1 year old)
- Test duration: 21 days on 20-34% load
- Engine load up every second day to 75% load

Conclusion

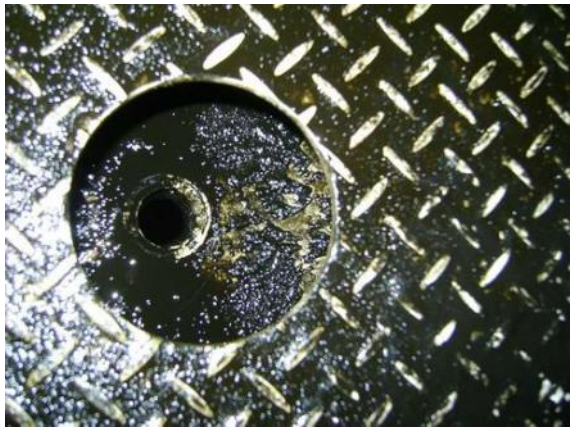
No significant change in fouling condition

Low Load Operation
Service Feedback

Sample pictures:

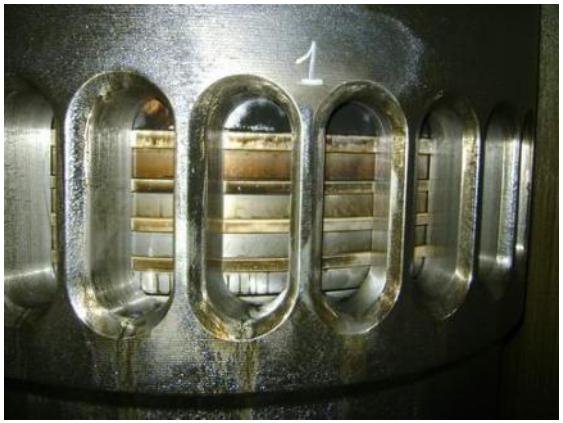
Scavenge air receiver





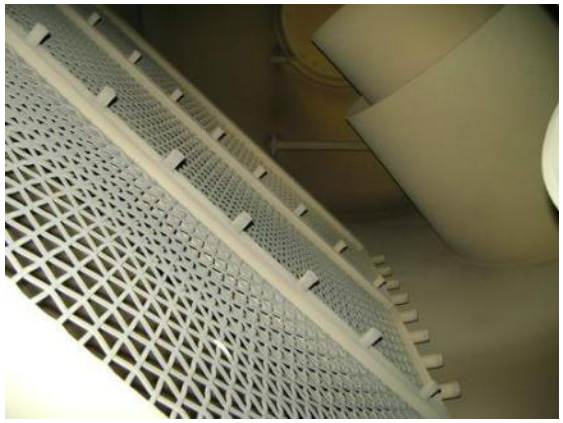
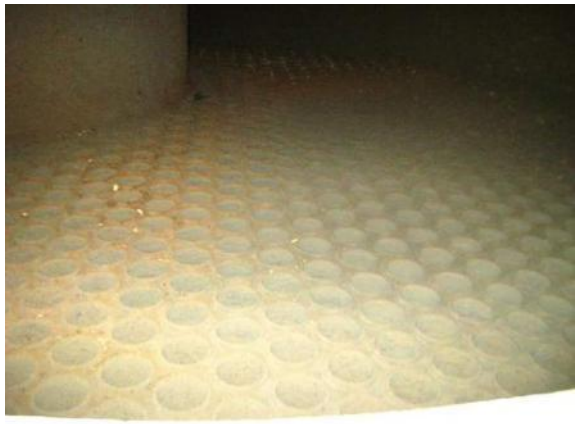
Low Load Operation
Service Feedback

Cylinder unit 1



Low Load Operation
Service Feedback

Exhaust receiver / boiler top

C/E's remark :

- Was it necessary to increase the maintenance intervals while slow steaming? (cleaning of receivers, buffer spaces, T/Cs, boilers, etc?)

After 509 hrs of slow steaming we do not see the dire necessity of cleaning it. Did not find any abnormalities or signs of over-lubrication. Sludge amount in the corners and on the walls was normal.

Low Load Operation
Service Feedback

Service feedback report (Jan 2009):

- Engine: 8S50MC (17 years old)
- Retrofitted with Slide Fuel Valves
- Load: 15% load
- Engine load up every day (to 10,000 TC rpm)

Conclusion

No change in fouling condition

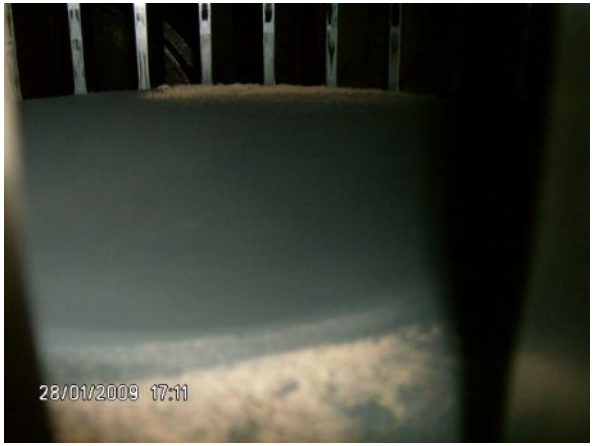
Low Load Operation
Service Feedback

Sample pictures:

Scavenge air receiver

Low Load Operation
Service Feedback

Cylinder unit 1



Low Load Operation
Service Feedback

Exhaust receiver / boiler top

C/E's remark :

- Did you experience any problems related to the slow steaming operation?
  Answer: NO

Low Load Operation
Service Feedback

Feedback from vessels

General comment:

- No problems observed

Comments on C/E's experience gained (from the 21 reports):

- engine load up considered essential
- less mechanical stress on engine is expected to have positive influence on maintenance of the engine
- more often cleaning of the scavenge air receiver
- boiler seems to be more clean
- more frequent cleaning of boiler and scavenge air space considered necessary
- Alpha lubes have too high feed rate <25% load
- too little fresh water production
- scavenge air space more dirty
- increased wet deposits in scavenge air receiver
- 4-day load up interval ok
- more soot in exhaust receiver and on boiler top.

Low Load Operation
Service Experience

General recommendations

- Service letter: SL09-511
- Service letter: SL11-544
- Inspection report template

Action code: WHEN CONVENIENT

Low Load Operation
10% to 40% Engine Load

SL09-511/MTS
May 2009

Concerns
Owners and operators of MAN B&W two-stroke marine diesel engines.
Type: MC/MC-C and ME/ME-C

Summary
Long-term low load operation down to 10% engine load is generally possible with appropriate precautions and without major modifications.
For application with 3-4 turbochargers, MAN Diesel recommends installation of a turbocharger cut-out system.

Action code: WHEN CONVENIENT

Low Load Operation
2011 Update

SL11-544/MTS
June 2011

Concerns
Owners and operators of MAN B&W two-stroke marine diesel engines.
Types: MC/MC-C and ME/ME-C/ME-B

Summary
Feedback on low-load operation from the operators has generally been positive. Only a few issues have emerged, but have been dealt with by few countermeasures.

MAN Diesel

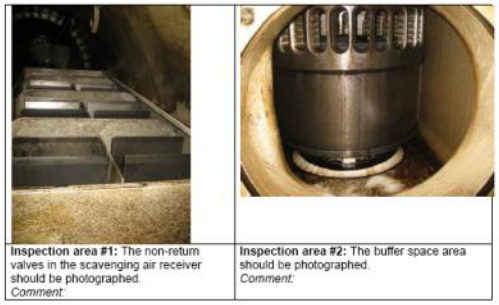
Two Stroke Low Load Operation - Inspection report template

The purpose of this report is to define the necessary inspection areas in order to follow and document the service experience gained during continuous engine operation below 50% engine load.
The reports should be used to optimise the low load operation procedures with regard to engine load up for cleaning of boiler and turbocharger, cleaning of scavenge and exhaust space, and with regard to cylinder lubrication optimisation.
The report should preferably be made before and after the low load operation period, or 3 to 4 times a month. This could be reduced with experience and unchanged load pattern.

Below items should as minimum be noted and inspected:

Date of inspection	: *2000-01-01*
Vessel name	: *M/V xxxx*
IMO number	: *90xxxxx*
Engine Builder / Number	: *xxxx / xxxx*
Engine Type:	: *12K98MC-C*
Main engine running hours:	: *50000 Hours*
Load range [%]:	: *22%*

Pictures, as shown as examples, should be inserted in the report and relevant comments should be added.



Inspection area #1: The non-return valves in the scavenging air receiver should be photographed.
Comment:

Inspection area #2: The buffer space area should be photographed.
Comment:

Low Load Operation
Service Experience

Operating at low engine load, below 40%, can create issues in relation to:

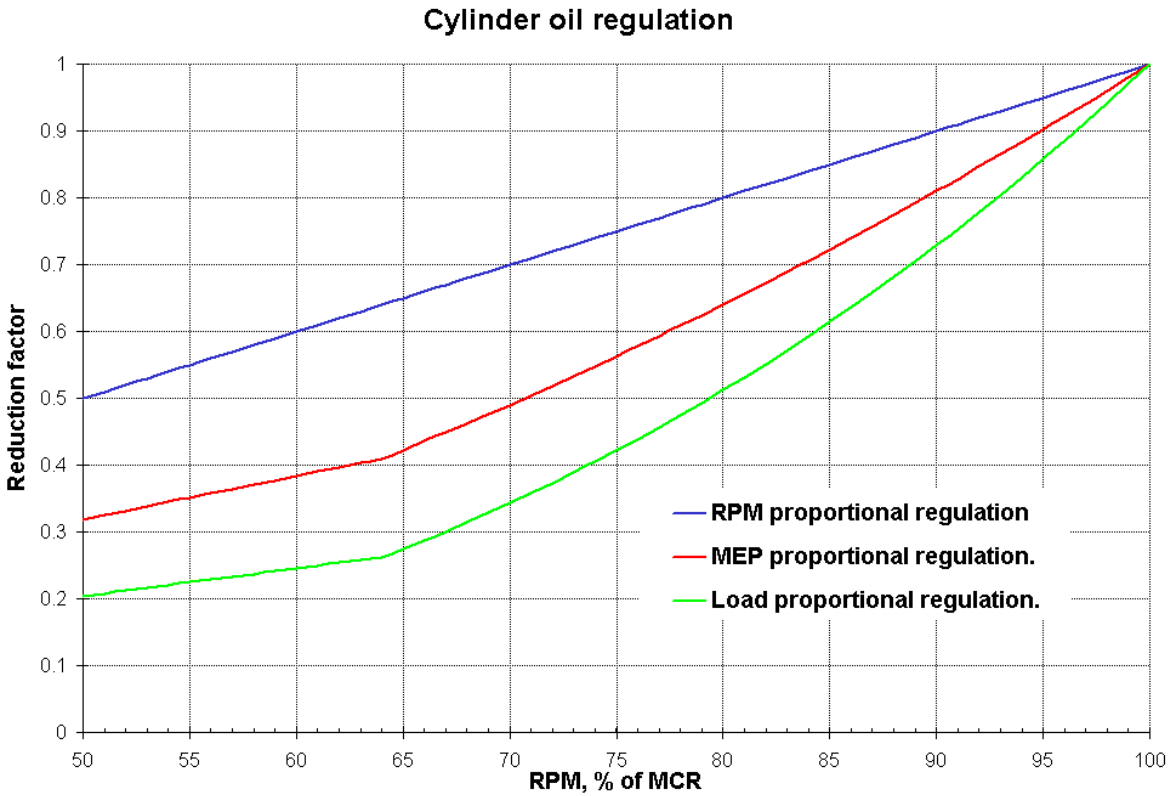
- Cylinder lubrication
- Continuous operation of auxiliary blowers
- Increased stress on flap valves in scav. receiver

Low Load Operation
Service Experience

Cylinder Lubrication

For engines with Alpha lubricators (lubrication as a function of engine load), significant savings can be made on cylinder lube oil consumption

80% RPM of MCR results in a reduction of 50%



Super Slow Steaming (SSS) Service Experience

From SL11-544 – June 2011

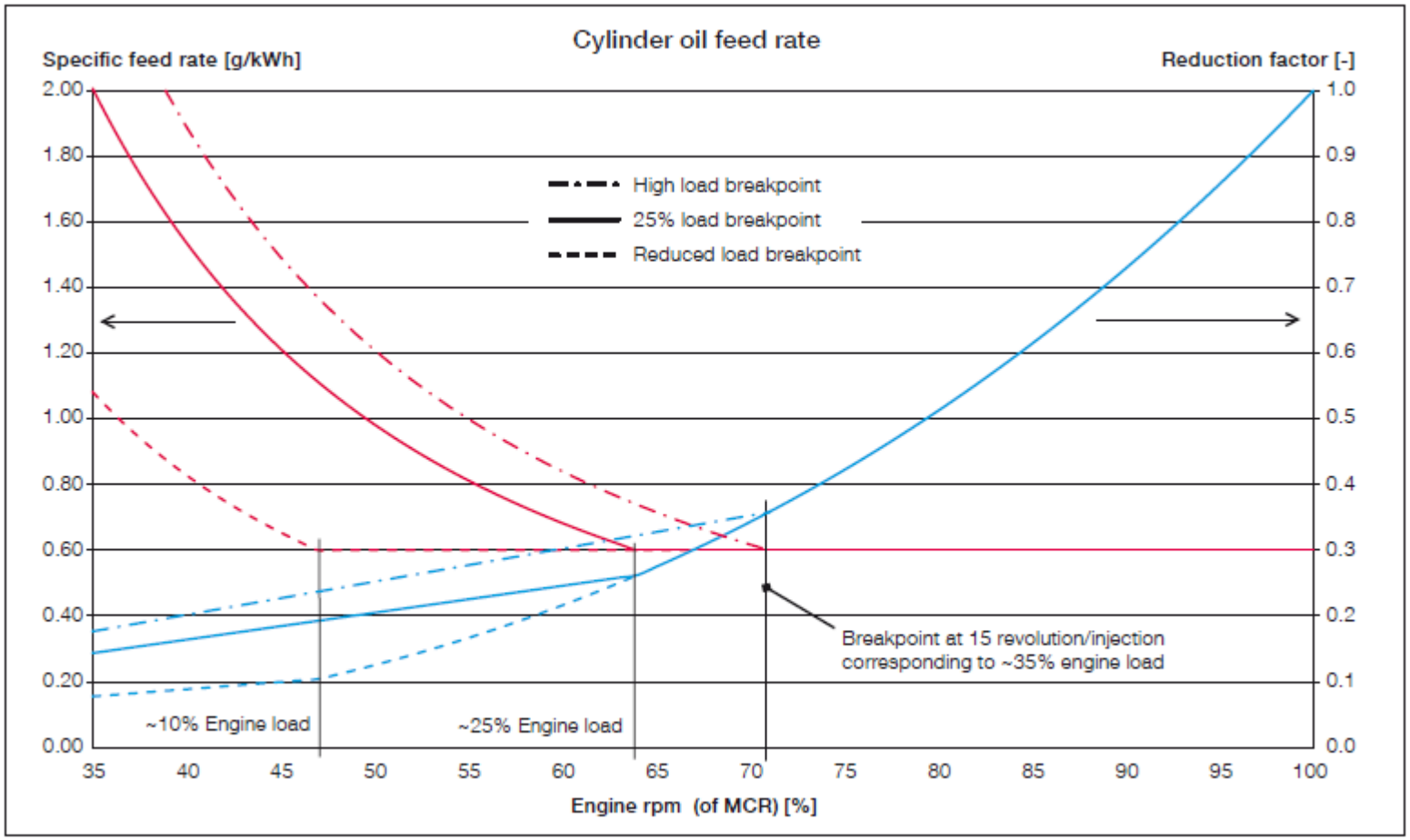


Fig. 3: Alpha Lubricator feed rate algorithm

Easy Low Load Optimization for ME-Engines

Low Load Operation
Service Experience

Cylinder Lubrication - Alpha Lubricators

During operation at low load it has been experienced that over-lubrication can happen, due to layout of lubricators.

Countermeasures

- Retrofit of lubricator pistons with reduced diameter
- Modification of lubricator by reducing piston stroke

Low Load Operation
Service Experience

Operating at low engine load, below 40%, can create issues in relation to:

- Cylinder lubrication
- **Continuous operation of auxiliary blowers**
- **Increased stress on flap valves in scav. receiver**

Service Experience of MAN B&W Two-stroke Diesel Engines

- Total Cost of Ownership for Large Marine Propulsion Engines
- New ECS Software for ME/ME-C Engines
- Operation on Low Sulphur Fuels
- Low Load Operation Update 2011
- **Cylinder Condition Update – New Engine Types**
- G-type Engines – Short Introduction

7K80ME-C9.1: Cylinder Condition

Details, scavenge port inspection:

Unit no. 1

Running Hours: 12157

Condition of piston and rings:
Good condition with no signs of abnormal wear.

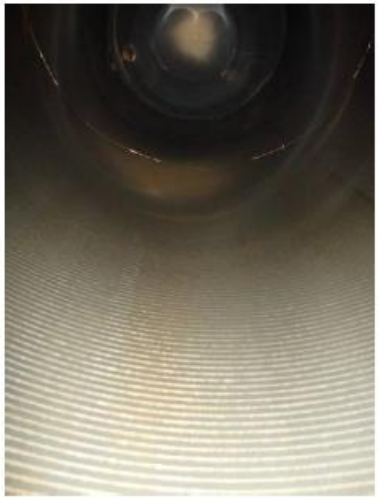
Topland: Light deposits **Ringland:** Clean

Cermet coating thickness:	
Ring	Measurement: [µm]
1	367
4	247

Mo c□atin□ thickness, skirt:	
Area	Measurement: [µm]
Top part	232
Middle	344
Lower part	277

Liner: Excellent condition. WC still visible.

Cylinder oil dosage:
Flat rate test at 0.55g/kWh.



Unit no. 3

Running Hours: 12157

Condition of piston and rings:
Good condition with no signs of abnormal wear.

Topland: Light deposits **Ringland:** Clean

Cermet coating thickness:	
Ring	Measurement: [µm]
1	349
4	240

Mo c□ating thickne□s, skirt:	
Area	Measurement: [µm]
Top part	325
Middle	474
Lower part	432

Liner: Excellent condition. WC still visible.

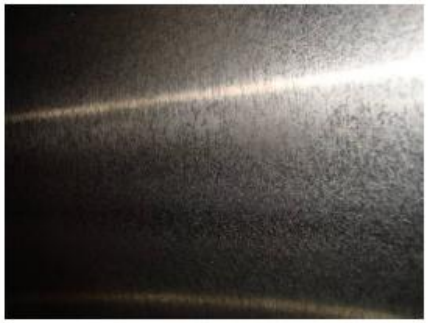
Cylinder oil dosage:
Flat rate test at 0.55g/kWh.

7K80ME-C9.1: Cylinder Condition

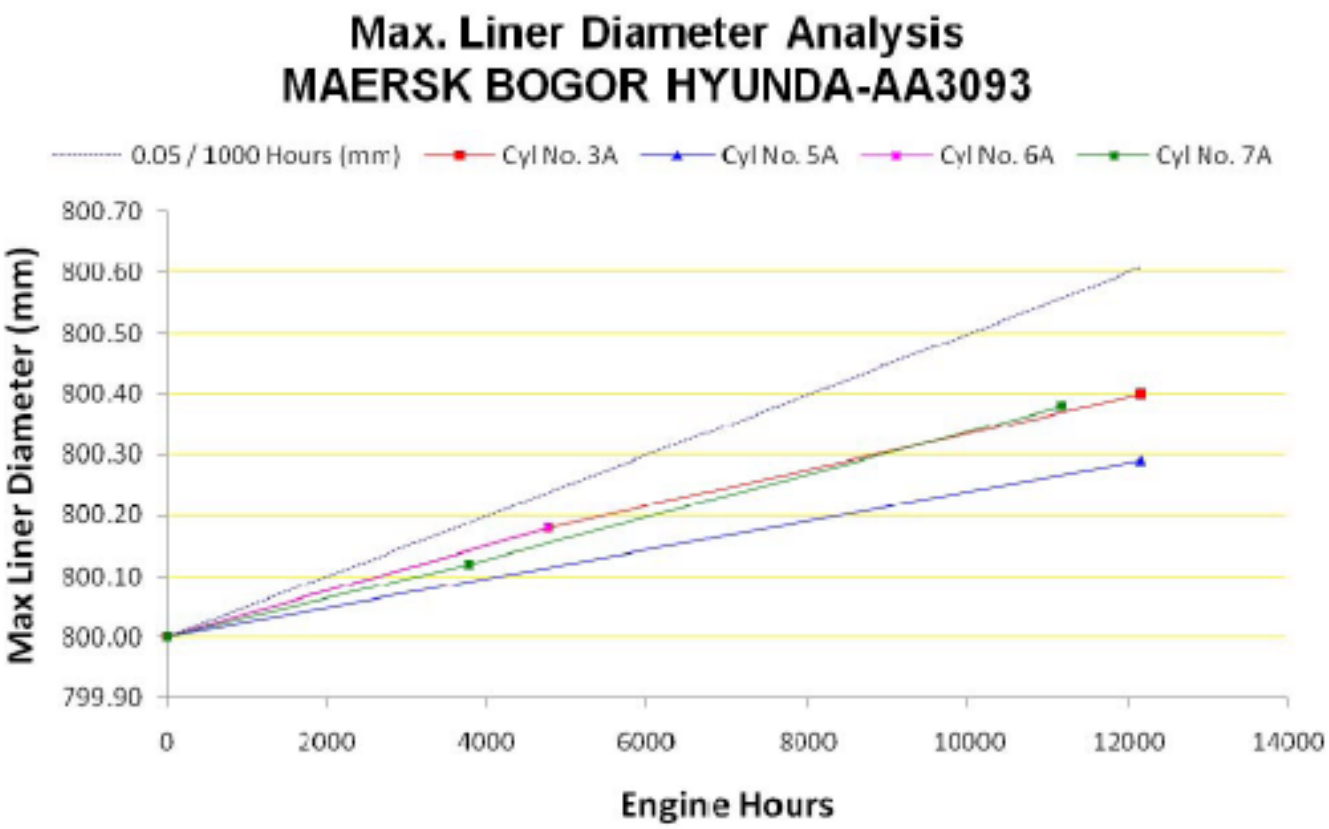
Cylinder unit No. 3 running surface:

Cylinder unit No 3 was inspected and found in good condition. On this unit a test with soft delivery cylinder lubrication is active.

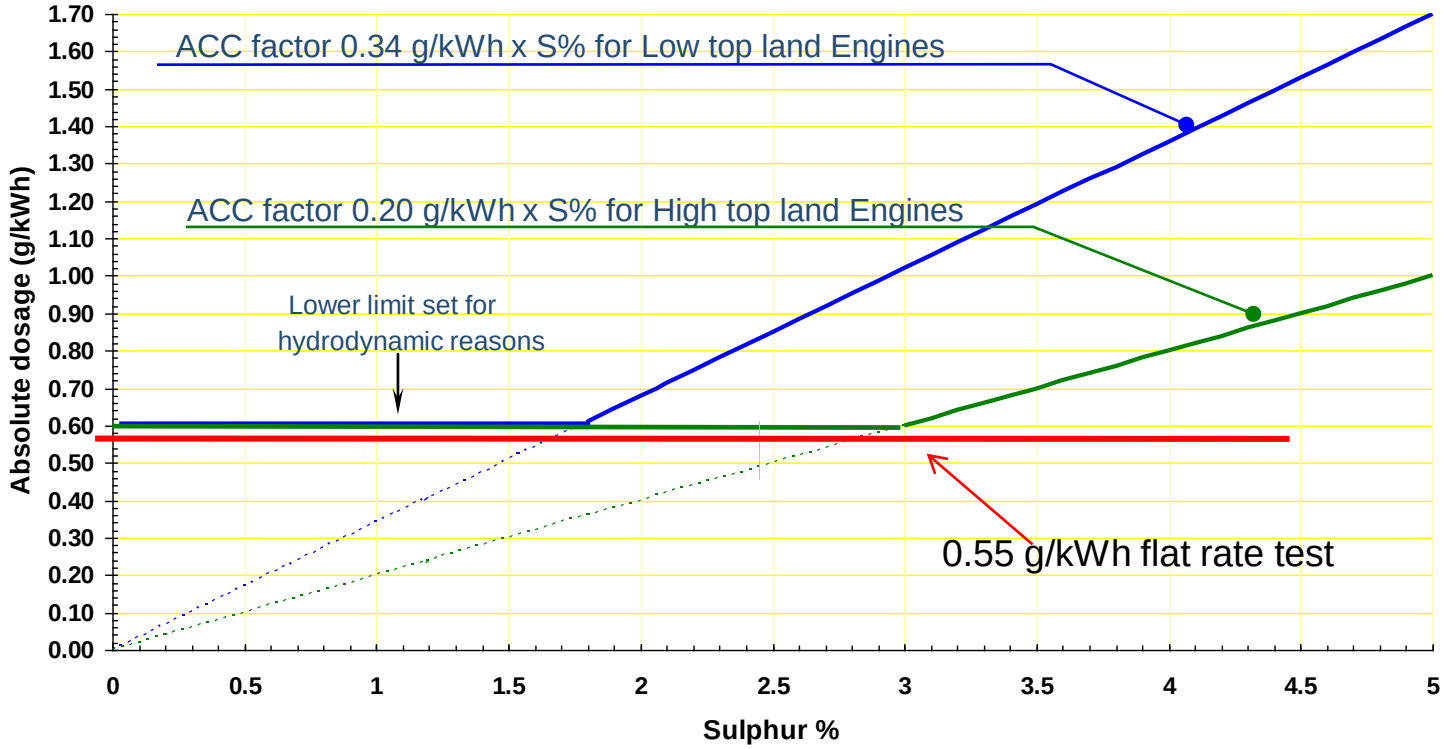
The liner surface was found to be smooth, wth no indication of abnormal wear. The surface lamella structure appeared slightly corrosive with an open graphite lamella structure, as indicated on the photo below, taken in measuring point No. 2, manouvering side.



7K80ME-C9.1: Cylinder Condition



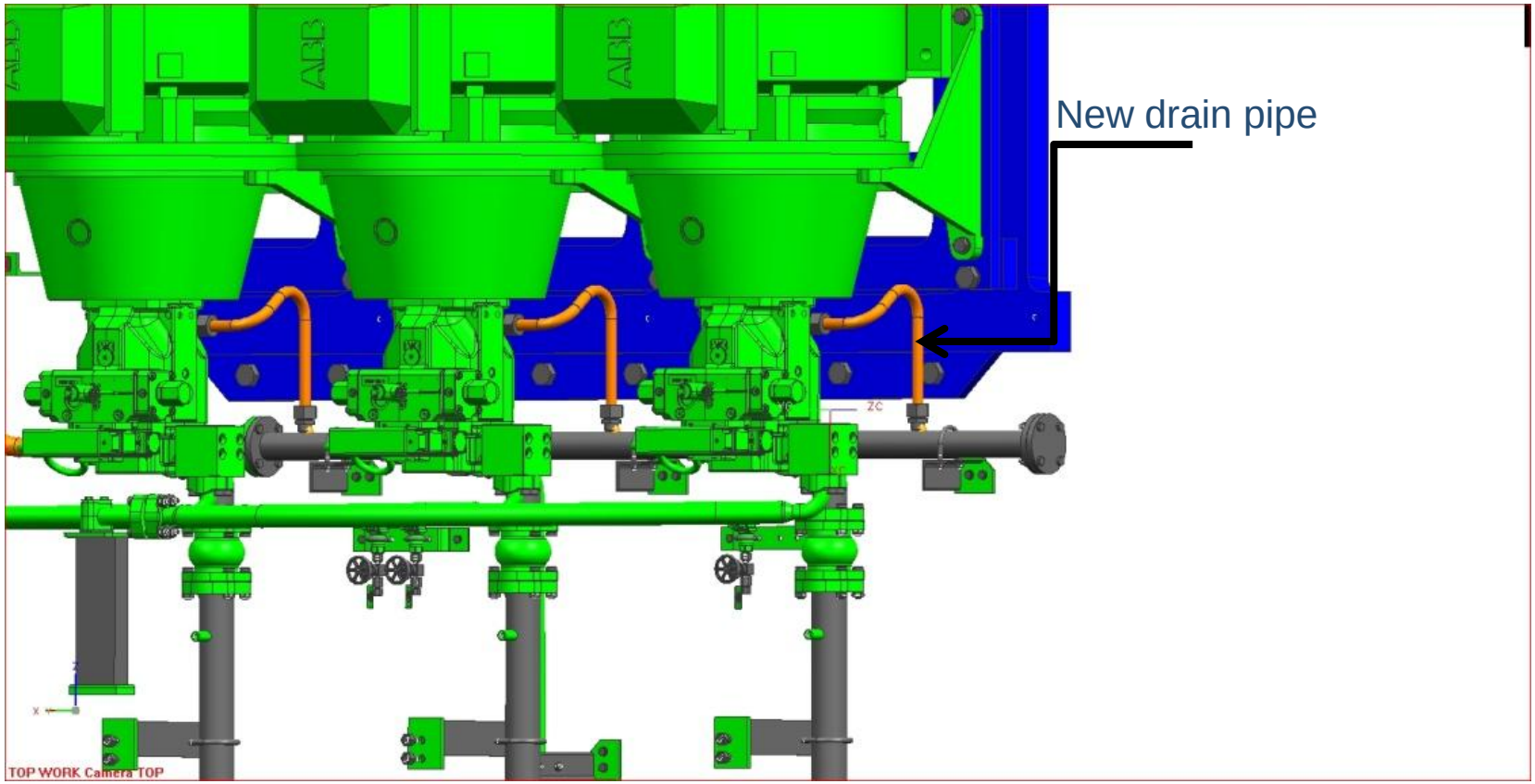
Cylinder Lubrication, Corrosion Control



6S80ME-C9.1
Test Bed, October 2010

Electrically Driven Hydraulic Power Supply (HPS)

Electrically Driven
Hydraulic Power Supply (HPS)



6S80ME-C9.1
PMI AutoTuning

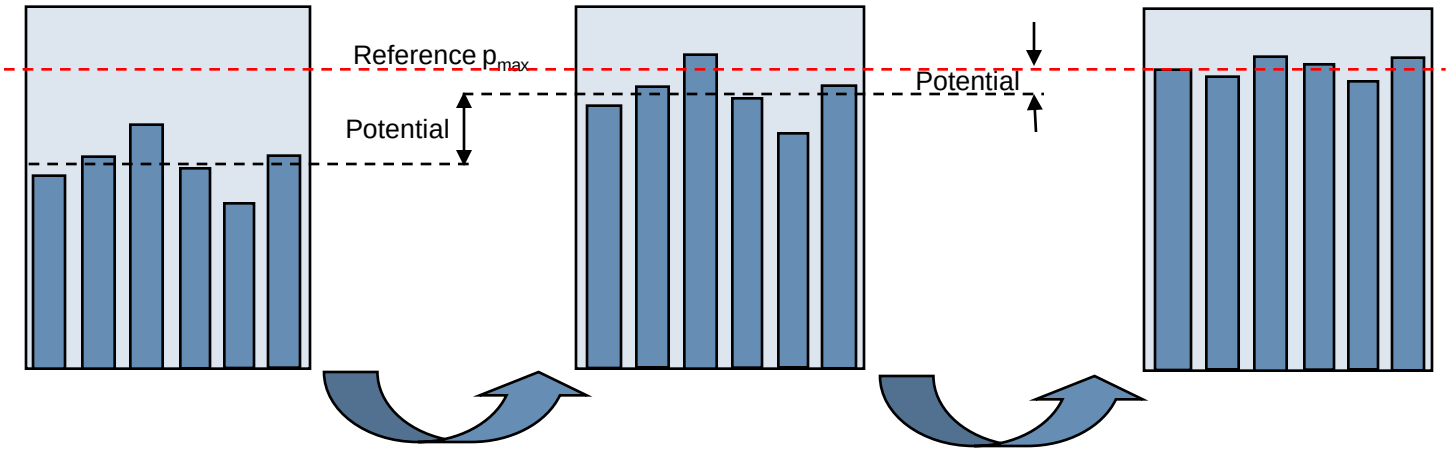
Data Acquisition Unit (DAU)

Pressure Sensor

AutoTuning: Potential Fuel Reduction

Reduction in fuel oil consumption / CO_2 emission

1 bar increase in average p_{max} => 0.20-0.25 g/kWh decrease in fuel oil consumption



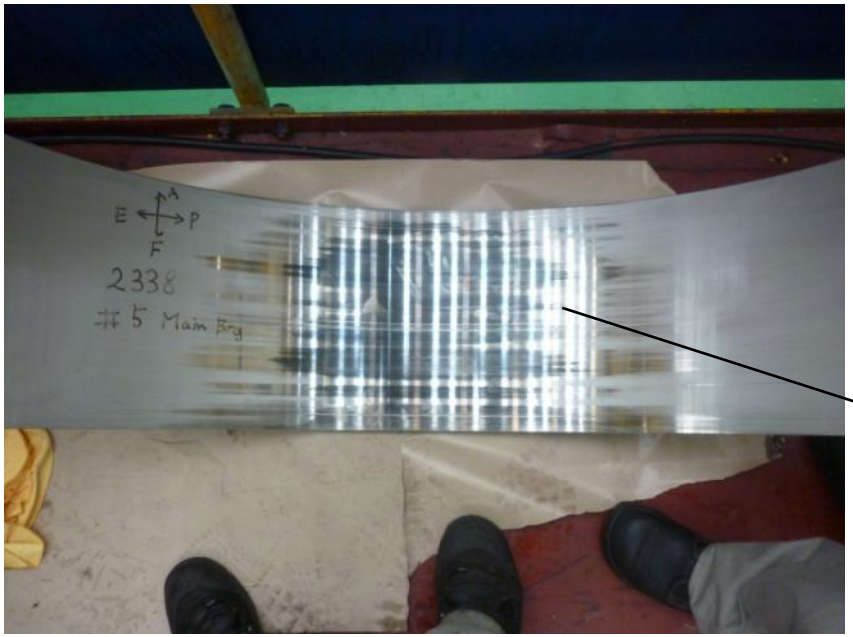
Pure p_{max} level increase
Potential 5-10 bar
Potential 1-2.5 G/kWh

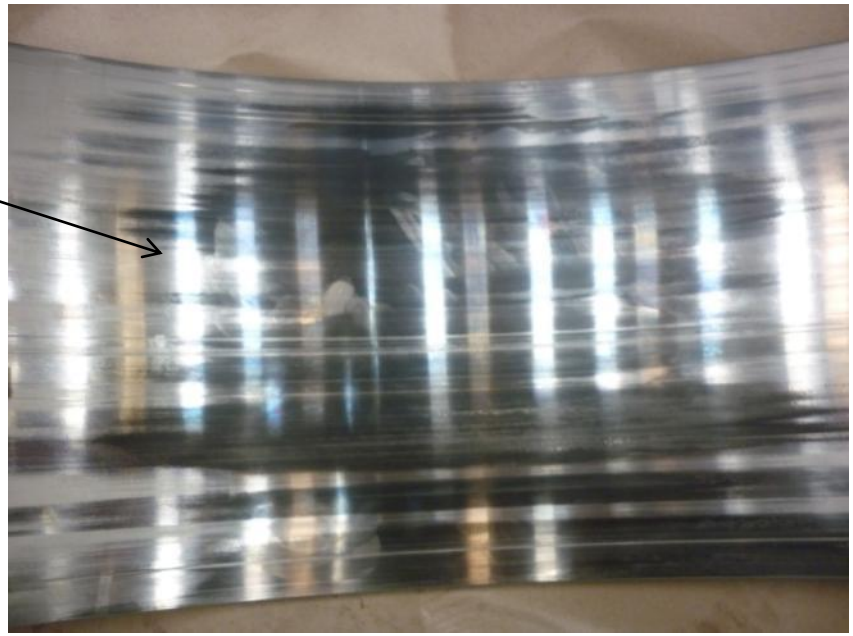
Balancing + p_{max} level increase
Potential additional 2-5 bar

Total potential 1.4 – 3.75 g/kWh

Gain also with engines already being operated within recommended limits

Overhaul Inspection after Prototype Shop Trial: Main Bearing no. 5





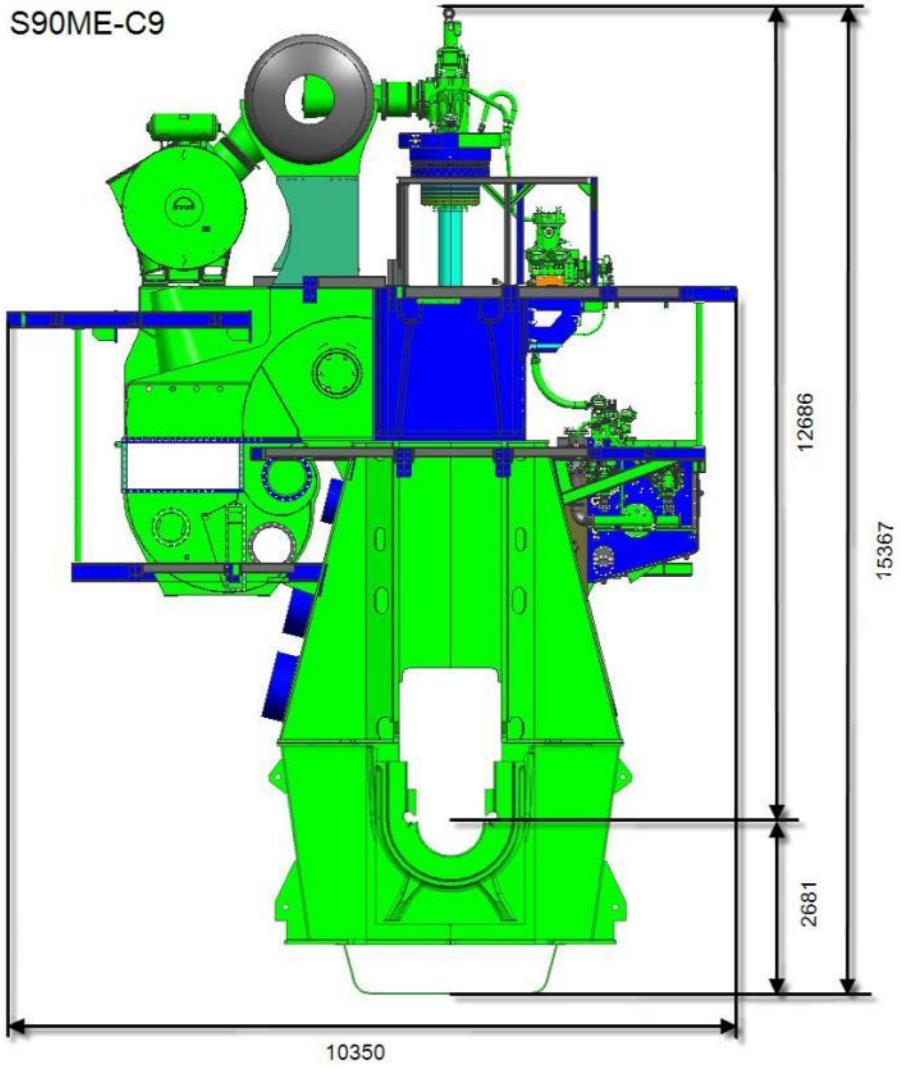
Engines for Large Container Ships

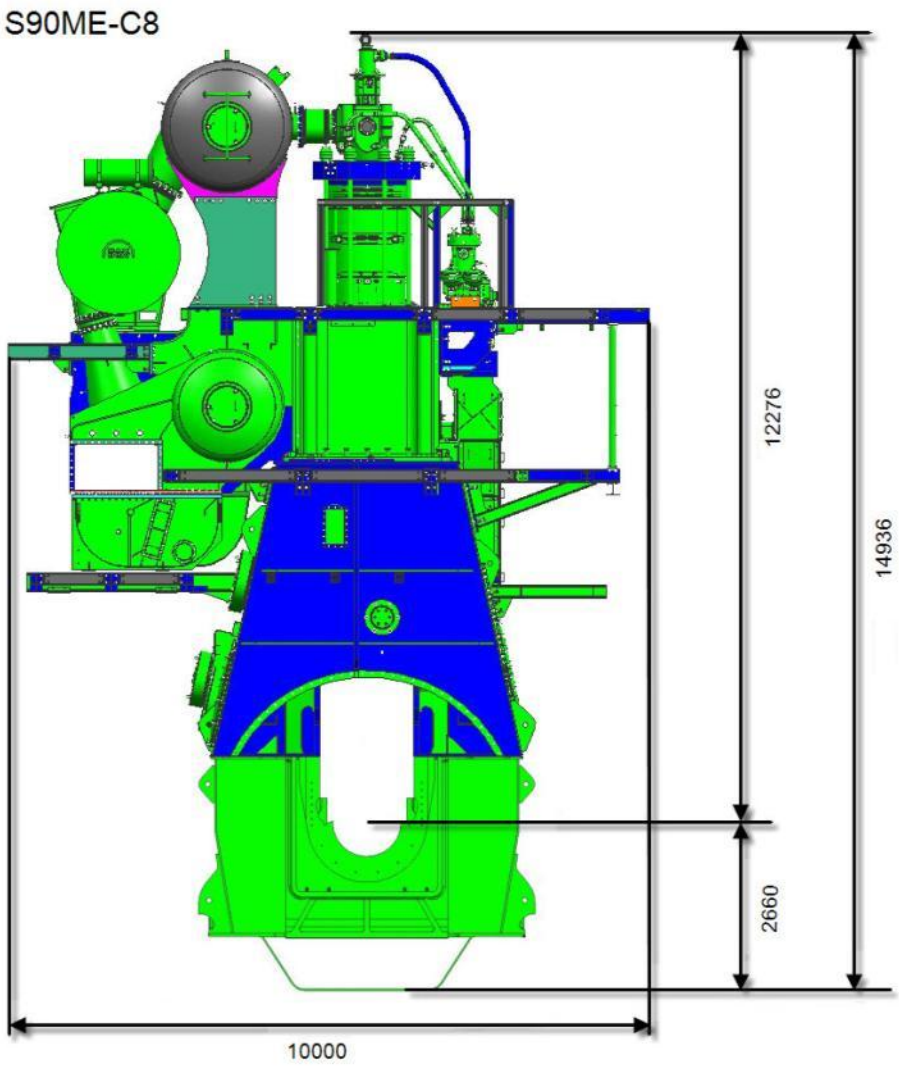
Recent Trend: S90ME-C for Container Vessels

Order list for Large Container Vessels

No of Ships			Engine				Mark	Owner	Capacity TEU	Yard	Hull no	Eng. Builder
18			9	S	90	ME-C	8.1	A.P. Moeller	7.000	DSME	4214->	Doosan
4			9	S	90	ME-C	8.2	Zodiac	9.000	DSME-Mangalia	4090->	Doosan
3			9	S	90	ME-C	9.2	Bernard Schulte	9.000	Shanghai Jiangnang CHI	1066A ->	HHI EMD
3			9	S	90	ME-C	9.2	Costamare	9.000	Shanghai Jiangnang CHI	1068A ->	HHI EMD
6			9	S	90	ME-C	8.2	Bernard Schulte/Ofer	9.000	HSHI	S592 ->	HHI EMD
6			12	S	90	ME-C	9.2	OOCL	13.000	SHI	2002 ->	HHI EMD
8	+	17	10	S	90	ME-C	9.2	SEASPAN	10.000	New Yangzi	2011-983 ->	CMD
7	+	10	9	S	90	ME-C	8.2	Costamare	9.000	Sungdong	4010 ->	HHI EMD
4			9	S	90	ME-C	8.2	MSC	9.000	Sungdong		HHI EMD
6			8	S	90	ME-C	8.2	Hamburg Sued	9.600	HHI	2521 ->	HHI EMD
12			10	S	90	ME-C	9.2	NOL	9.000	DSME	conversion from K98ME-C	Doosan
10			11	S	90	ME-C	9.2	NOL	13.800	HSHI	S630 ->	HHI EMD
Total			**87 ships**									

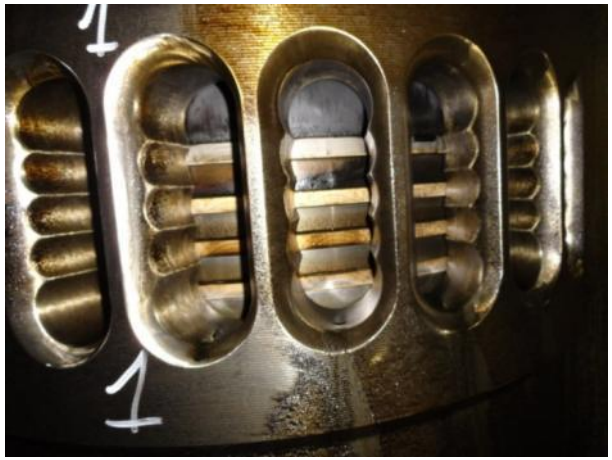
S90ME-C8&9 – Outline





9S90ME-C8.1: Cylinder Condition

Cylinder no. 1 at 1,803 hours: Excellent Condition



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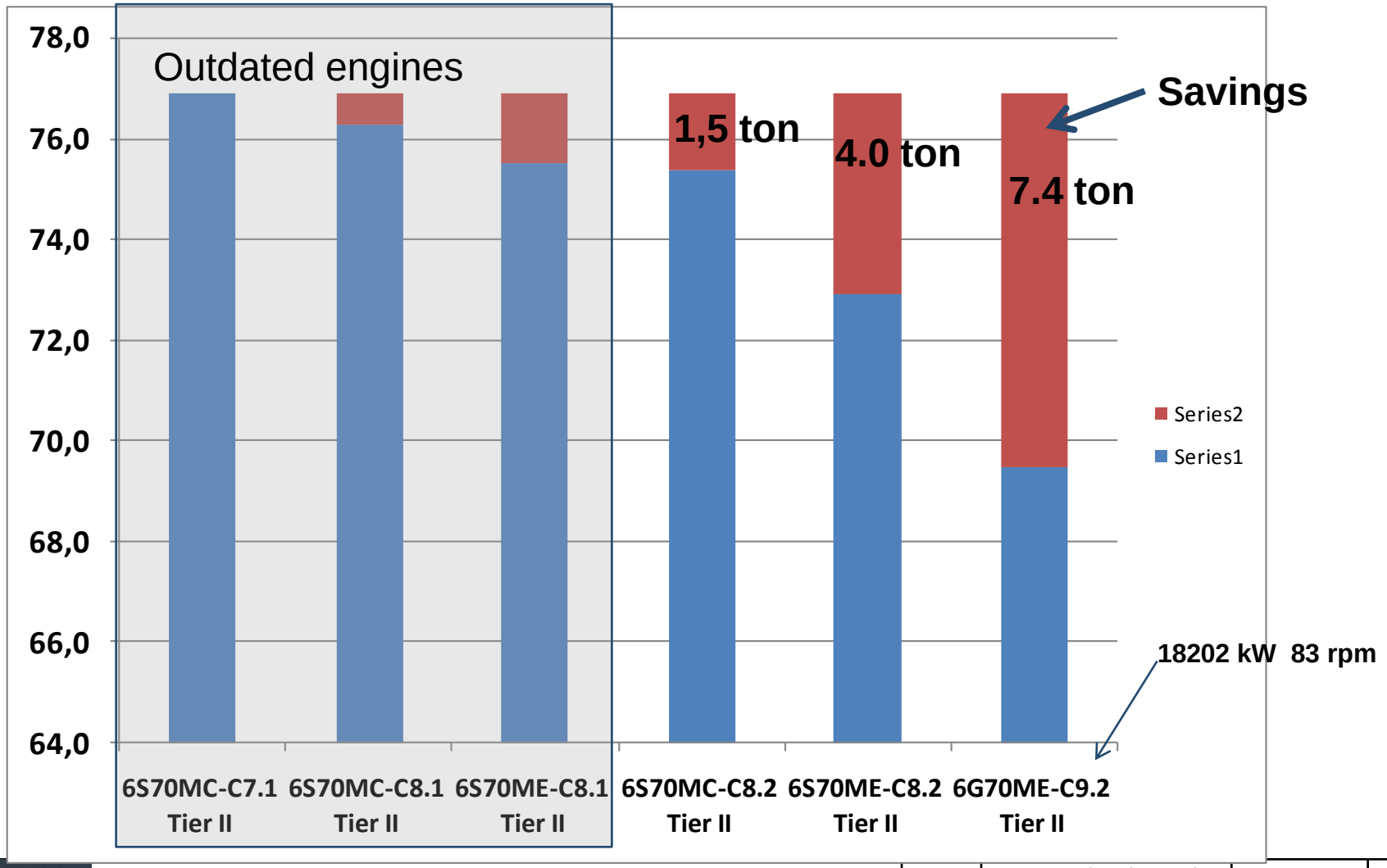
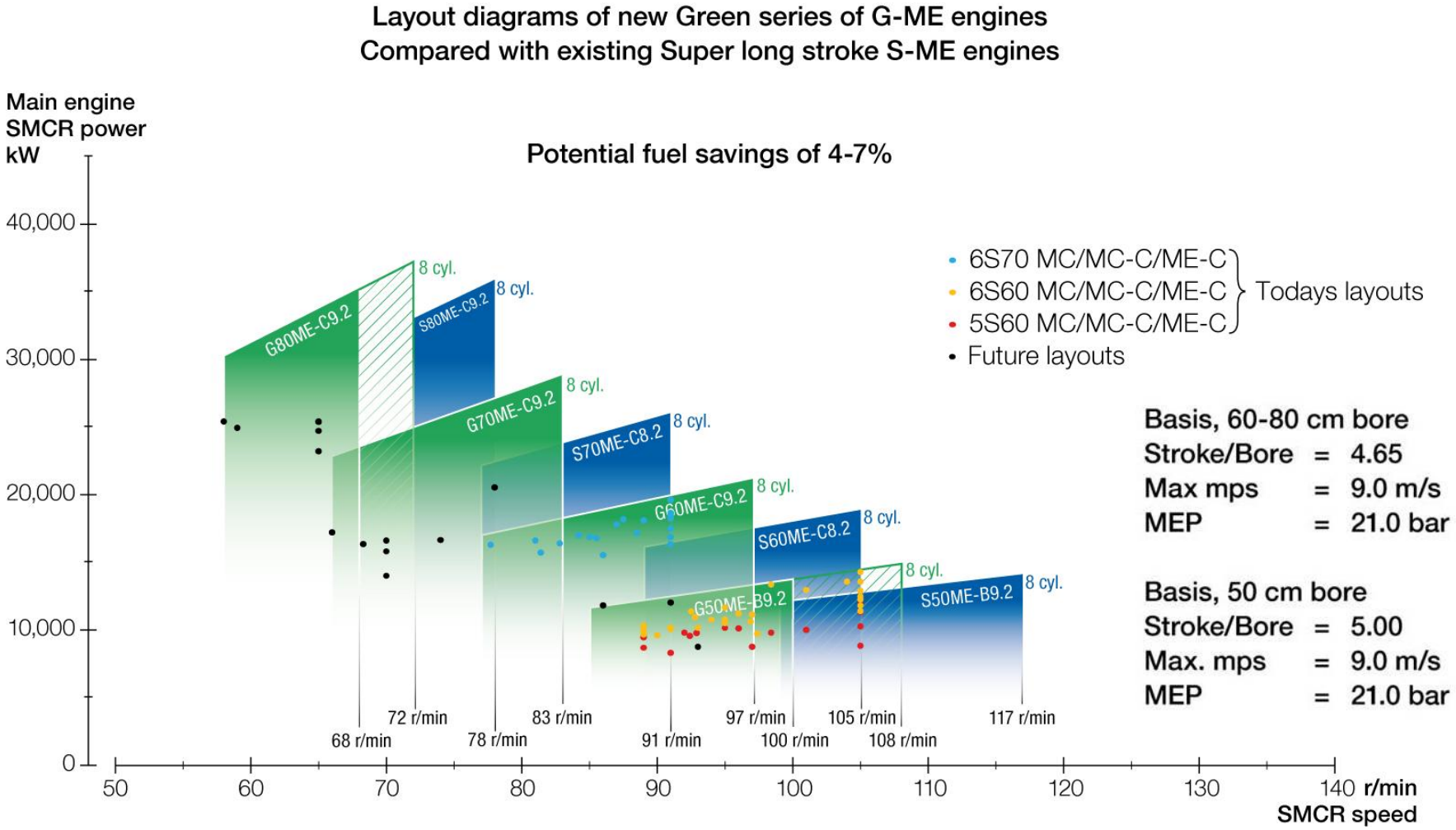
Daily Fuel Oil Consumption 6S/G70MC/E types and versions

Daily fuel consumption at 70% load

SMCR 18660 KW 91 rpm, figures at 70% load

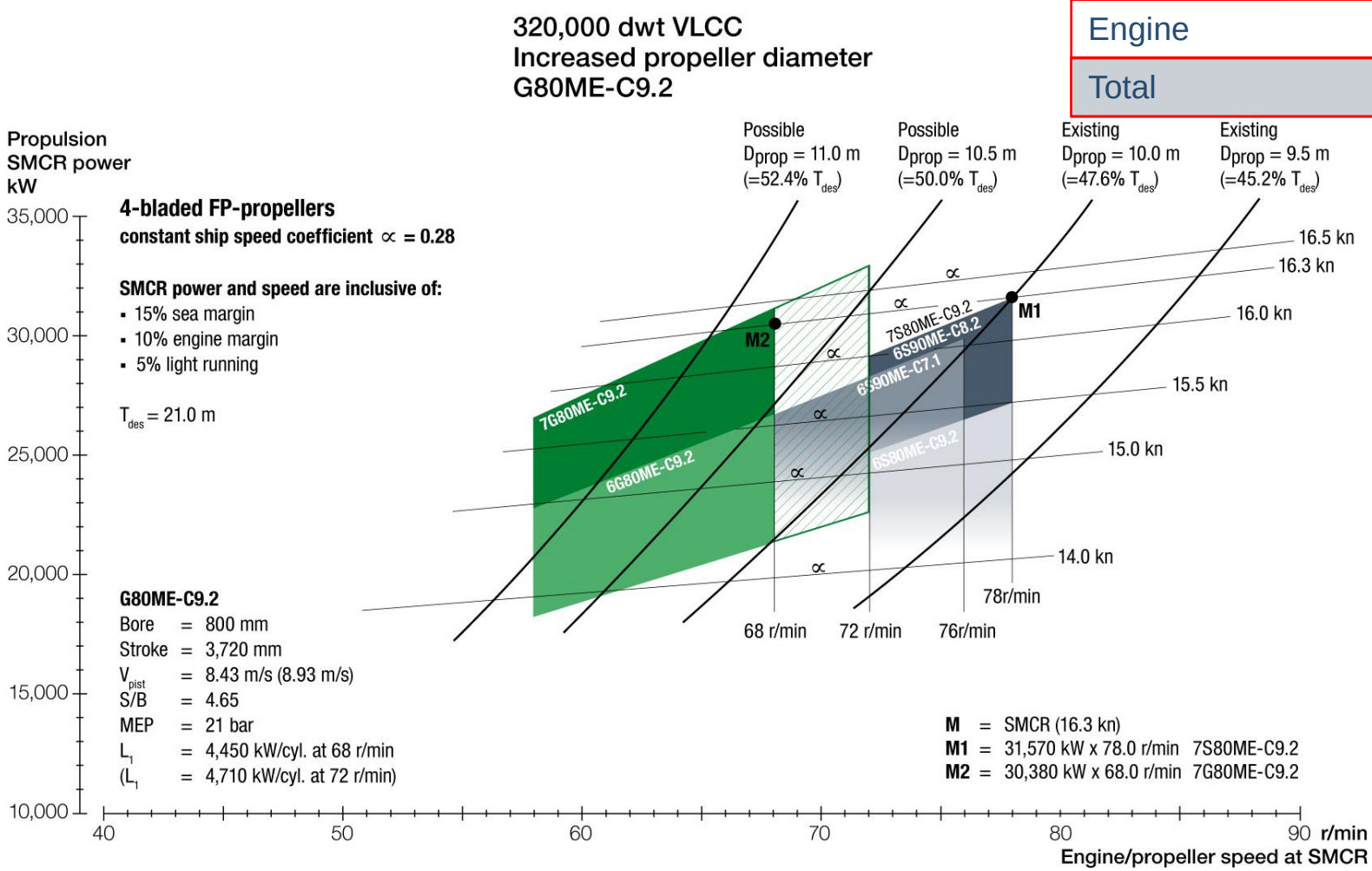


Green Series of G-ME Engines



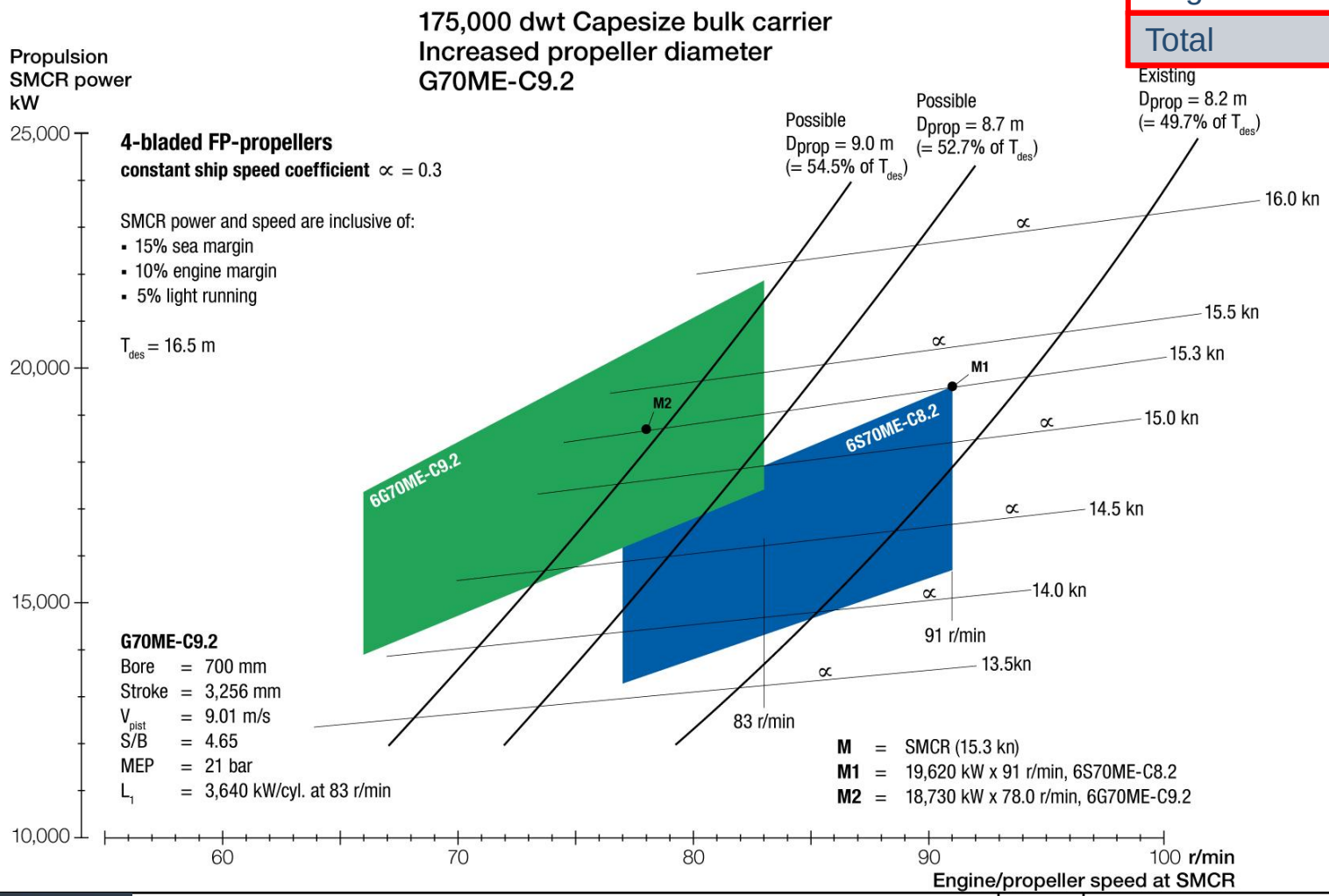
G80ME-C9.2

Propeller		3.7%
Engine		1.0%
Total		4.7%



G70ME-C9.2

Propeller		4.5%
Engine		2.0%
Total		6.5%



Thank You for Your Attention!

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