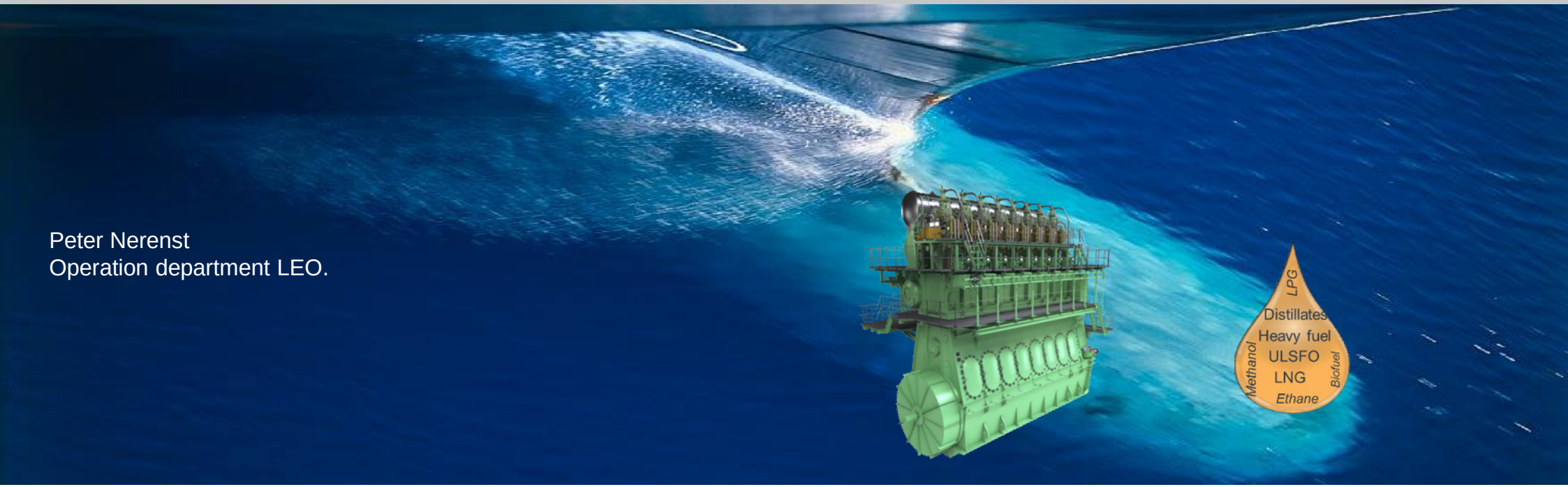
MAN Energy Solutions
Future in the making

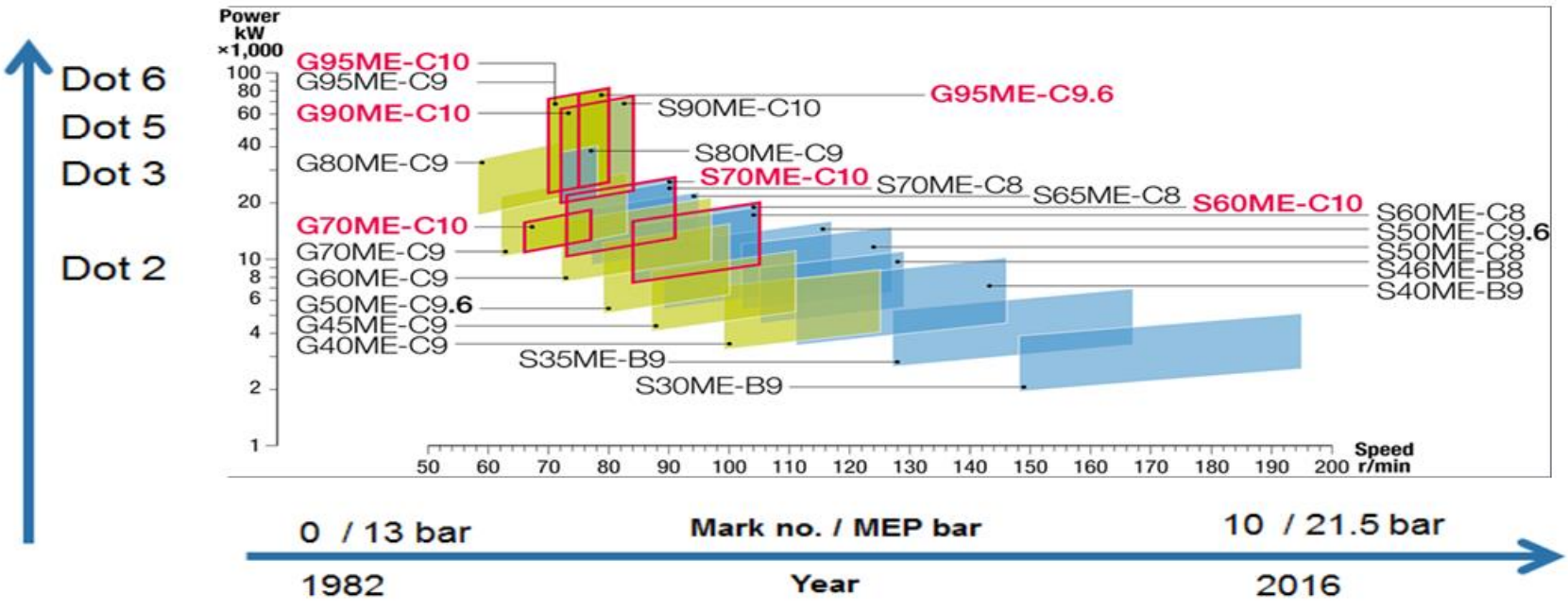
Machinery damages in modern shipping and lesson learnt.

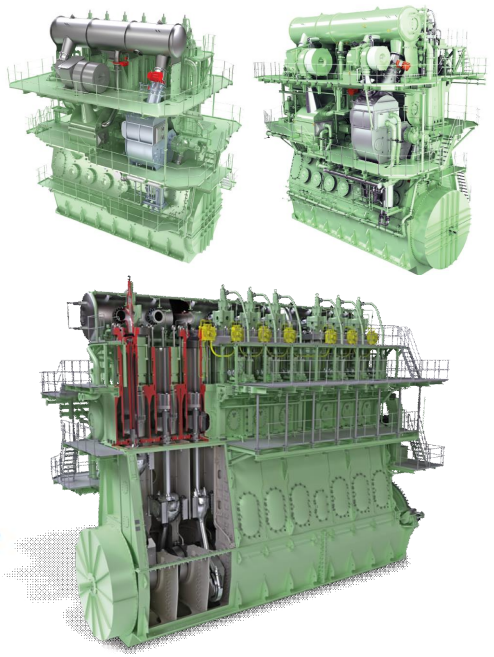
Class NK , Turkish owners, MAN Energy Solution.

Peter Nerenst
Operation department LEO.



Engine Programme Development



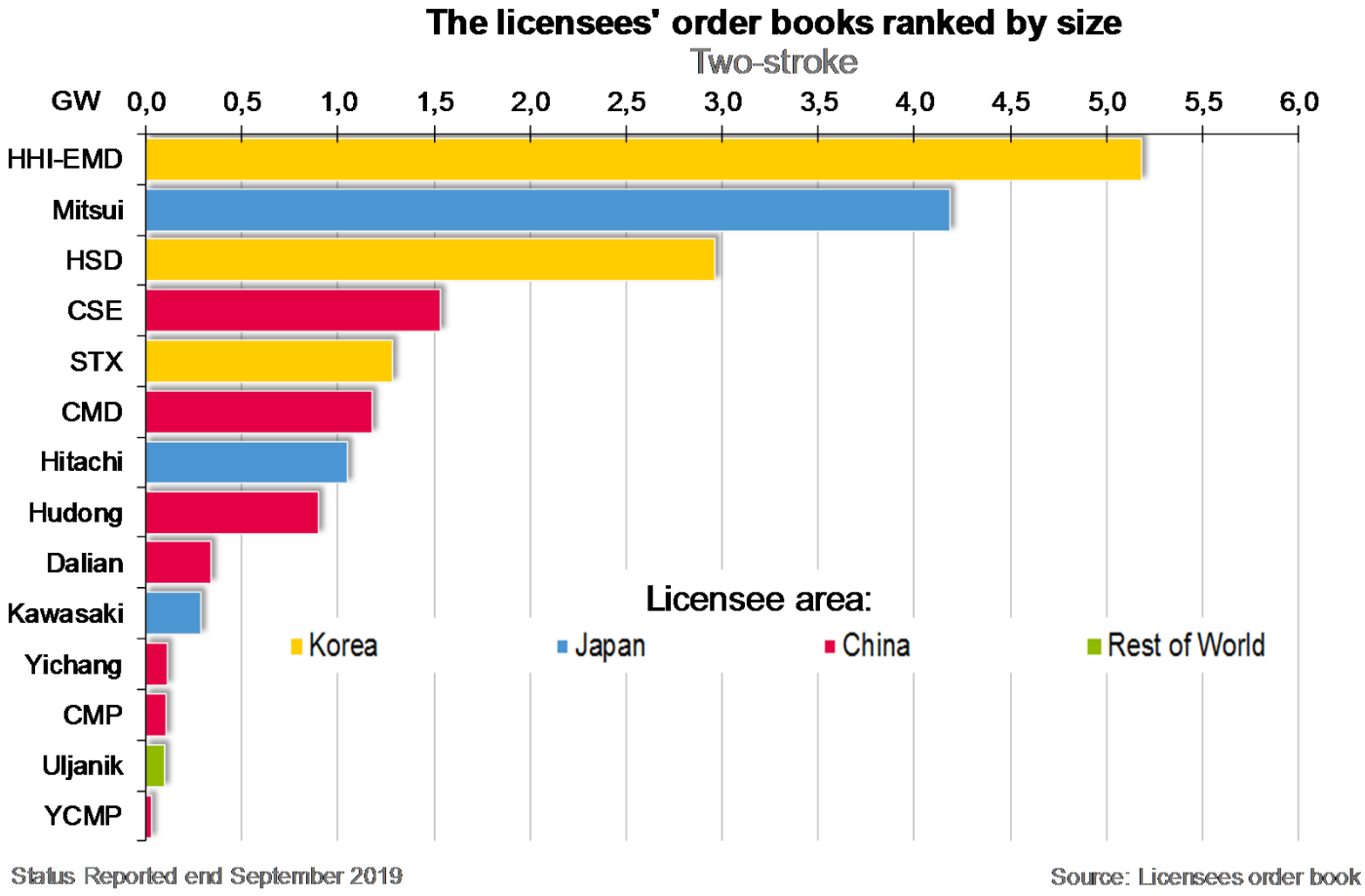


Mission: Meet any combination of propeller power and speed the naval architects will need

The Licensees Reported Order Book

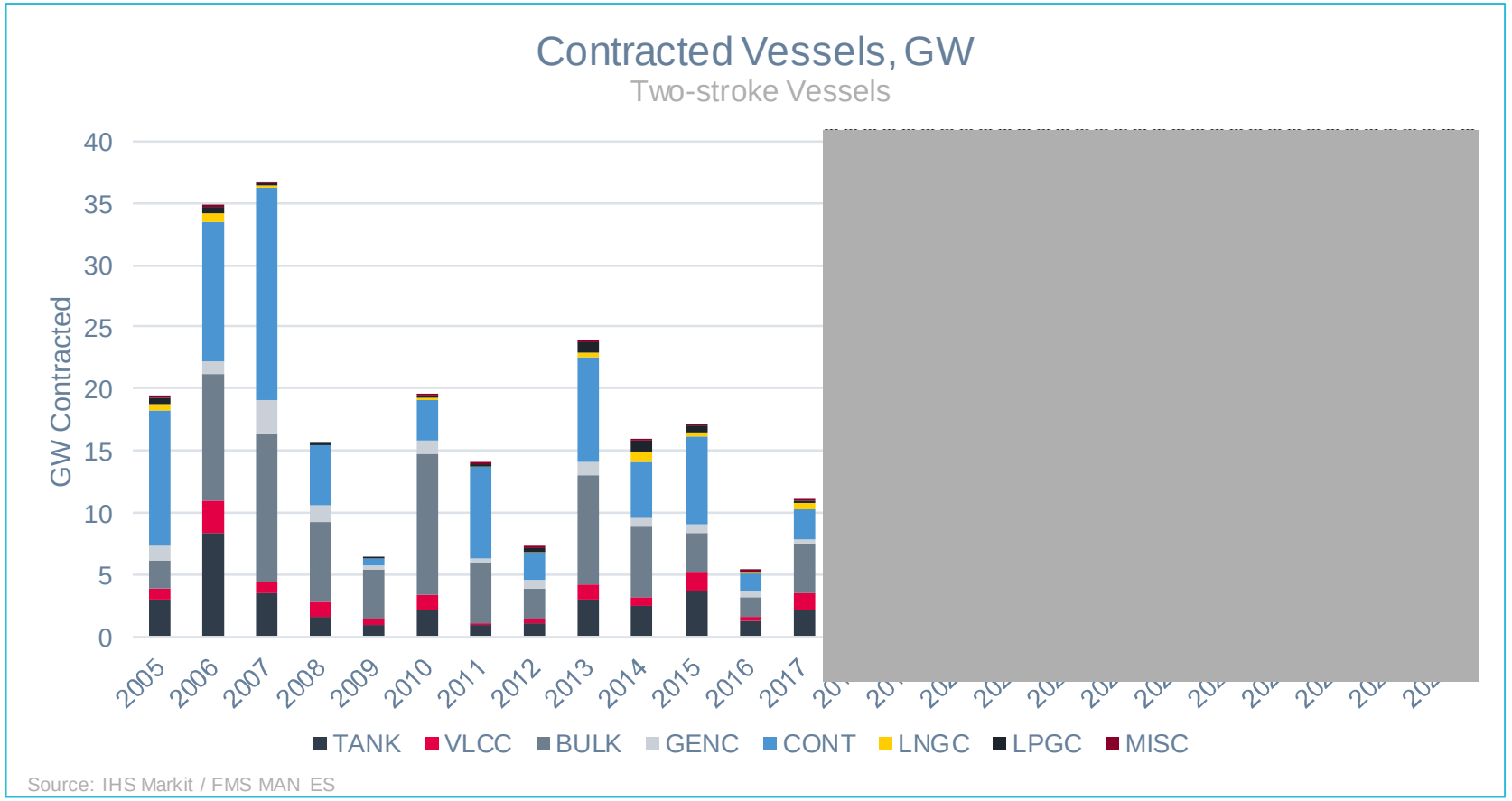
Confidential

Two-Stroke Low Speed



Two-Stroke GW Contracting

Vessel Propelled by Two-Stroke Engines



Summary of Claims reported

Main engine claims account for 28% of all machinery claims and 34% of the costs, with an average claims cost close to USD 650,000.

The claims frequency has for the last ten years been steady at between 0.020 and 0.025 claims per vessel and year.

Passenger vessels/ferries have the highest frequency with 0.066 claims per vessel and year.

Vessels propelled by medium/high speed engines have a claims frequency 2.5 times higher compared with slow speed engines.

Lubrication oil related failure is the most common cause of damage.

The most expensive type of damage is on crank shaft/bearings with an average cost of MUSD 1.2 per claim.

Important Incidents reported 2019-2020.

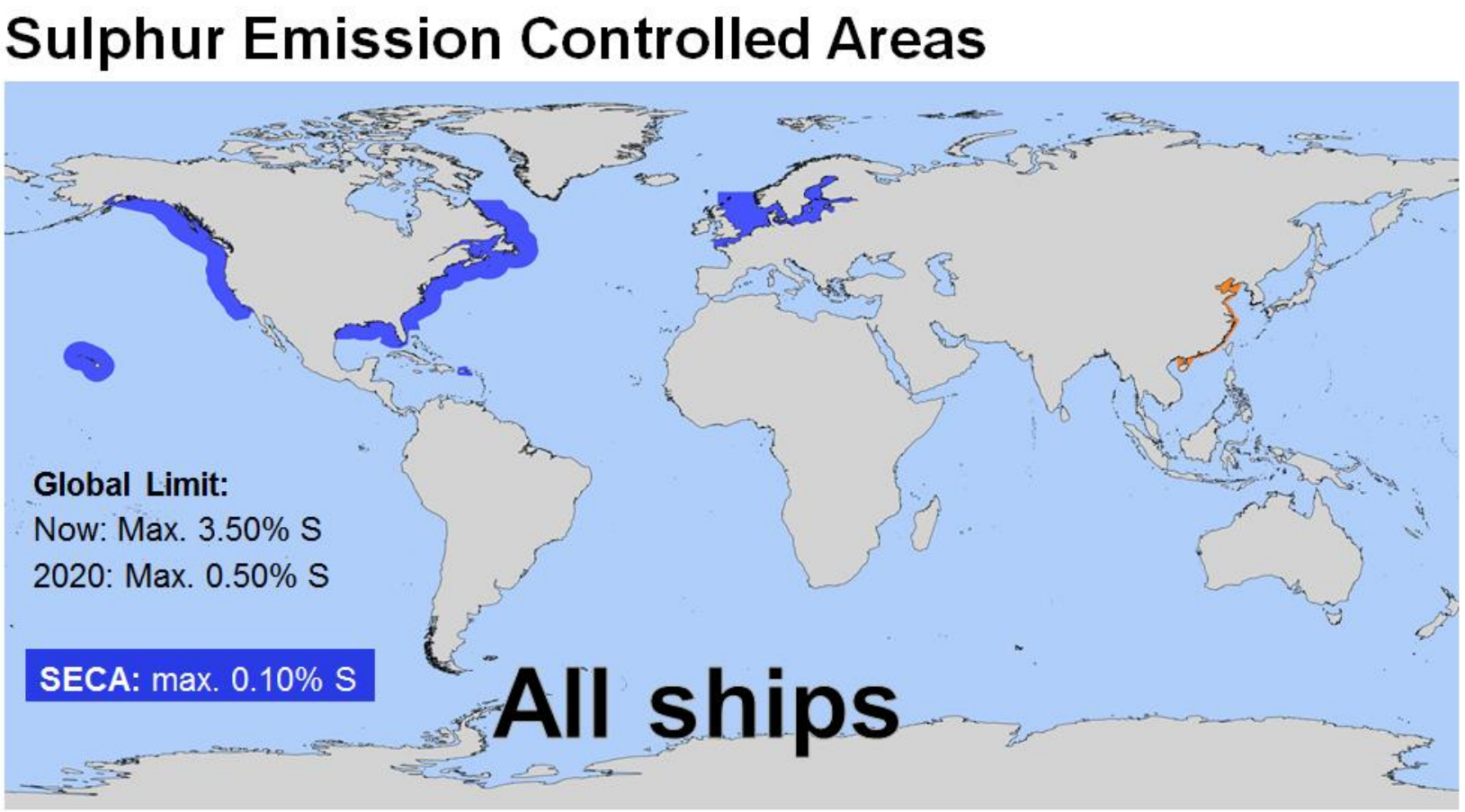
- 1) Cylinder condition: Cylinder liner scuffing due to Worldvide 0,5% S Low Sulphur Regulation 1 Jan 2020.
- 2) Fuel contamination.
- 3) Bearings problems.
- 4) Untimed fuel injection.
- 5) Casting defect EXH valve housings. (Chinese foundries)
- 6)EXH gas scrubbers.
- 7) Dual fuel engines.

Service Letter & General Guide Lines

Preparing for 2020 and 0,50% Sulphur Fuels

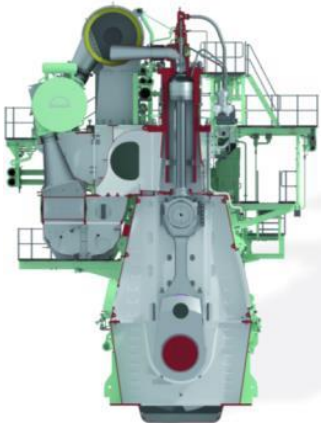
- **1st of January 2020, IMO global 0,50% sulphur limits enters into force.**

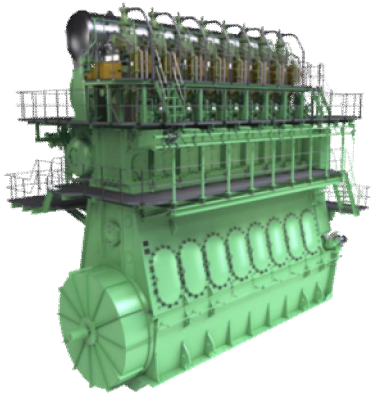
- **1st of March 2020, IMO carriage ban enters into force. Only vessels with SOx scrubbers are allowed to carry fuel on board with sulphur content higher than 0.50% in the fuel tanks.**

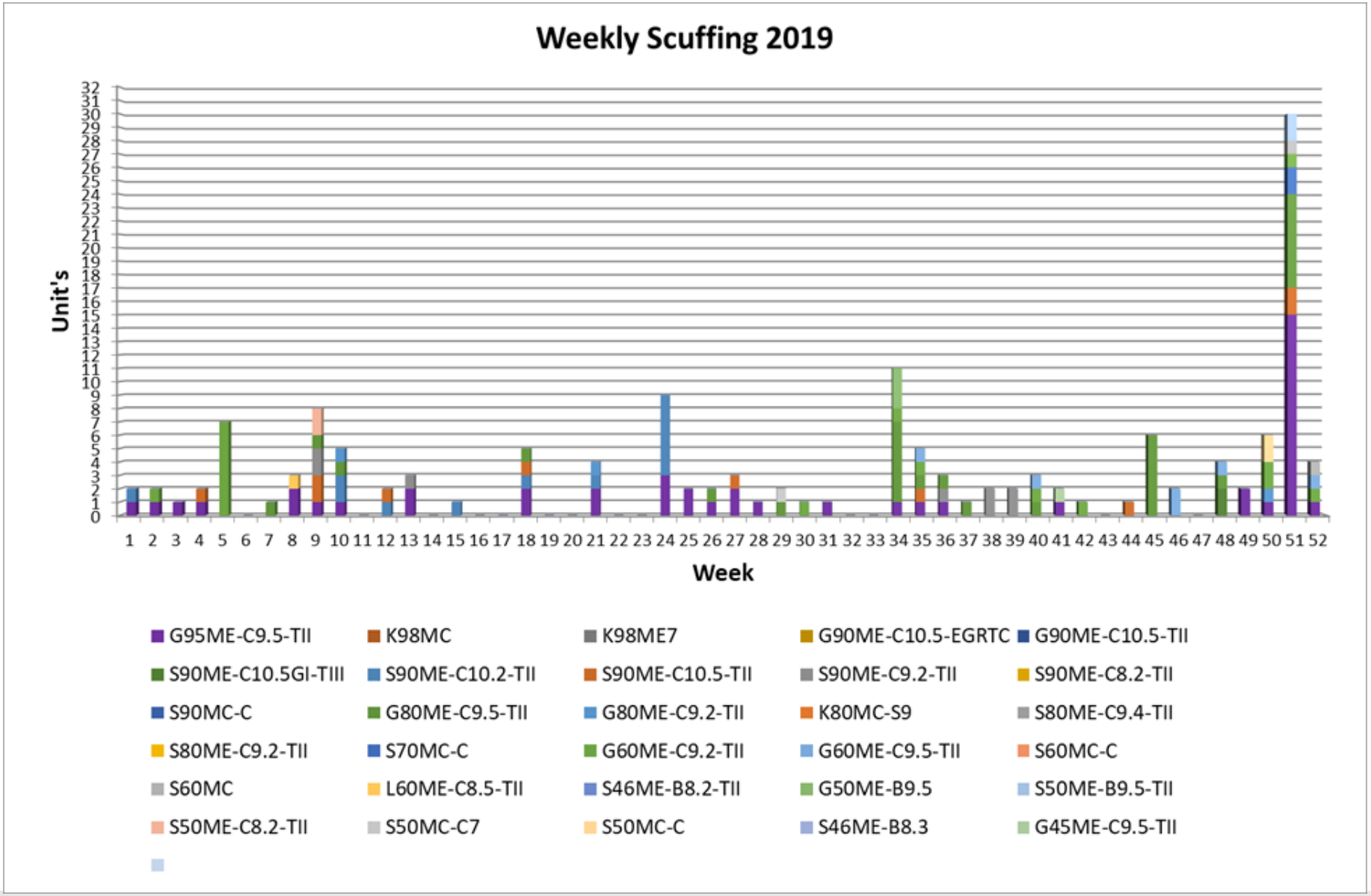


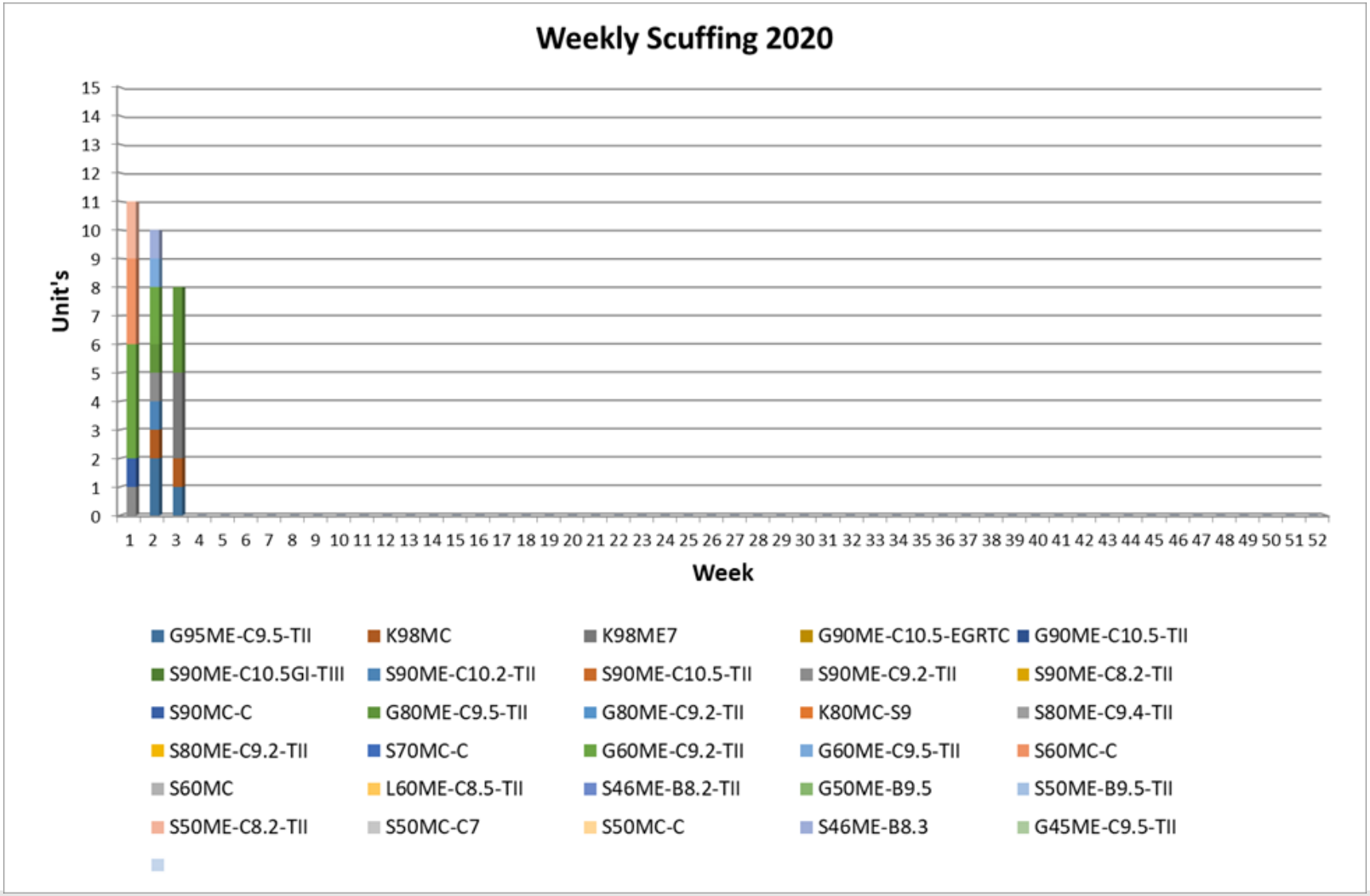
What Fuel will be used in 2020 and beyond?

Compliant fuel		High sulphur fuel
MC/ME/-C engine Single Fuel: 0.10%S fuel, 0.50%S fuel	ME-GI/ME-LGI engine Dual Fuel: LNG, Ethane, LPG, MeOH	MC/ME/-C engine 0 ï 5%S fuels: HFO/MDO + Scrubber

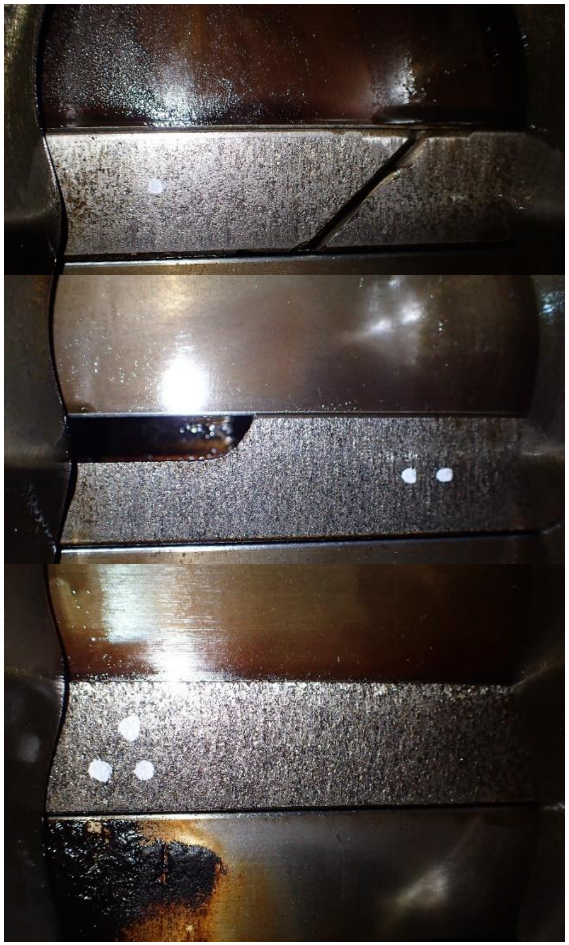


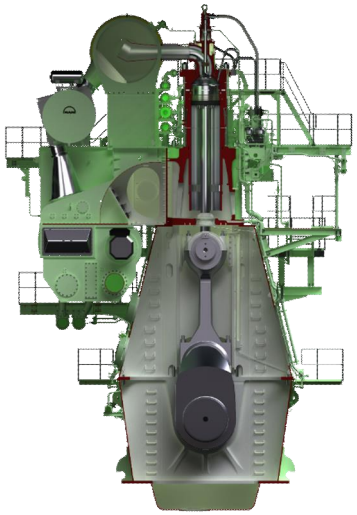



Weekly Scuffing 2019
Unit's
Week
G95ME-C9.5-TII
K98MC
K98ME7
G90ME-C10.5-EGRTC
G90ME-C10.5-TII
S90ME-C10.5GI-TIII
S90ME-C10.2-TII
S90ME-C10.5-TII
S90ME-C9.2-TII
S90ME-C8.2-TII
S90MC-C
G80ME-C9.5-TII
G80ME-C9.2-TII
K80MC-S9
S80ME-C9.4-TII
S80ME-C9.2-TII
S70MC-C
G60ME-C9.2-TII
G60ME-C9.5-TII
S60MC-C
S60MC
L60ME-C8.5-TII
S46ME-B8.2-TII
G50ME-B9.5
S50ME-B9.5-TII
S50ME-C8.2-TII
S50MC-C7
S50MC-C
S46ME-B8.3
G45ME-C9.5-TII


Weekly Scuffing 2020
Unit's
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
Week
G95ME-C9.5-TII
K98MC
K98ME7
G90ME-C10.5-EGRTC
G90ME-C10.5-TII
S90ME-C10.5GI-TIII
S90ME-C10.2-TII
S90ME-C10.5-TII
S90ME-C9.2-TII
S90ME-C8.2-TII
S90MC-C
G80ME-C9.5-TII
G80ME-C9.2-TII
K80MC-S9
S80ME-C9.4-TII
S80ME-C9.2-TII
S70MC-C
G60ME-C9.2-TII
G60ME-C9.5-TII
S60MC-C
S60MC
L60ME-C8.5-TII
S46ME-B8.2-TII
G50ME-B9.5
S50ME-B9.5-TII
S50ME-C8.2-TII
S50MC-C7
S50MC-C
S46ME-B8.3
G45ME-C9.5-TII

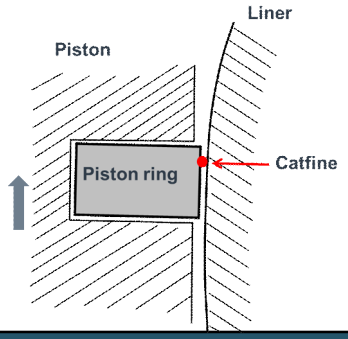
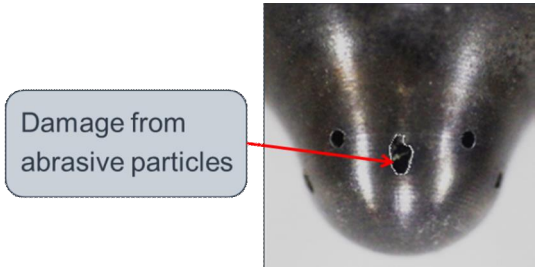
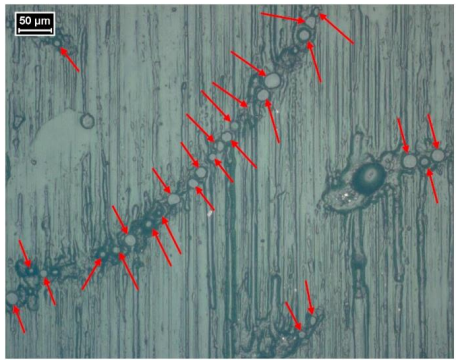
Cylinder liner scuffing in service due to cat fines.





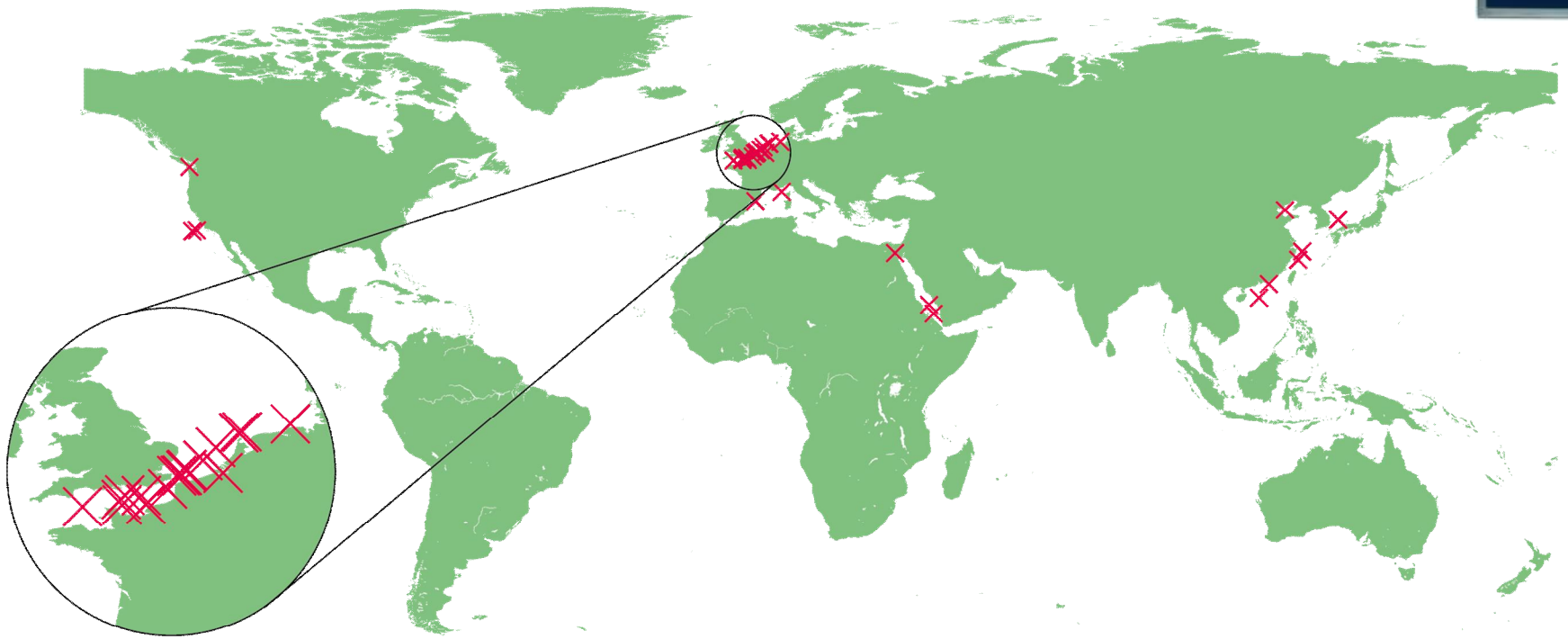
Cat fines affected piston rings

Overview of damages
Found in two-stroke engines and small four-stroke Gensets

Damages found in two-stroke engines	Damages found in small four-stroke Gensets
Wear in combustion chamber parts	Wear in fuel equipment
	
Resulting in high wear	Resulting in poor combustion
	

Service Experience

MAN B&W G95ME-C9.5



Location of scuffing incidents for G95 engines ï SECA locations are dominating

Change over from HSHFO to 0.50% S VLSFO

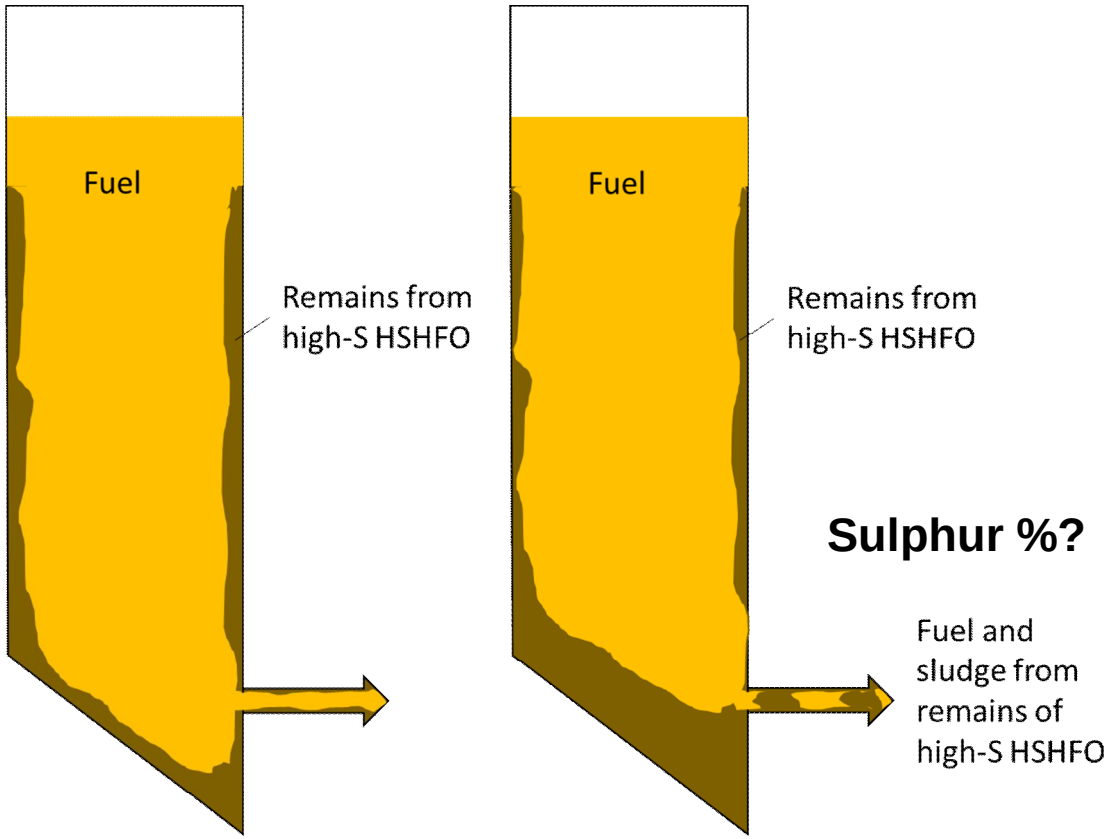
Å 1st January 2020: The engine must burn max. 0.50% S fuel, and that the fuel delivered must be with max. 0.50% S.

If the owner chooses to remove the remains of HSHFO by diluting and dissolving with low-S fuelé

..it may have to be **repeated several times** as the fuel can only dilute and dissolve a limited amount.

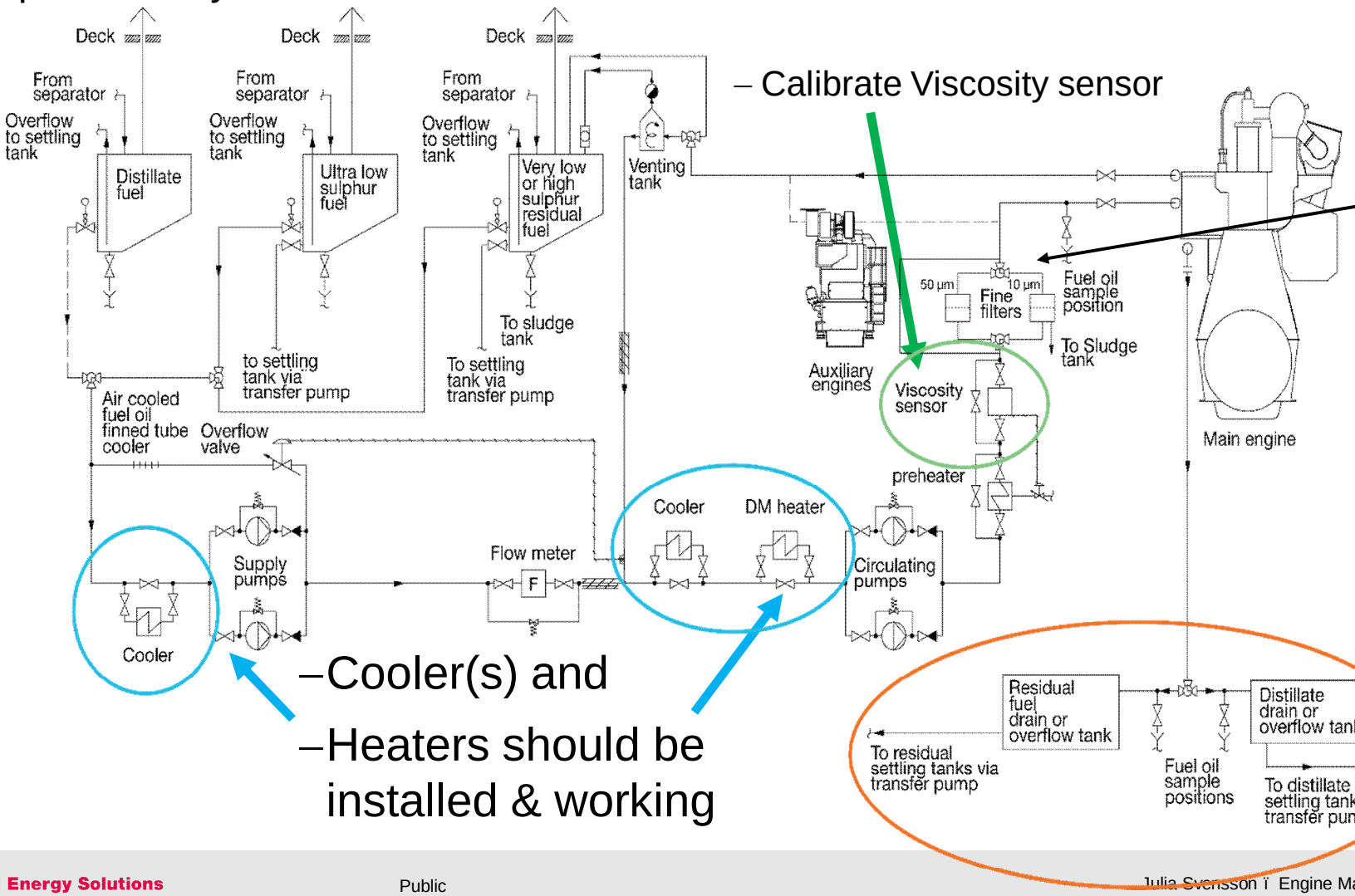
It is important to make sure that the sludge and cat fines do not reach the engine.
Fuel cleaning procedures!

Try to strip the tanks as much as possible before filling it up with the new fuel.



Fuel System diagram

Update the systems to handle 0.50% S VLSFO fuels



– Calibrate Viscosity sensor

–**Fuel filter to be changed to 10 micron filter mesh**

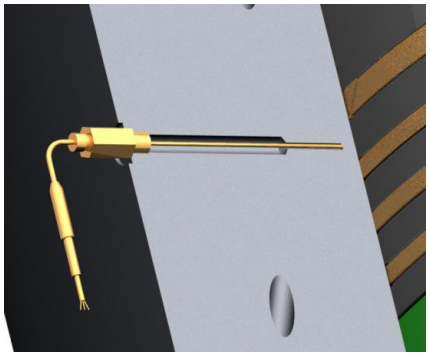
–Fuel pump drain overflow tank

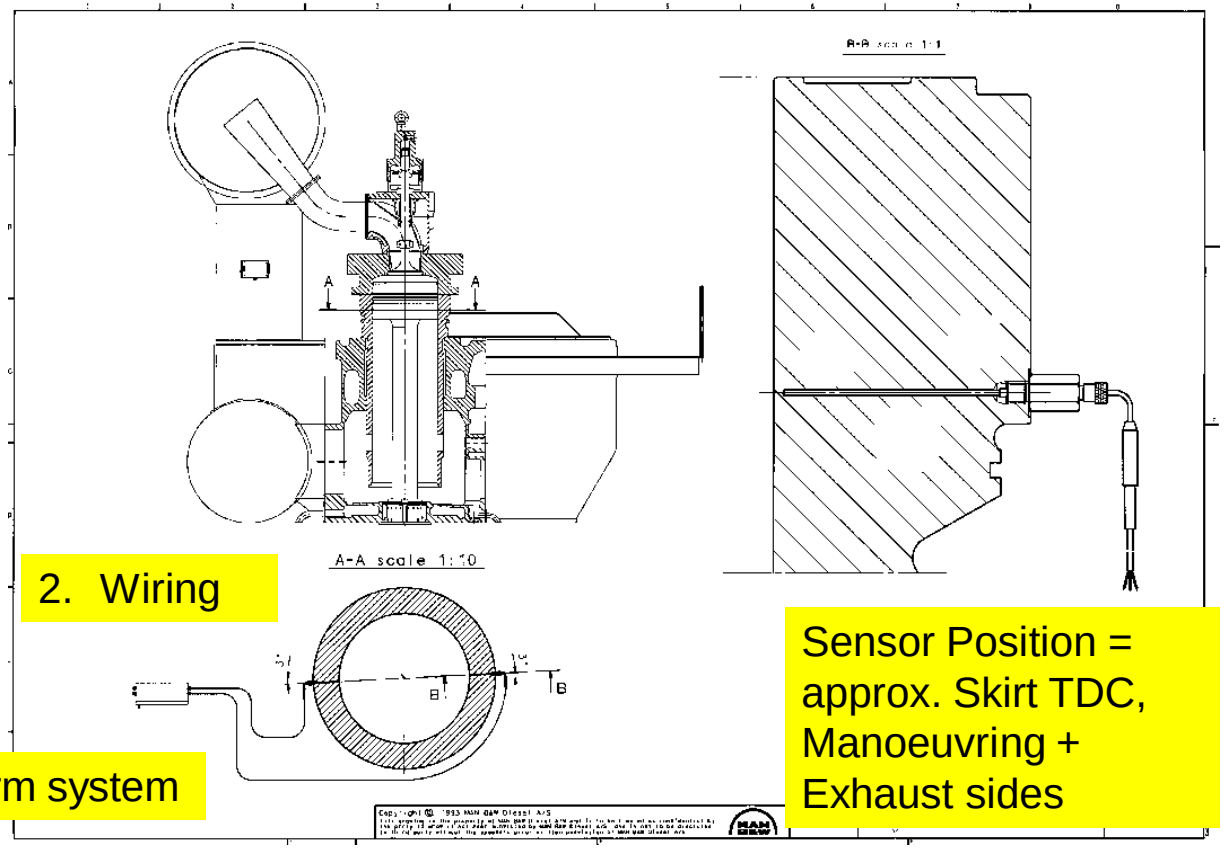
–Cooler(s) and

–Heaters should be installed & working

Liner Wall Monitoring System Requirements

1. Sensors





2. Wiring

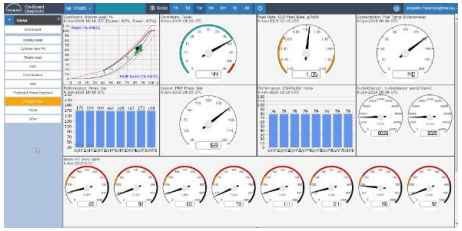
3. Connection to alarm system

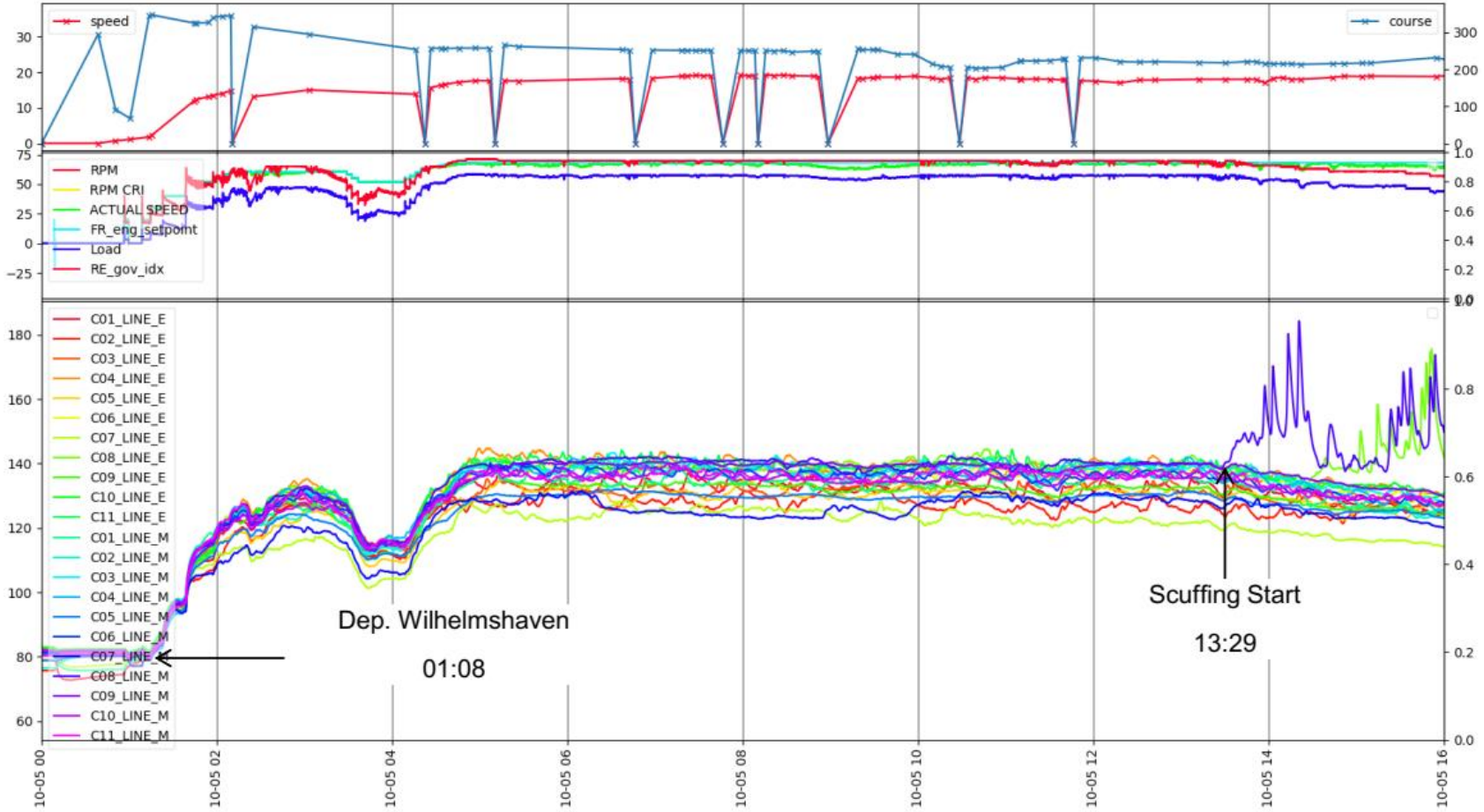
4. Definition and setting of alarm criteria

Sensor Position = approx. Skirt TDC, Manoeuvring + Exhaust sides

Service Experience

Cylinder liner wall temperature monitoring.





Cyl liner honing machine

Piston ring for ULS

Preparing for 2020 fuel

Service Letter SL2016-633/JAP — MAN Diesel & Turbo

Action code: WHEN CONVENIENT

Hard-Coated Piston Rings for Operation on Ultra-Low Sulphur Fuel

Including gas and liquefied gas

SL2016-633/JAP
November 2016

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

Summary
New narrow hard-coated piston rings for continued operation on ultra low sulphur fuel including gas and liquefied gas.

Reference is made to: SL93.5(JAP), SL2014-590/TAUS and SL2016-611/JAP

Dear Sirs

Since 1 January 2015, the specified fuel sulphur limit in SECAs (sulphur emission controlled areas) has been 0.1% sulphur or lower. The owners of engines operated on ultra low sulphur fuel (ULSF) (0.1% sulphur or lower) face certain challenges with scuffing between the cylinder liner and piston rings.

Operation on gas or liquefied gas containing no sulphur gives challenges similar to those faced when operating on LS for in a SECA. Prolonged operation on ULSF may lead to more polished liner surfaces and increases the risk of liner surface smearing with a subsequent risk of liner scuffing as the consequence.

To increase the margin against damage to the piston rings and cylinder liners, which will lead to overhaul of the engine on short notice, we have introduced a piston ring configuration that incorporates cermet hard coating on the running side of all the piston rings.

Cermet hard-coating on the piston ring running surface increases the reliability of the main engine. In many cases, the cermet coated rings continue to perform after oil outbreak with deposits, provided the scrapers are stopped. This ensures that the engine can continue in normal operation until the next planned overhaul.

Additionally, special attention should be paid to ensure a proper running-in of new rings in liners surfaced from polishing. Wave cut grinding or honing may be needed in such cases.

Yours faithfully

Mikael C Jacoves — Vice President, Engineering
Stig B Jakobsen — Senior Manager, Operation

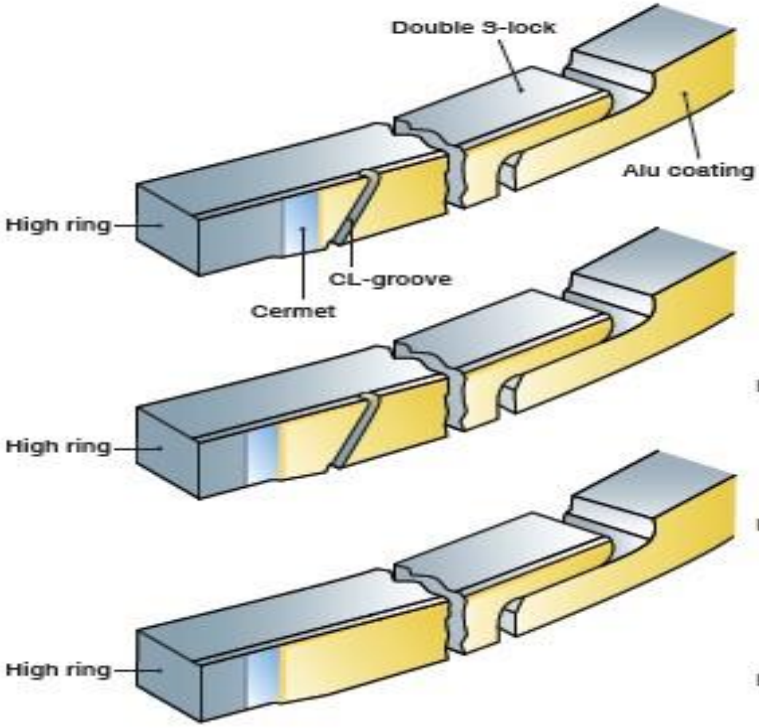


Fig. 1: *The CPR ring pack containing 3 high rings with cermet-coating on all rings for 70 bore and above (SL2016-611/JAP).*

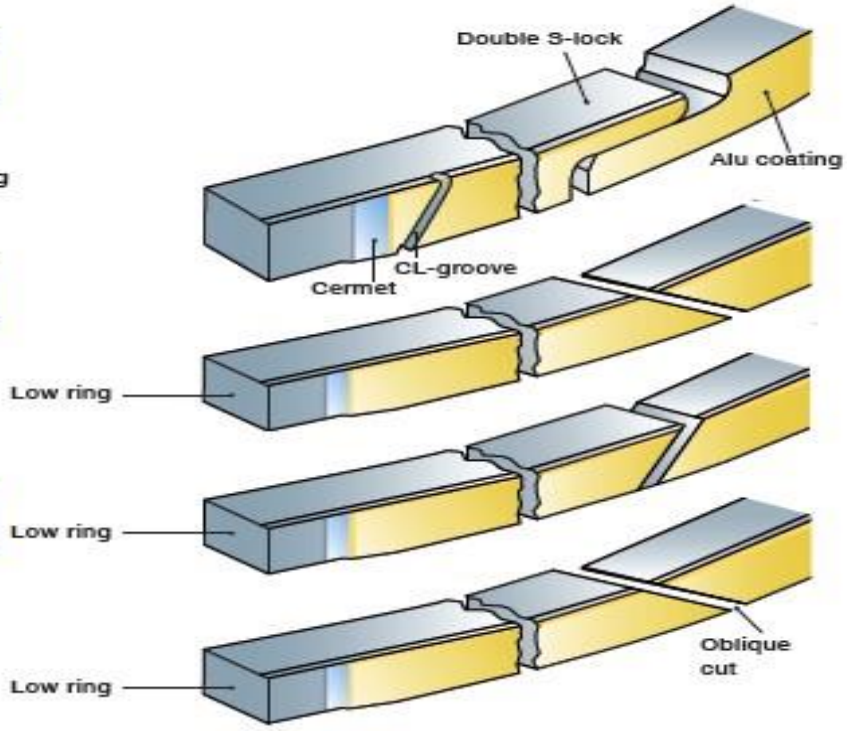


Fig. 2: *The CPR ring pack containing 1 high ring and 3 low rings with cermet-coating on all rings.*

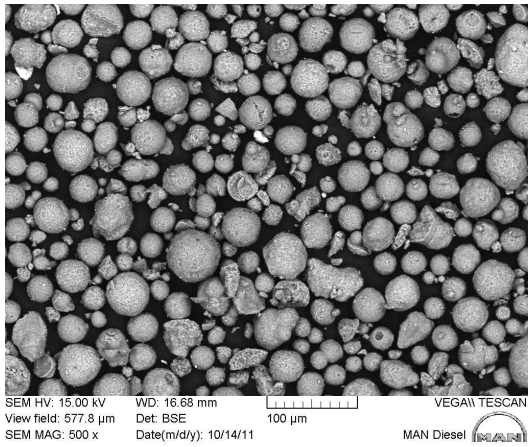
We can learn from the SECAs ULSFO Ò0.10% Sulphur fuels

There are a range of different types fuels

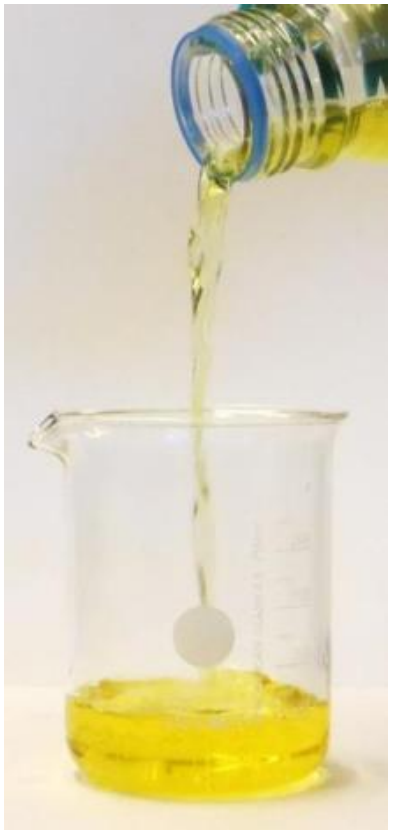
These are not distillate types, rather new blends or types

General characteristics are:

- Higher viscosity than distillate
- Some contain cat fines (Al+Si)
- Some have high pour points
- Compatibility with other fuels may also be an issue.



Service letter
2019-670 and 671



Possible problem when blending fuel onboard.

– Blending residual feedstocks with paraffinic cutter stocks increases the risk of asphaltene precipitation

– Special knowledge needed to avoid stability, compatibility and pour point issues

Unstable fuel or incompatibility of fuels.

Instability can happen if the fuel is not blended in such a way that the asphaltenes are well suspended and the rest of the fuel does not have the enough aromatic components to keep the asphaltenes in suspension. Asphaltenes need other aromatic components in order to stay in suspension, whereas if they are blended with high amounts of paraffinic cutter stocks, the risk of instability is large.

The result of an unstable fuel might be excessive sludge formation in tanks or further down in the fuel system, which then can block filters and separators. Once the asphaltenes have precipitated and formed sludge, there is very low possibility that the process can be reversed and the asphaltenes can be re-suspended in the fuel again, neither by physical nor by chemical means.

Figure 34 Heavy sludging and block separators as a result of either unstable fuel or incompatibility between two fuels.

2020 Fuels

Cold flow properties -

Managing cold flow properties

In the distillate marine fuels system, it is recommended to keep a temperature between 30-40°C in order to minimize the risk of wax crystallization and to decrease the risk of too low viscosities. Higher temperatures increase the risk of viscosity becoming too low. It is recommended that the distillate marine fuel circulating cooler is always turned on during operation on distillate fuel to ensure an adequate temperature and minimizing the risk of potential cold flow issues.

VeriFuel
Understanding Marine Fuel

Analysis methods - stability

In ISO 8217:2017 fuel stability for distillate fuels, DM grades, is characterized by Total Sediment by hot filtration (ISO 10307-1), which is typically called Total Sediment Existent (TSE) (Figure 35, TSE). The method includes filtering a known volume of fuel through a filter. This method should correlate with the sediment currently existing in the fuel and which can likely be removed on board by the separators.

The stability for residual fuels, RM grades, is characterized by Total Sediment – Aged (ISO 10307-2), where either Total Sediment Potential (TSP) or Total Sediment Accelerated (TSA) can be used (Figure 35, TSP and TSA). In the TSP method the fuel sample is heated to a specific temperature during a certain time before filtered. In the TSA method the fuel sample is treated with chemicals before the filtration. These methods aim to correlate with the total sediments that can be formed under normal storage conditions and use.

The limit for TSE, TSP and TSA is max. 0.10% mass in ISO 8217:2017. The higher the amount of sediment measured on the filter, the more sediment is expected to fall out of the fuel. Initial studies indicate that TSP is the most consistent method. More elaborate methods exist in the market to evaluate fuel stability, but experience with these methods is limited.

Fuel incompatibility

Fuel incompatibility – between different fuels

Compatibility is defined as the ability of two or more fuels to be commingled (mixed) at a defined ratio without evidence of material separation, resulting in the formation of multiple phases e.g. flocculation or separation of asphaltenes, making sludge in the fuel system. It is a measure of how stable a fuel is when mixed with another fuel and the tendency of the mixture to form sludge and deposits. The process of the asphaltenes dropping-out can be very quick and is non-reversible. Sludge formation can occur immediately after mixing or later depending on the stability reserve. The resulting issues are the same as for an unstable fuel; problems in the fuel cleaning system with sludge in tanks and further in the fuel system and thereby blocked filters and separators.

Incompatibility issues between marine fuels have always been present. However, MAN ES foresee that problems caused by incompatibility will be more frequent in the future. The challenge is that the 0.10% S ULSFO-RMs and 0.50% S VLSFOs will be made of a diverse range of various blending stocks, varying from highly paraffinic to highly aromatic. When mixing two fuels, one paraffinic and one aromatic, which are stable by themselves, the resulting mixture might be unstable. And the result will be excessive amount of sludge because the asphaltenes in the aromatic fuel will drop out of the suspension. Note that these fuels could well be supplied as the same ISO grade, e.g. RMG 380, and with the same sulphur content. Hence, it is important to always remember that different fuel batches may not be compatible. It is recommended to keep different types of fuels separated.

Compatibility testing,

Compatibility Testing

Compatibility testing can be done manually with a kit on board (ASTM D4740, aka spot-testing or coffee filter test) (Figure 36 and Figure 37) or via an independent laboratory. The latter often being a slow process, since the ship will have left the port before the test results are finished. On board testing give fast and indicative results. It is recommended to test the following fuel ratios: 90/10, 50/50 and 10/90, or as the actual ratio of the fuel batches will be in the tank. 50/50 is the worst case scenario.

ASTM D4740 is developed for aromatic fuels containing asphaltenes. If a black ring or spot is formed in the middle of the filter paper, asphaltenes have precipitated and the fuels may be incompatible (Figure 37). Hence they should be kept in separate tanks. The test requires that one of the fuels tested is a residual fuel otherwise there will not be any asphaltenes to precipitate. Very paraffinic fuels and distillate blends may show false results, indicating that fuels are incompatible, when they are actually compatible. The false negative result is due to pigment separation. Care should therefore be taken when evaluating the results.

Compability testing Onboard at different mix ratios

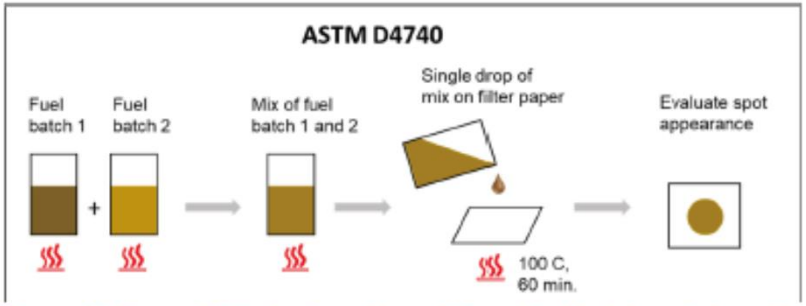


Figure 36 Compatibility testing of two different fuel batches. Schematic process flow: ASTM D4740.

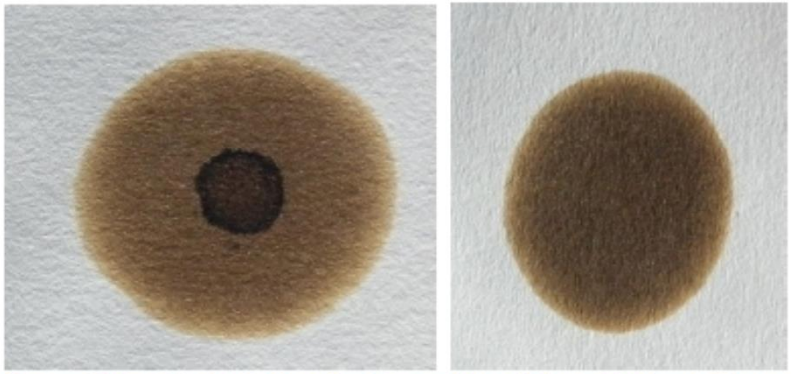


Figure 37 Spot test: photos of mixture of two different fuels on filter paper. A. Incompatible fuel blend. The black ring is the asphaltenes which have precipitated. B. Compatible fuel blend. ASTM D4740 shows 5 different classes for compatibility, ranging from compatible to incompatible.

The reason why it is advisable to make compatibility testing at different blending ratios (90/10 and 10/90, 50/50) is that it can be established if it is possible to mix at some ratio. If an aromatic fuel and a paraffinic fuel are mixed at the 90/10 ratio, e.g. 90% of an aromatic fuel and 10% of a paraffinic, this blend may be compatible. This is because the aromatic molecules in the fuel has enough solvency power to keep the paraffinic molecules in suspension, as well as the asphaltenes.

Fuel stability testing Laboratorie ashore

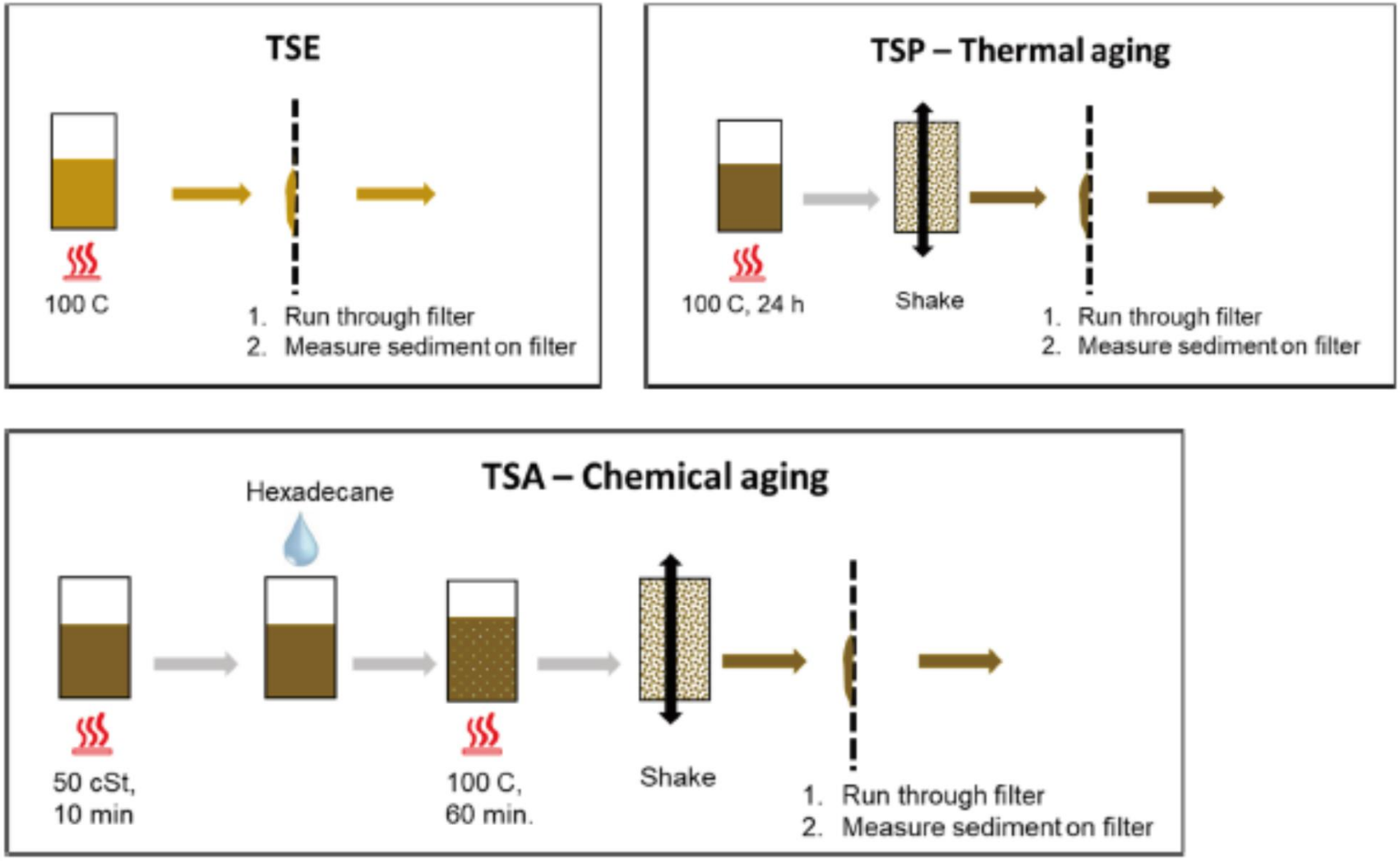


Figure 35 Fuel stability testing. For DM-types: TSE (ISO 10307-1). For RM-types: TSP and TSA (ISO 10307-2)

Managing incompatibility of fuels

Fuels should not be mixed until it is ensured that the fuels are compatible with each other.

Establish **good fuel switch-over procedures** in advance.

Establish **procedures for fuel cleaning in advance**. For normal operation, and for when excessive sludging occurs.

If mixing is unavoidable

– Reduce the amount of fuel in the tank before bunkering.

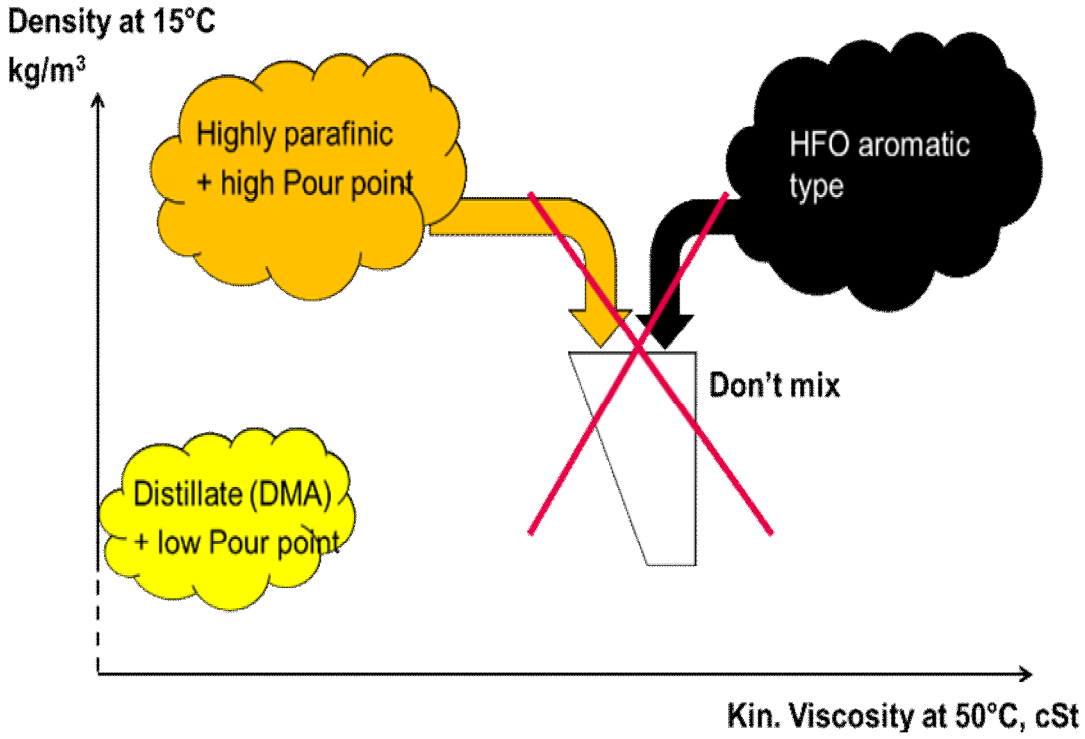
– Keep blending ratios as large as possible. (80/20)

– Fuels with similar viscosity, density and pour point often show acceptable compatibility.

– Check compatibility of the fuels

  – Use on-board method for indication of compatibility.

  – If the fuels indicate compatibility, mixing may be possible.



Fuel tank systems

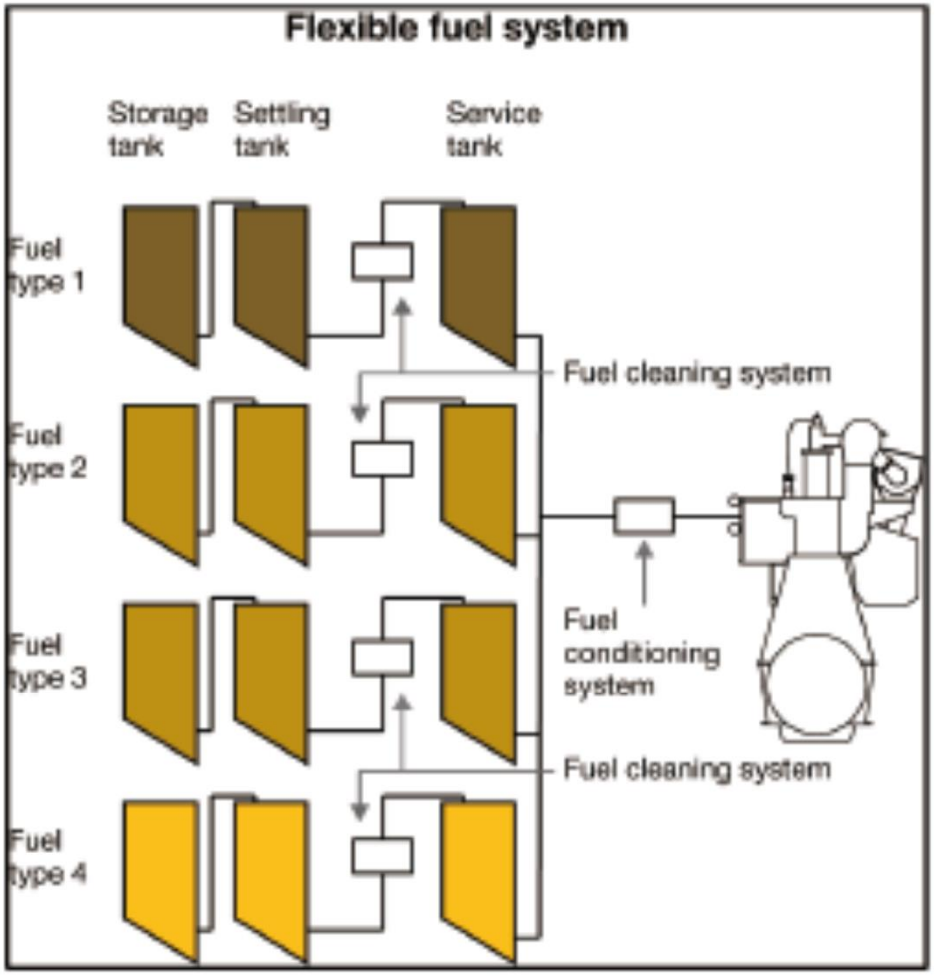


Figure 39 Schematic: Flexible fuel system.

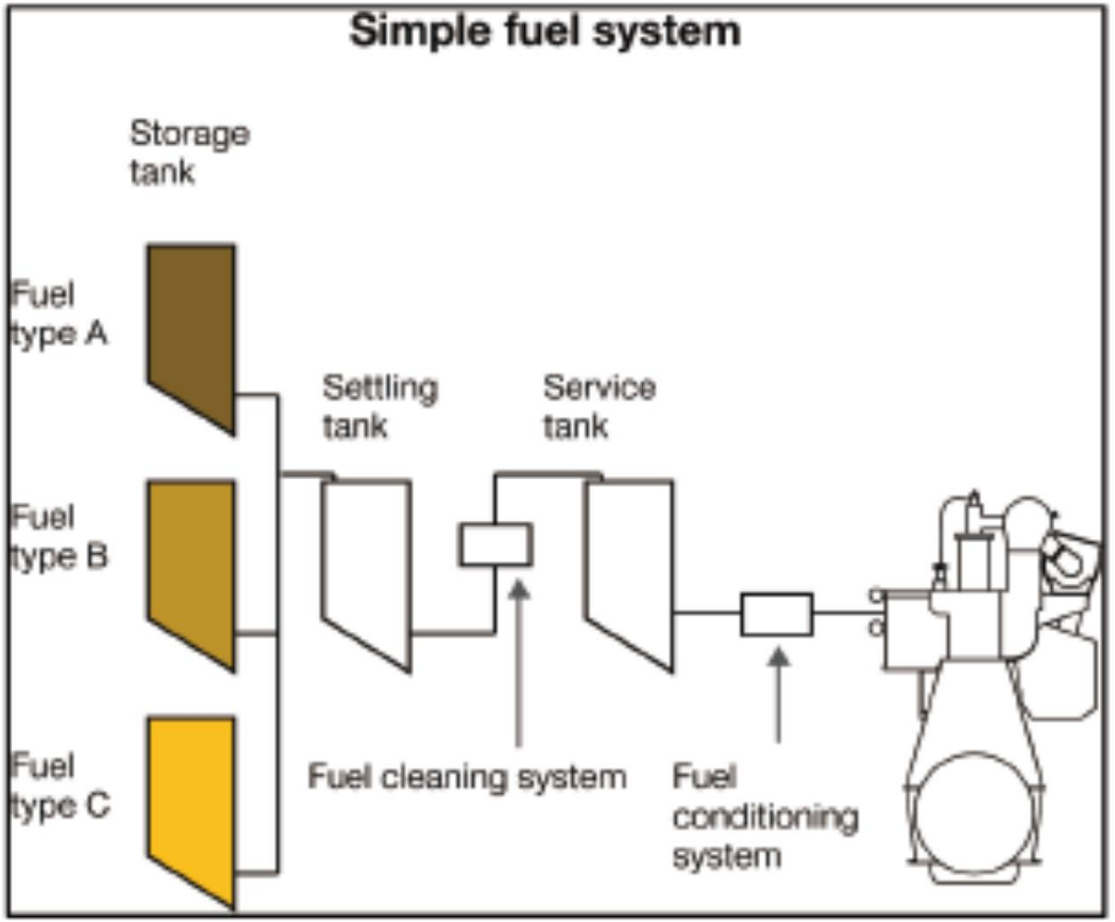
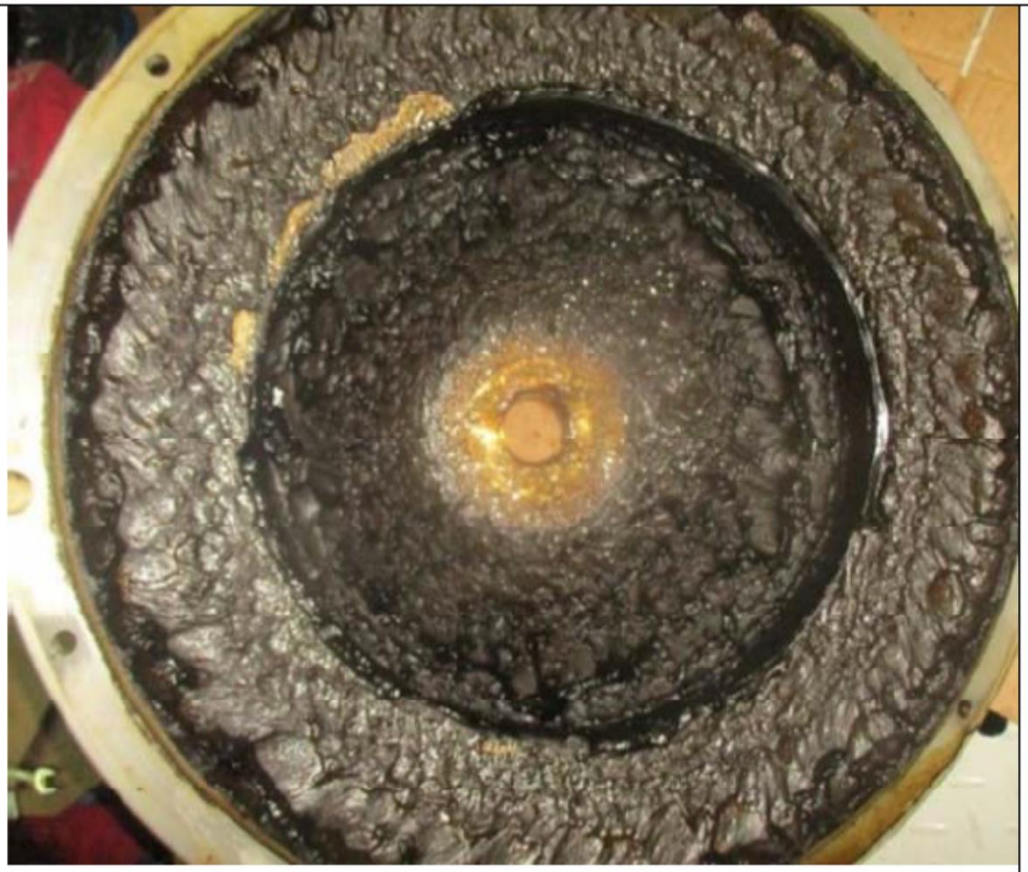


Figure 40 Schematic: Simple fuel system.

The symptoms are a typical incompatibility case, probably mixing of the VLSFOs in the settling tanks.



Fluffy sludge- at 40°C separation temp-1

Fluffy sludge- at 40°C separation temp-2

Action code: WHEN CONVENIENT

Operation on fuels with maximum 0.50% sulphur

SL2019-670/DOJA
February 2019

Concerns
All MAN B&W ME/ME-C/ME-B/MC/ MC-C, ME-GI and ME-LGI engines.

Summary
For operation on max. 0.50% S fuel:
- The 0.50% S fuel family will show diverse characteristics, also within the same fuel grade.
- Avoid mixing different fuel batches.
- Pay attention to the actual fuel parameters and act accordingly.
- Adjust the fuel temperature to ensure correct viscosity.

Relevant Service Letters:
SL2018-659, SL2014-593, SL2017-638, SL2018-663 as well as the most recent SL on cylinder lubrication (currently SL2014-587).

Service Letter & General Guide Lines SL2019-670/DOJA

Recommendations for operation on 0,50 % S VLSFO:

- Stability of of the fuel ï resistant against heating and long term storage.
- Incompatibility between different fuel batches ï stability agains mixing different fuels
- Fuel pump drain overflow tank ï consider to keep different fuels seperated.
- Fuel tanks ï consider posibilities for incompatible fuels.
- Viscosity ï standard value of minimum 2 cSt and maximum 20 cSt.
- Density ï important for fuel cleaning in seperators.
- Cold flow properties ï capability for the fuel to flow freely.
- Cat fines (Al + Si) ï best possible cleaning and maximum 15ppm at engine inlet.
- Change-over from high-sulphur fuel (HSHFO) to 0,50% low-sulphur fuel (VLSFO) - tanks and system cleaned or emtptied from HSHFO.
- Change-over process (viscosisty/temperature) ï standard value of 2°C/min.
- Combustion ï test for combustion characteristics.
- Familar fuels on board ï beneficial to have more than one fuel onboard.

Market Update Note

11 September 2019

0.50% S fuel operation 2020

Important service letters and papers on MAN B&W two-stroke engines

Do you have questions about 0.50% sulphur (S) operation? Or do you consider retrofitting a scrubber? MAN Energy Solutions has issued information and recommendations relevant to 0.50% S operation and how to prepare for IMO's global 0.50% sulphur limit. Click on the links below and check it out!

Main 2020-information on 0.50% S fuel operation

The service letter and paper listed below provide information and guidance on 0.50% S fuel operation and how to prepare for the change from operation on high-sulphur fuel to 0.50% S fuel. Attention is drawn to specific fuels properties that should be in focus and how 0.50% S fuels affect the equipment on board. Expectations for the new types of fuels are given, and information on fuel testing, biofuels, and fuels that are not fit for purpose is also included.

- SL2019-670 – Operation on fuels with max 0.50% S
- Paper: 0.50% S fuel operation 2020 – detailed information on fuels with less than 0.50% sulphur – preparation and operation

Cylinder lubrication

The cylinder lubrication recommendation has undergone extensive revision. The three most important factors are: 1. cleanliness in the piston ring pack; 2. feed rate and 3. close monitoring of the cylinder condition and appropriate action.

- SL2019-671 – Cylinder lubrication update for 0 to 0.50% sulphur fuels
- SL2014-587 – Cylinder lubrication update (for vessels with scrubbers and for running-in)

Piston rings

Cermet-coated rings are recommended for VLSFO operation. Cermet coating increases the margin against damage to rings and liners and increases the reliability of the main engine.

- SL2018-659 – Cermet coated piston rings for operation on low-sulphur fuels (0.50% S or lower)

Fuel cleaning

Fuel cleaning and removing cat fines (Al+Si) are and will still be very important.

- SL2019-674 – Fuel tank cleaning
- SL2017-638 – Cleaning of heavy fuel oil and maximum 0.10% S fuels – How to remove cat fines
- Paper: Cat fines – impact on engine wear and how to reduce wear

Scrubbers

MAN PrimeServ offers a SO_x scrubber retrofit package with recommendations on the turbocharger re-matching parts.

- SL2018-665 – SO_x scrubber retrofit on two-stroke engines in service

Link to Service Letters (SL):

- https://marine.man-es.com/two-stroke/service-letters

Link to Technical Papers:

- https://marine.man-es.com/two-stroke/technical-papers

TOP BUNKER PORTS Some affected by severe mix of chemical waste into bunker fuel

VLSFO READY (IN GREEN)

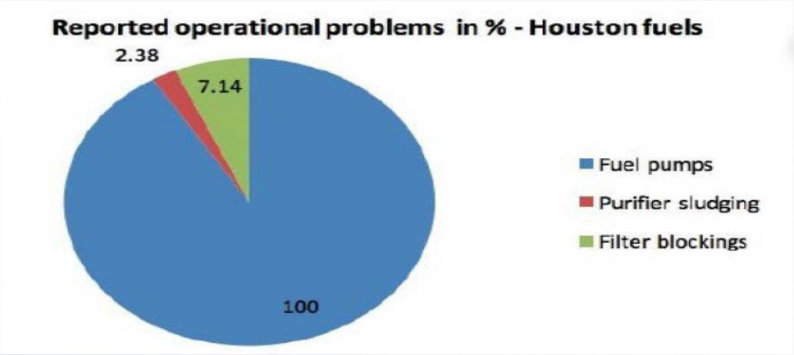
VeriFuel
Understanding Marine Fuel

Based on tested samples, CoQ and statements from suppliers

OVERVIEW OF HOUSTON BUNKER CASE

- There are more than 100 vessels being affected in the past few months on the fuel bunkered from Houston and wider US Gulf area including Panama
- Some 700k MT also shipped to Singapore and some to Gibraltar
- All fuels were found to meet ISO 8217 specification
- Almost all vessels reported malfunction of fuel injection system
- Some vessels reported filter blocking and excessive sludge generation at purifiers

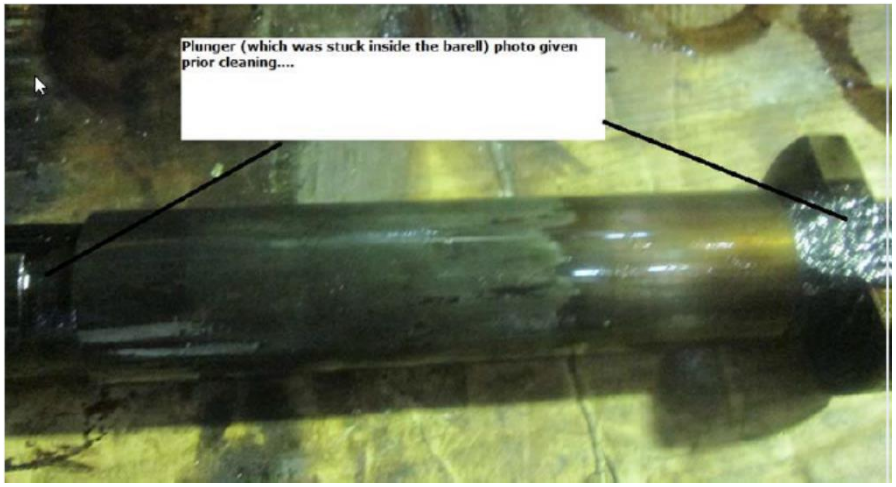
Source: FOBAS & Viswa

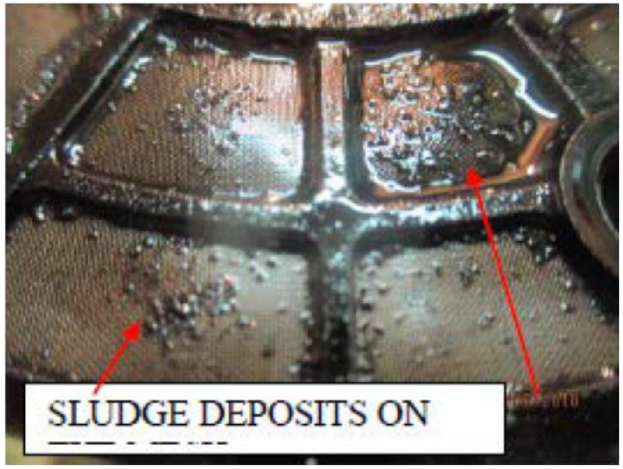


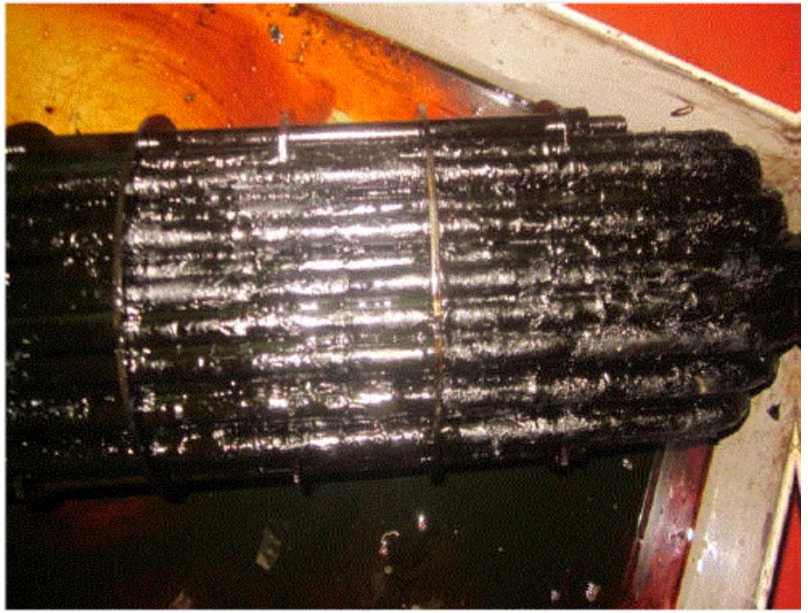
innospec
chemistry matters

ASTM D7061 test for Reserve Stability Number (RSN) values were between 9.5
and 14.1. This is high. Problem Fuel Identification Number (PFIN) for these fuels
was also found to be high between 151 and 259. If the PFIN exceeds 130 there is
85% chance of cyl condition problem.

TRY TO SEPARATE PLUNGER FROM BARREL PUMP USING SPANNER BY TURNING.







Sludge deposit in fuel purifier.

a) HFO transfer pump filter

b) Sludge from filter

c) Thick sludge in purifiers

d) Sludge removed from purifier

Low Sulphur fuels - alert

FOBAS alert released early Jan 2020 for LSHFO with high sediments

FOBAS alerts on off spec sediment bunker fuel oil from Singapore

On January 9, FOBAS issued an alert informing all shipowners and operators of o spec marine fuel oil at Singapore that according to its testings, the sediment of bunker fuel oil is above the limit as specified in ISO 8217 for an RMG380.

FUELS | 10/01/19

Specifically, FOBAS proceeded on testing a number of samples from Singapore, which were ordered as ISO-F-RMG380 grade.

Yet, Total Sediment Potential results were unobtainable, with samples failing to filter within the 25 minutes given for the test method. This means that the sediment exceeded the specified limit. On the contrary, other fuel parameters indicate satisfactory results.

GET THE SAFETY4SEA IN YOUR INBOX!
ENTER YOUR EMAIL ADDRESS
SUBMIT

Moreover, fuels with high sediments can result in excessive sludge deposition in tanks and throughout the handling and treatment/fuel injection systems.

In addition, when using this kind of fuels, it will most likely result to highly compromised combustion leading to engine and turbocharger damage.

Advised bunker details from respective Bunker Delivery Notes (BDN) as well as FOBAS quality analysis indicate these samples appear to originate from same batch of fuel delivered over a period of time.

To these results, FOBAS recommends that if a shipper plans to bunker in that region, the suppliers should be able to provide with additional reassurance that they will adhere to the ISO 8217 requirements for the grade ordered.

Fuels with high sediment can result in excessive sludge in tanks which can lead to engine fuel starvation due to blocked filters.

An advisory notice from LR said attempting to use such fuels can result in highly compromised combustion leading to engine and turbocharger damage. LR also cautioned shipowners to seek assurance that the fuel grades they have secured are compliant with the ISO standard for marine fuels.

The International Chamber of Shipping (ICS) issued a statement after Fobas' warning.

ICS secretary general Guy Platten said "This is a pressing issue. Shipowners rely on many other stakeholders in the marine fuel supply chain, particularly bunker suppliers and oil refiners, to ensure we are all able to fully comply with the new regulations. We need the supply side to fully contribute to a smooth changeover so that we do not have any incidents due to incompatible fuels and we can ensure safe operations for our seafarers."

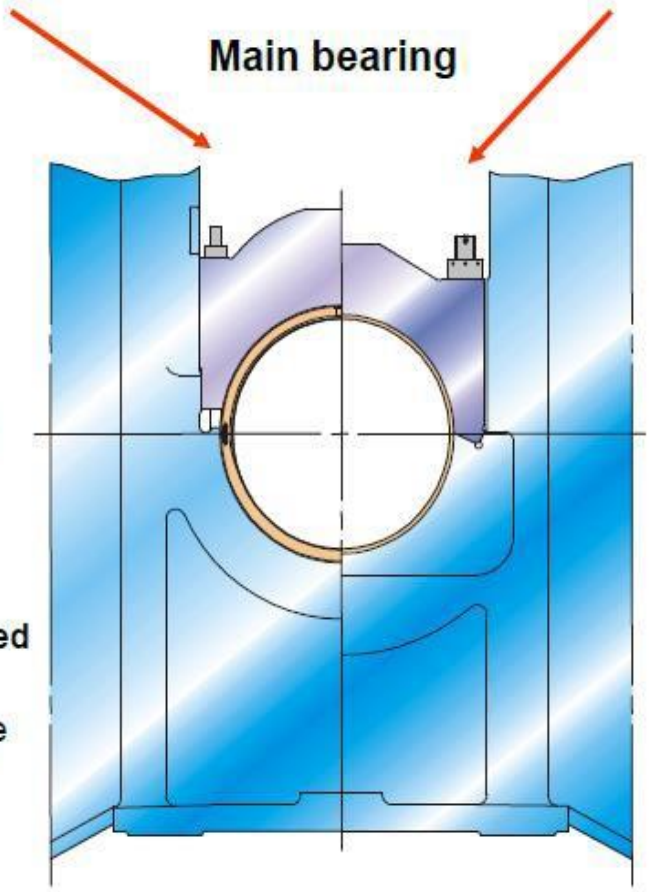
Main Bearing thick/thin.

Thick shell design
Original design on the MC engines

- S50 - S80MC
- L50 – L90MC
- K50-60MC-S
- K90MC

Lined with white metal
Machined separately

Improvements introduced
- Reduced clearances Optimum Lemon Shape
- Revised alignment procedure
- Off sets
- Vertical guide pins
- Flex edge



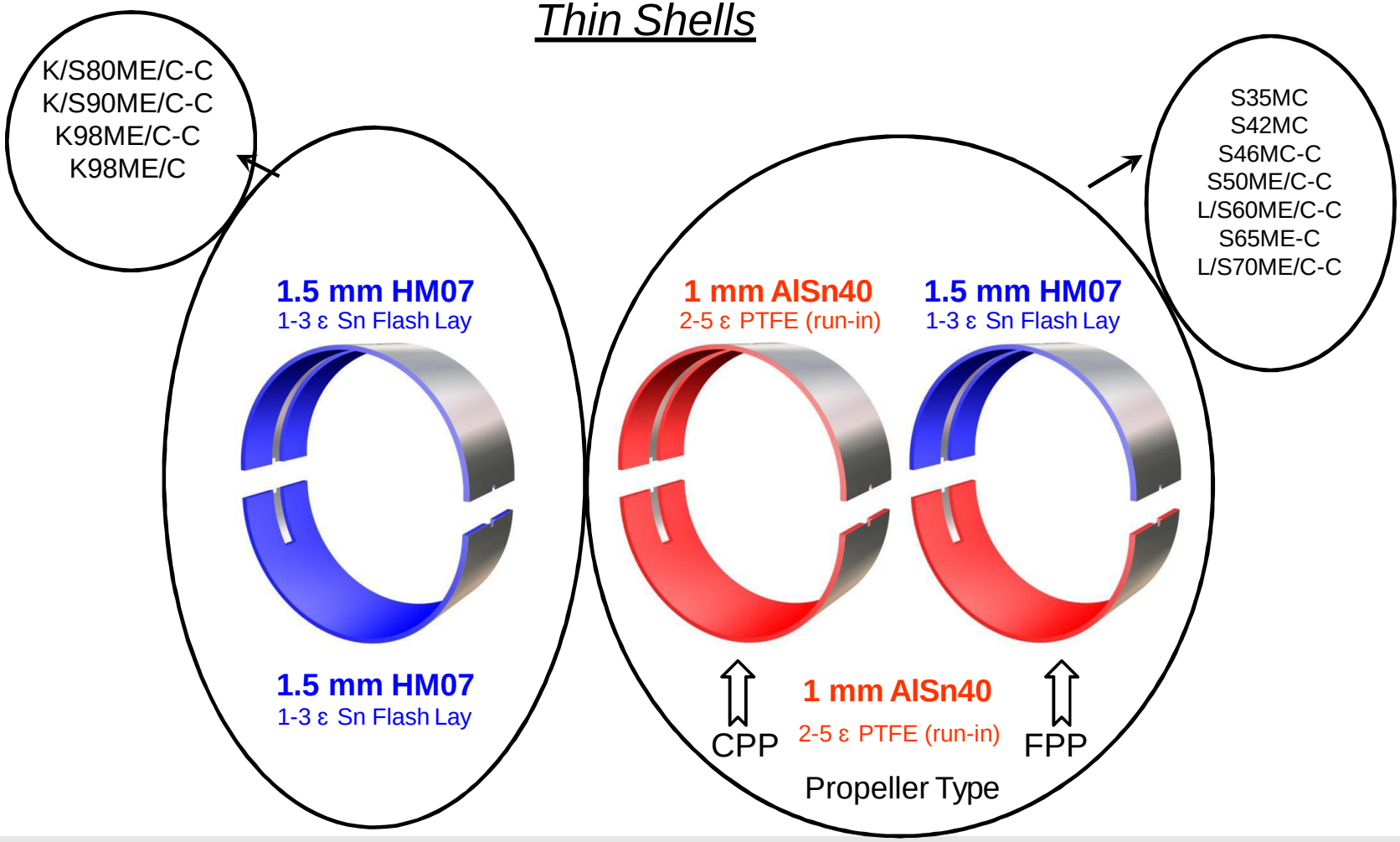
Thin shell design
Introduced gradually on the MC engines

- 26 - 42MC
- S46 – S90MC-C
- L60/70/90MC-C
- K80/90/98MC-C
- K98MC

Lined with white metal or AlSn40
Machined assembled

Improvements introduced
- Revised alignment procedure
- Off sets
- Running in Coating (AlSn40)
- Blend Edge
- Reduced top clearance

Main Bearing Design.



Bearings Service Experience

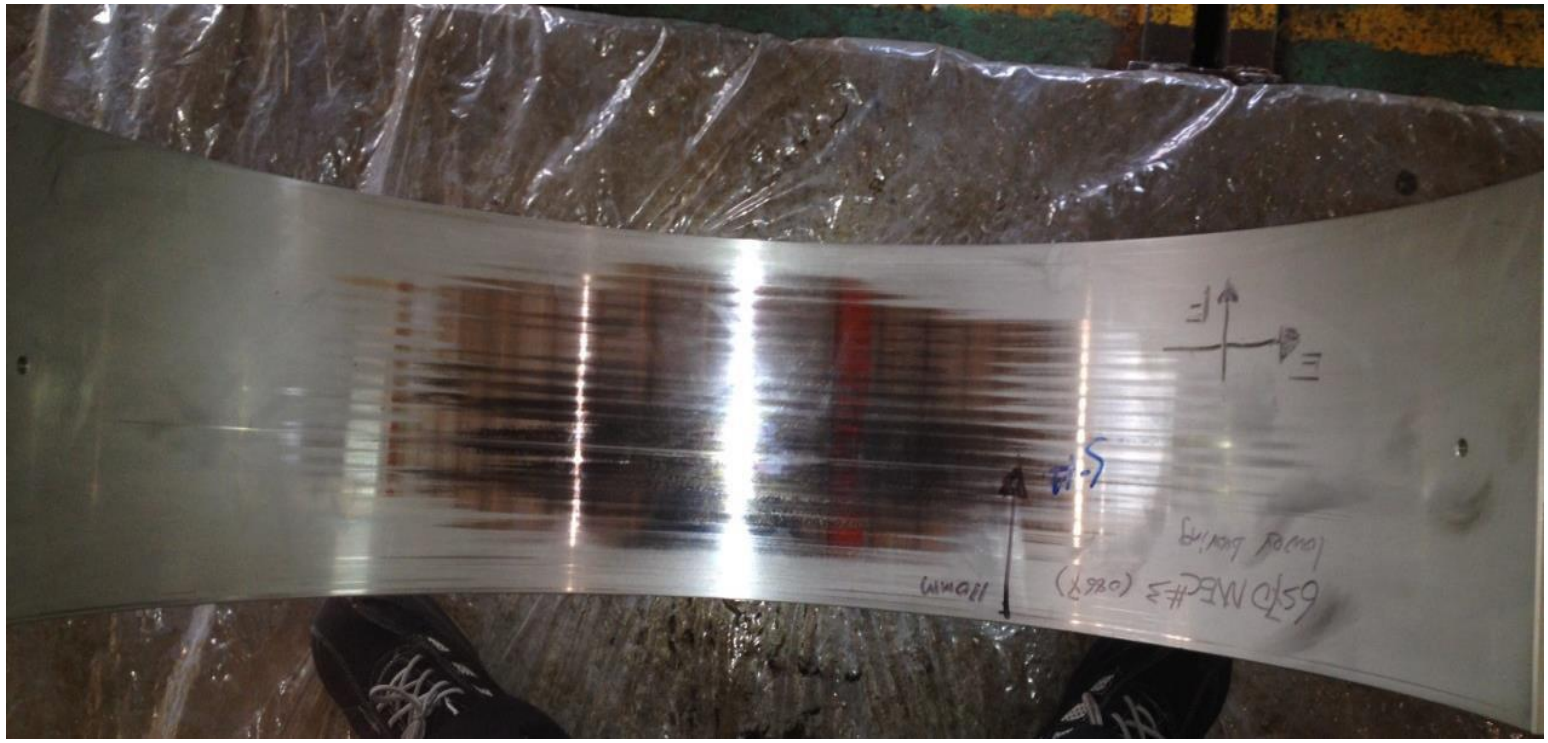
S50MC-C Main bearing lower shell - 18,000 hours

No remarks ï excellent condition

Thickness measurement of shell did not reveal indication of significant wear rate ï less than 0.01 mm

Main Bearings blended edge BE.

A normal òJournal Imprint Pictureòof a well functioning BE main bearing.

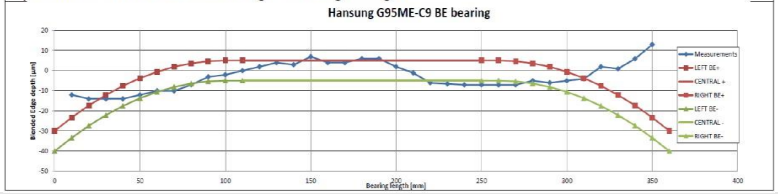


Main Bearings blended edge BE.

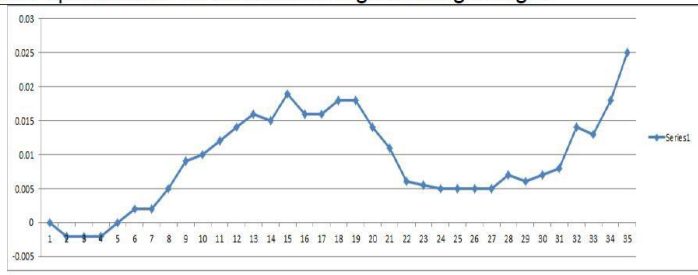
A device was made in order to carry out readings to the shell thickness.

This reading revealed bearing shells outside MAN specifications.

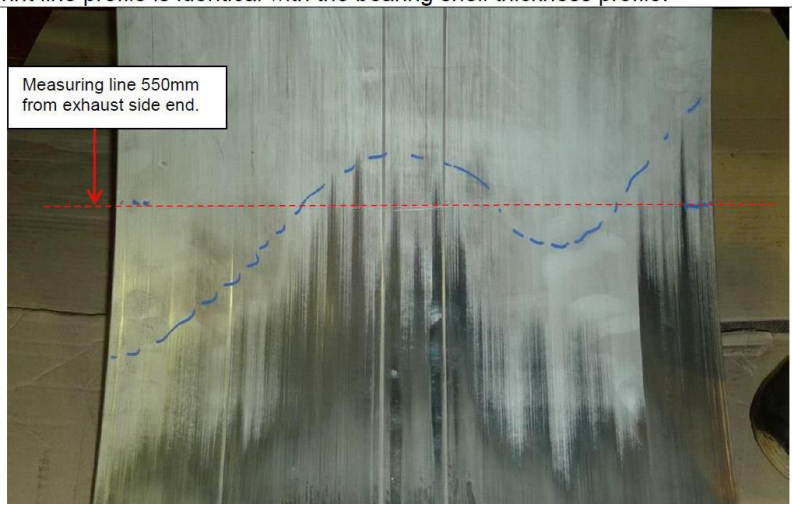
Old main bearing lower shell from #7. Marking Hansung 2014.11.03
The lower bearing shell was inspected in terms of thickness deviation by means of a dedicated wide micrometer. The lower shell was found with a thickness profile outside MDT specification for a Blended Edge bearing design.



Main bearing #7 lower shell was inspected in terms of thickness deviation by means of a dedicated wide micrometer. The lower shell was found with a thickness profile outside MDT specification for a Blended Edge bearing design.

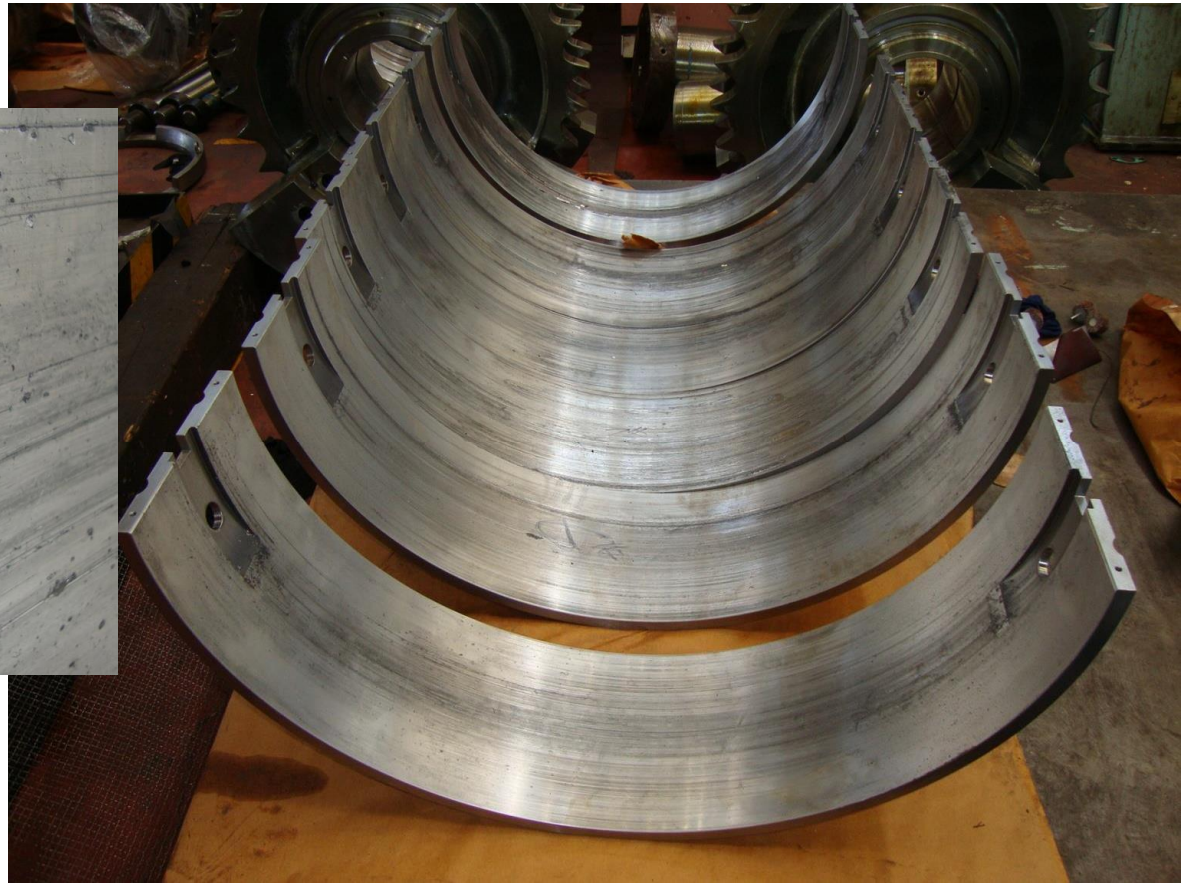


Main bearing #7 journal imprint transition zone exhaust side. Note the journal static imprint line profile is identical with the bearing shell thickness profile.

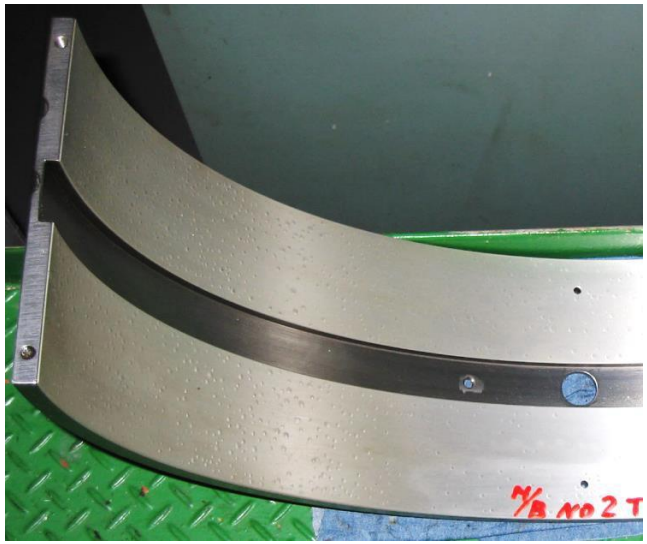


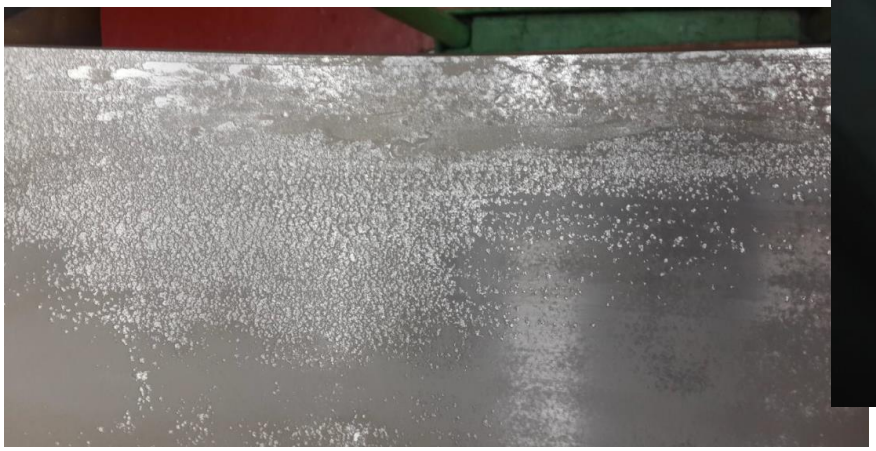
Main Bearings.

Severe dirt contamination with pellets from sand blasting.



Main Bearings. ï TinAlu. Blister due to water in oil.



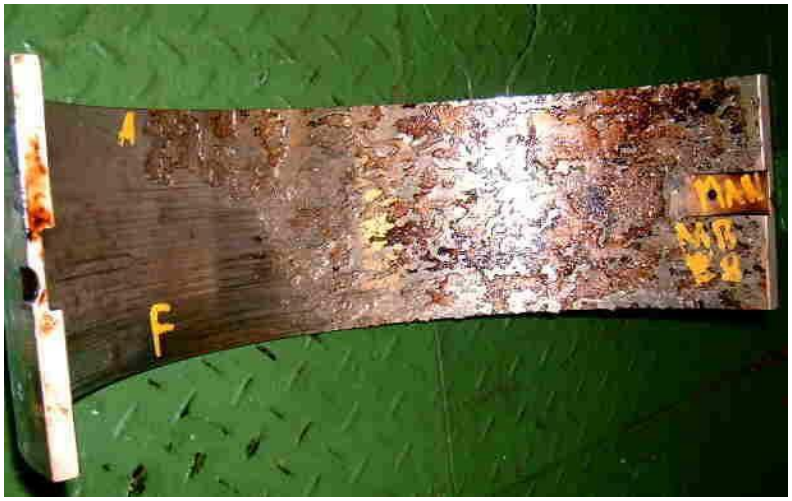


Only found to TinAlu bearing shells.

Water in oil = bearing problems.

Water in oil consequence to bearings:

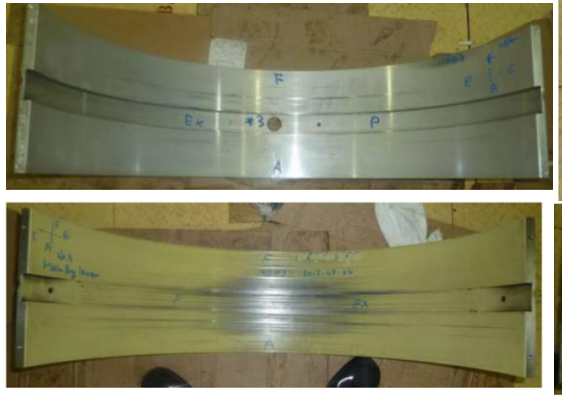
- Decreases viscocity of oil
- Decreases minimum oil film thickness
- Increase oil film pressure
- Increases cavitation
- Increases build-up of lacquer
- Chemical reaction?



Bearing Condition Monitoring Using Bearing wear monitoring system.

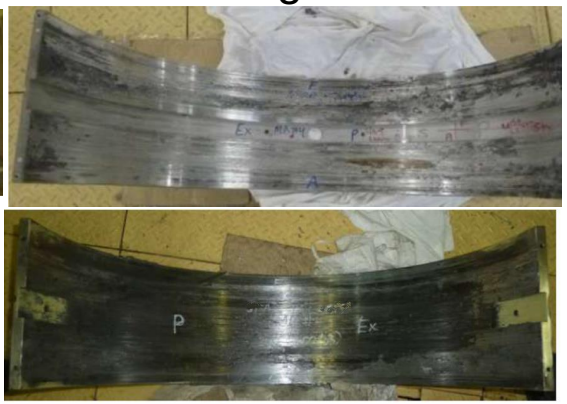
Time from BWM reaction to Oil Mist for damaged bearing shells.

Main Bearing 3



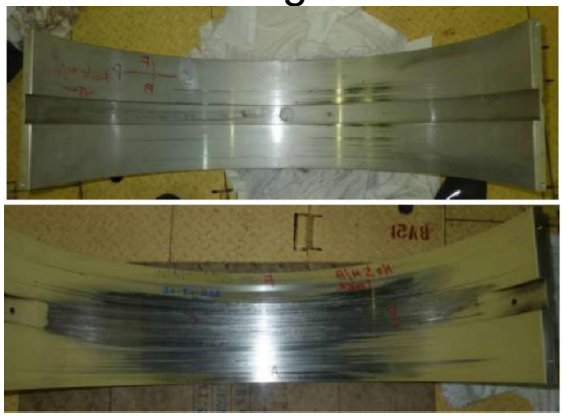
21 minutes between
BWM alarm and Oil mist

Main Bearing 4



48 minutes between
BWM alarm and Oil mist

Main Bearing 5



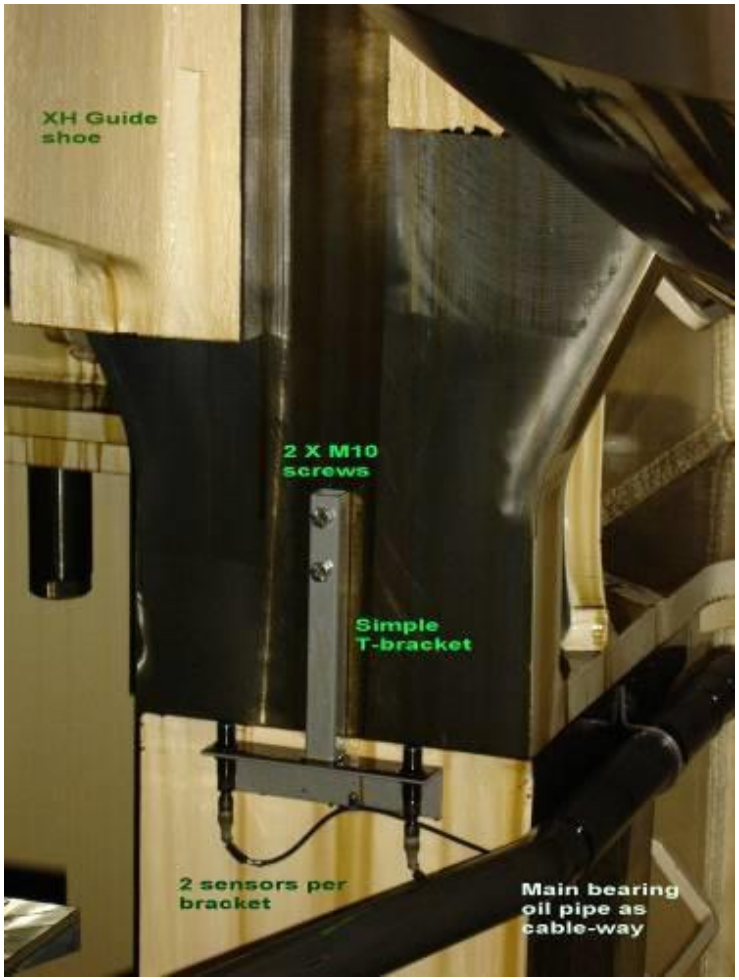
39 minutes between
BWM alarm and Oil mist

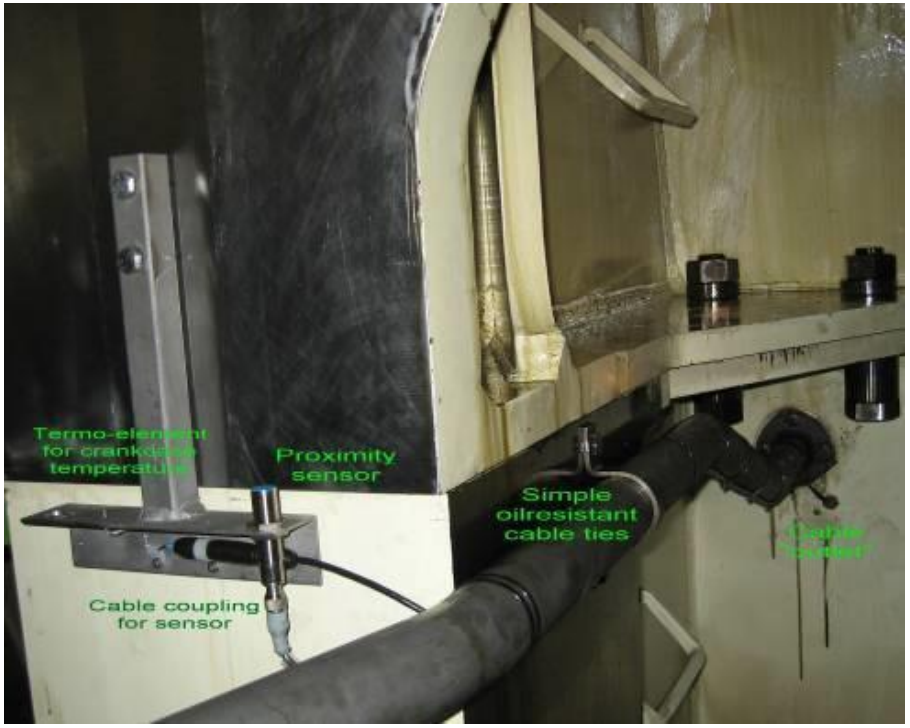
CONCLUSION:

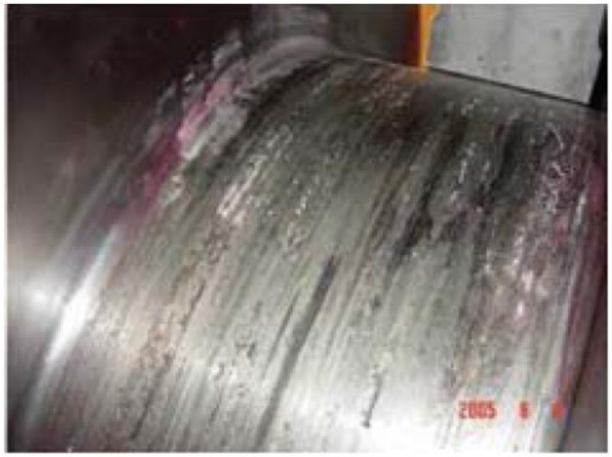
BWM Rapid Wear reacts much faster than the oil mist

Bearing Condition Monitoring.

Bearing Wear Monitoring system.







6S70MC-C on maiden voyage

- Continued running for 1½ hrs after 1st alarm
- Main bearing incorrectly assembled after inspection
- 3½ month repair

Fig. 8.37: Main bearing damage on 6S70MC-C

Consequences of continuesly operating 1,5 hr with active oil mist alarm.

Main bearing wrong assembled after seatrial

Bearing Condition Monitoring is standard now by below two parameters.

1) Water in oil sensor

2) Bearing Wear Monitoring.

- On-line monitoring, Alarm sounds before any bearing damage takes place!
- Rapid Wear feature give fast detection in case of sudden changes in the signal.

MAN Energy Solutions
Future in the making

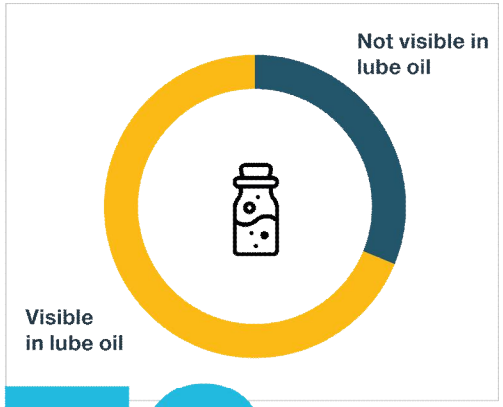
MAN Fluid Monitor for lube oil

MAN PrimeServ

Continuous and constant monitoring of the lube oil

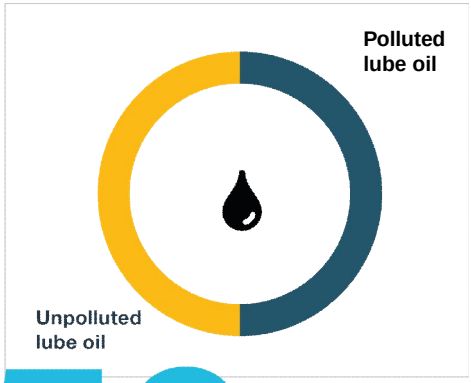
Lube oil, the blood of the engine

Lube oil, a major setting that must be monitored



70%

of anomalies can be seen in the lube oil



50%

of damages are caused by a lube oil contamination or deterioration

Measurement

Specific sensors

5 measurements

- Conductivity
- Dielectric constant
- Relative humidity
- Temperature
- Pressure

Sensor MAN ES 1

Sensor MAN ES 2

- Measurement of ferrous and non ferrous particles

- Tested pollutions: particles, water, fuel, soot, additives
- Tested on 15 different engines: HFO, dual fuel, gas, etcé
- Specific calibration MAN ES / **18 000 hours of tests (january 2020)**

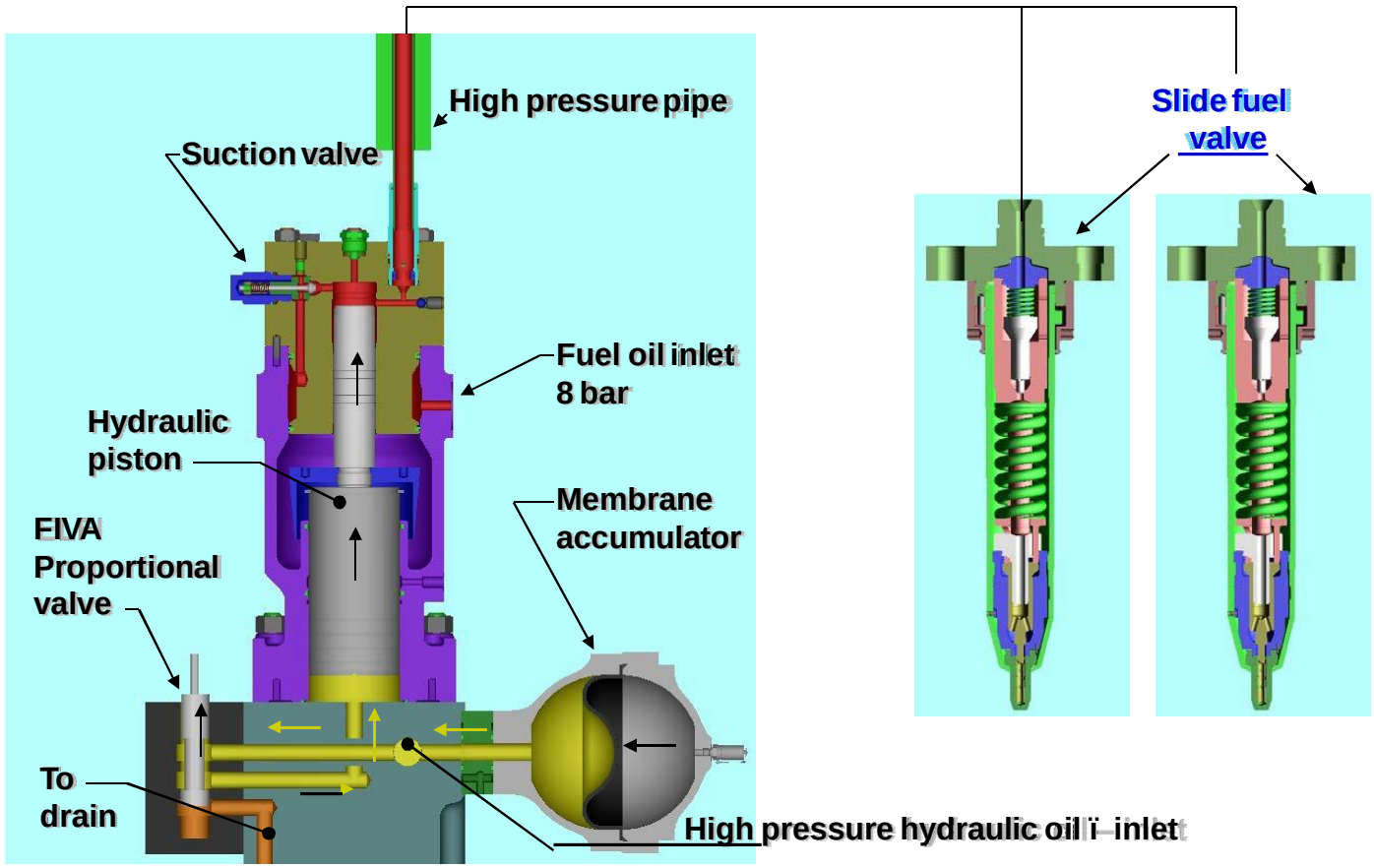
Detectable engine damages

Engine	Damage type
Crankshaft	Abnormal wear of the bearing
	Wear ageing of the bearing shell
Timing gear	Wear of the pinion tooth
	Wear of bushes
Connecting rod	Wear of the bearing shell
	Seizure of the bearing shell
	Wear/seizure of the bushes
Piston	Wear of piston rings
	Wear of piston skirt
Liner	Seizure
	Scuffing
Cylinder head	Wear of rocker arm bush
	Spring damage
Camshaft	Wear of the cam
	Wear of the roller tappet
Turbocharger	Wear of the bearing
Lube oil polluted	Water pollution
	Oil pollution: fuel or gas
	Soot pollution
Injection	Leak of oil towards the lube oil system

Detectable engine auxiliaries damages

Engine auxiliaries	Damage type
Water pump	Wear or fitting issue
Lube oil pump	Wear or fitting issue
Cooling	Cooling leak
Centrifuge	Wear or fitting issue
Filter	Deterioration / fitting issue
Quality of the new lube oil	Polluted new lube oil

ME Fuel Injection System. Untimed fuel injection.



Untimed Fuel injection causing cylinder cover lift. Reason: Dirt particles affecting free movement of FIVA proportional valve.

Damage to sealing surface Cylinder liner-Cylinder cover.

MAN FIVA valve.

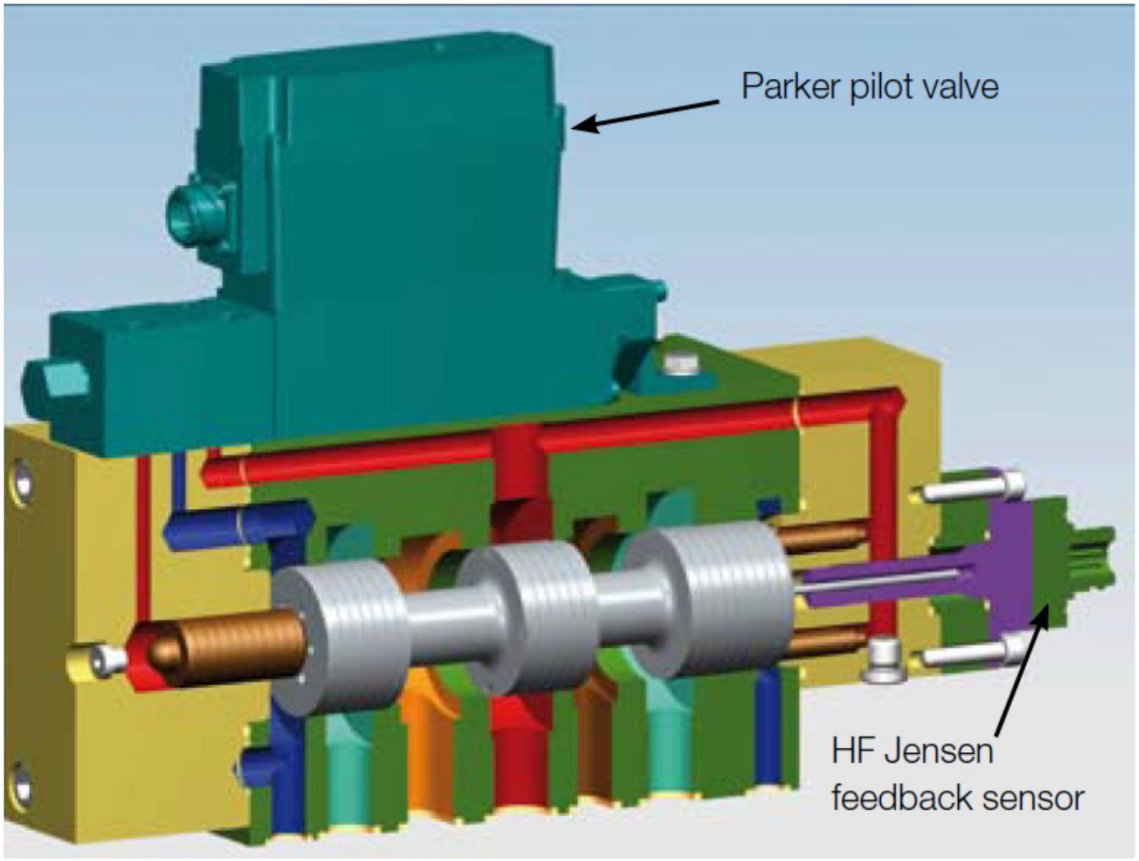
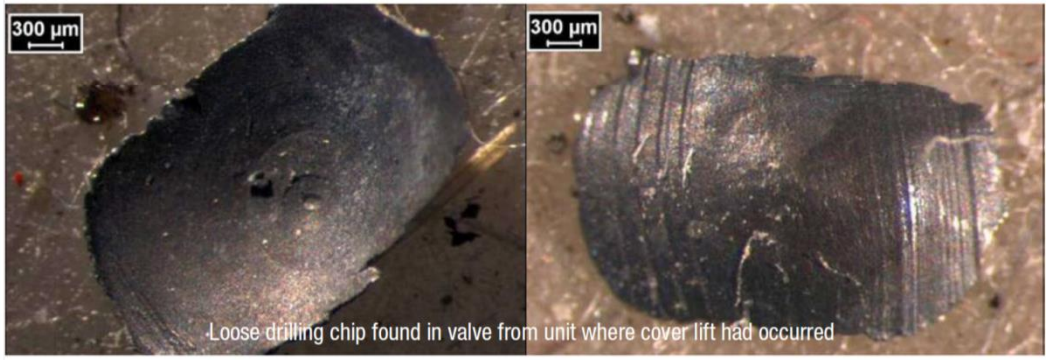


Fig. 8.7: MAN B&W FIVA valve



FIVA. Fuel injection and EXH valve control valve

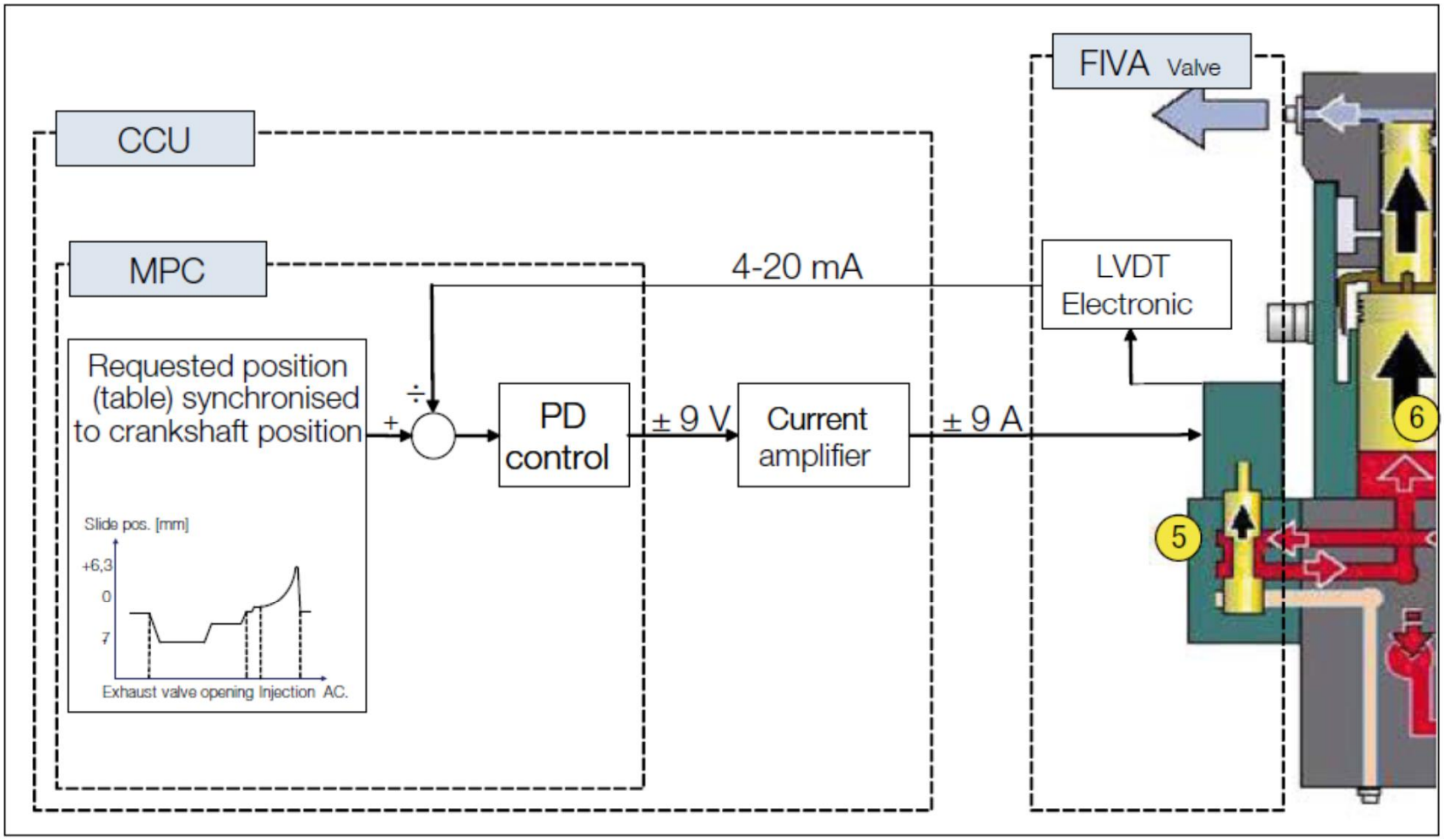


Fig. 8.3: FIVA valve position control

Upgrated Fiva injection control

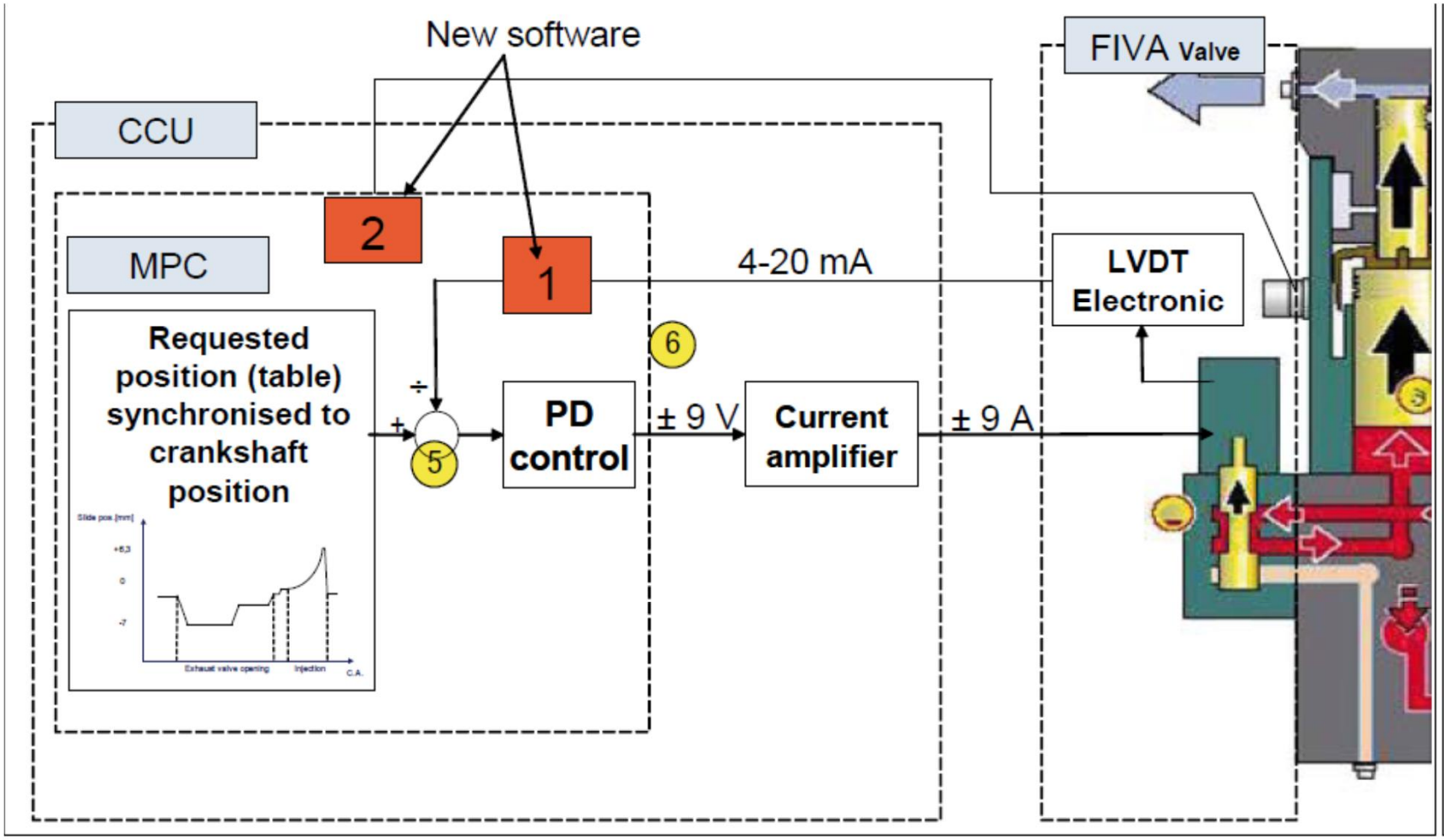


Fig. 8.17: FIVA valve position control

Updated timing control.

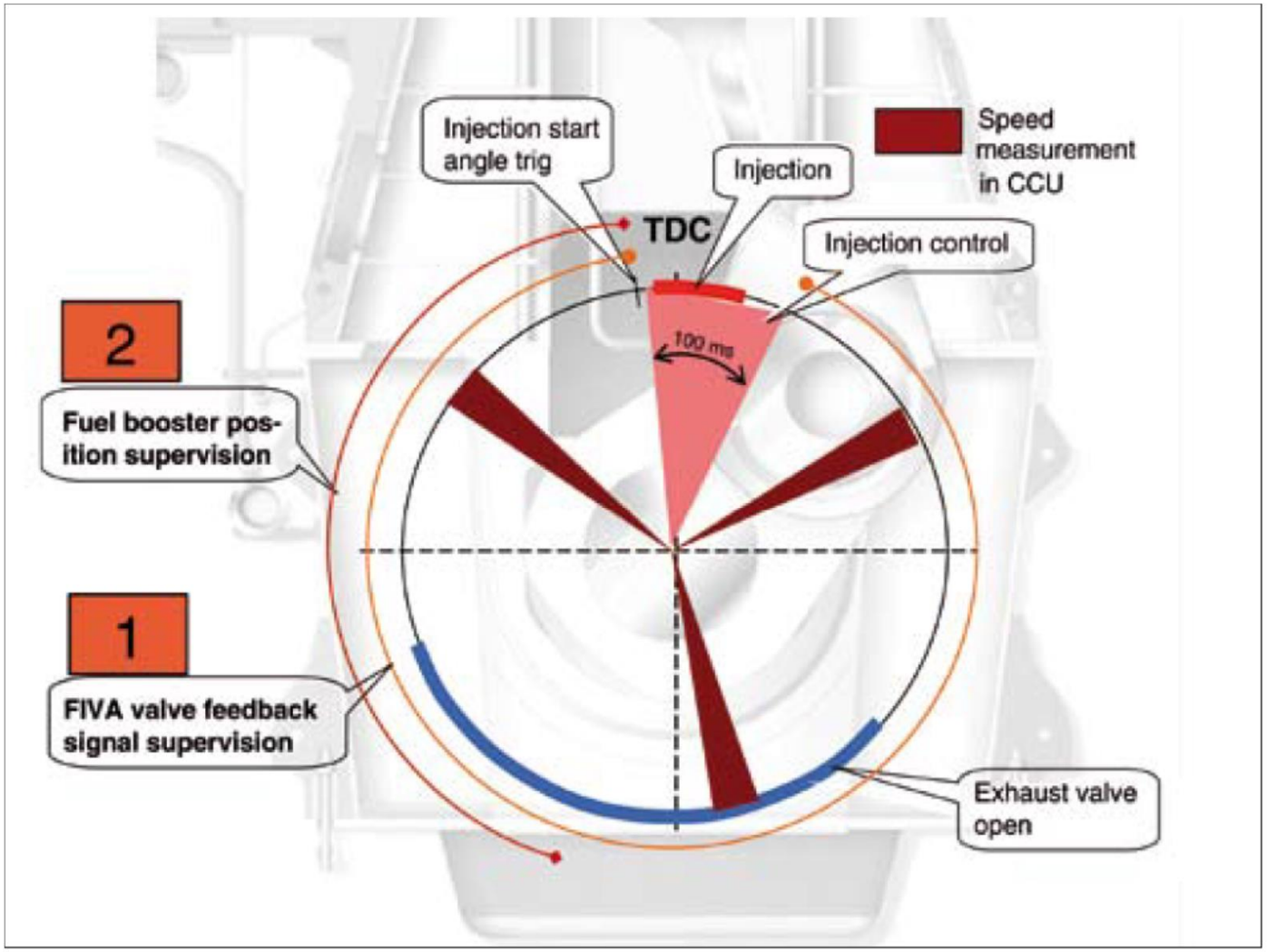


Fig. 8.18: Crankshaft related control processes

Craks in EXH valve housing G70ME-C 9.2 due to casting problem

Materiale anlyze of cracked EXH housings.

–Brinell hardness far below specifyed.

Specimen	Brinell Hardness HB(10/3000/15)
N10206	100, 104, 95, 101, 99
Spec. C2	Min. 160 HB Max. 210 HB
ISO185 Grade 200	Min. 120 HB Max. 190 HB

Table C.1 — Anticipated Brinell hardness ranges for different casting section thicknesses

Grade	2,5	5	10	20	40	80
350				280 to 200	260 to 185	
300			280 to 200	255 to 180	240 to 165	
250		280 to 200	250 to 180	235 to 160	220 to 145	
200	< 280	260 to 170	230 to 150	210 to 135	190 to 120	
150	260 to 170	225 to 140	205 to 125	185 to 110	170 to 100	
100	< 210	< 185	< 170	< 160	< 150	

Section thickness, mm

Tensile strenght measured on Exh valve housing

Measurement		Tensile strength (Rm) MPa
1 2 3 4		103 110 102 106
Spec. C2*	Min Max	200 300
ISO 185 Grade 200 for wall thickness 20-30 mm		Min 160 MPa

*The specified values are for the test pieces produced from a separately cast 30 mm diameter bar, test piece type A, according to ISO 185 - Latest edition

Service experience Exh gas scrubbers.

Materials - towers:

Scrubber towers always to be made in high grade steels.
Correct handling, welding and physical design is crucial for life time.
Potential scrubber buyers should be very aware of sub-quality Tier II products.

Service experience

Materials ï right choice essential:

Corrosion issues have been seen in both piping, internal spray nozzles and around hull penetrations.

Most are caused by wrong choice of material or poor workmanship during installation, coating and painting on yards.

Samples of corroded pipes - wrong material/coating used

Heavy corrosion on outlet pipe

Pin hole corrosion on coated steel pipes

Flaking on coated steel pipes

Coated steel pipes NOT suitable

Materials - piping:

Coated black steel piping not suitable – corrosion issues

Several different types of coatings tested – epoxy and ceramic - none perform convincingly

Service experience

Materials ï piping material of choice:

Almost all makers have replaced coated black steel pipes by GRE/GRP/GRV piping;

Advantages of GRE/GRP/GRV are durability and very easy installation

Disadvantages of GRE/GRP/GRV are slightly larger footprint and price

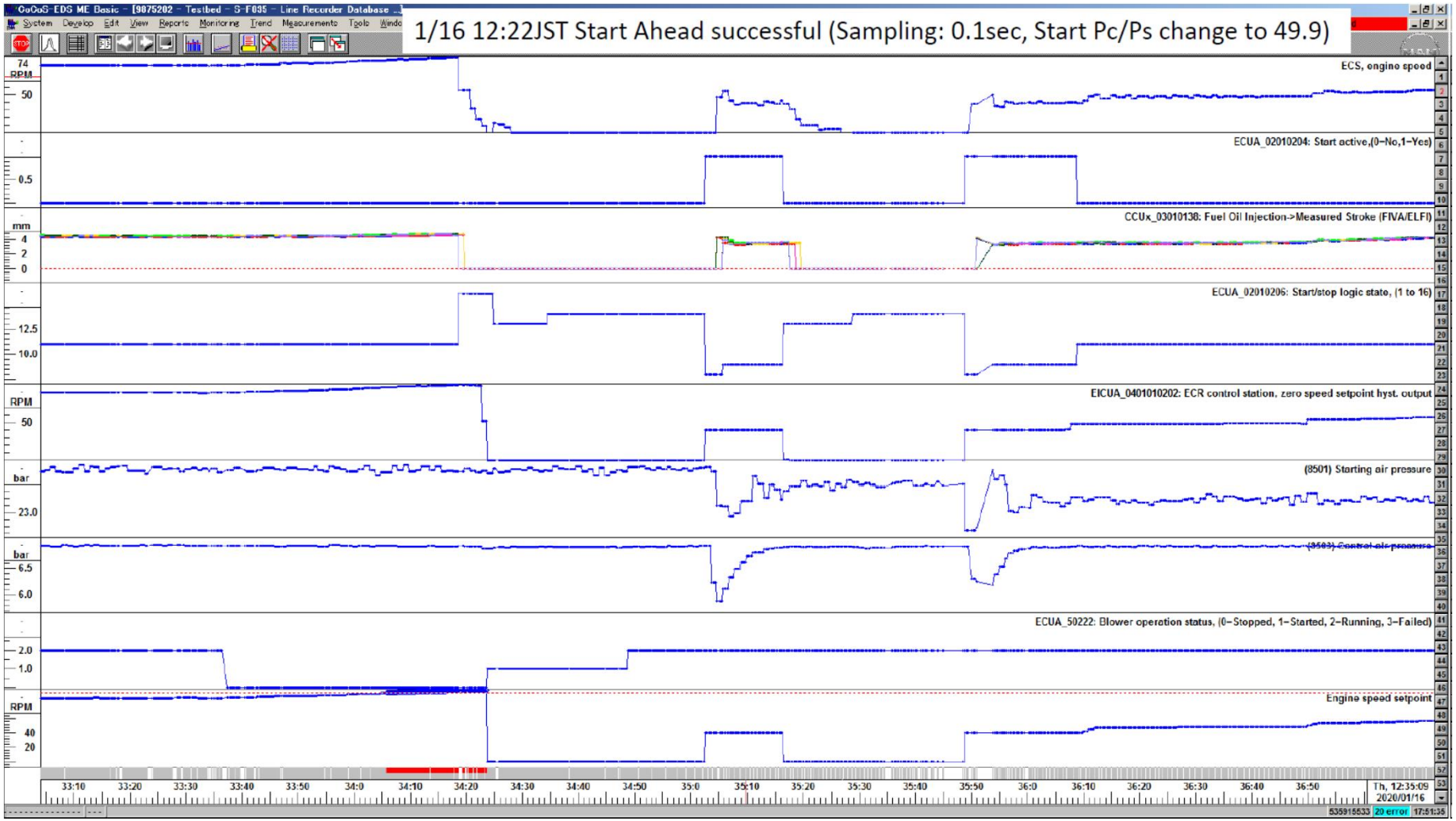
Coated black steel piping

GRE piping

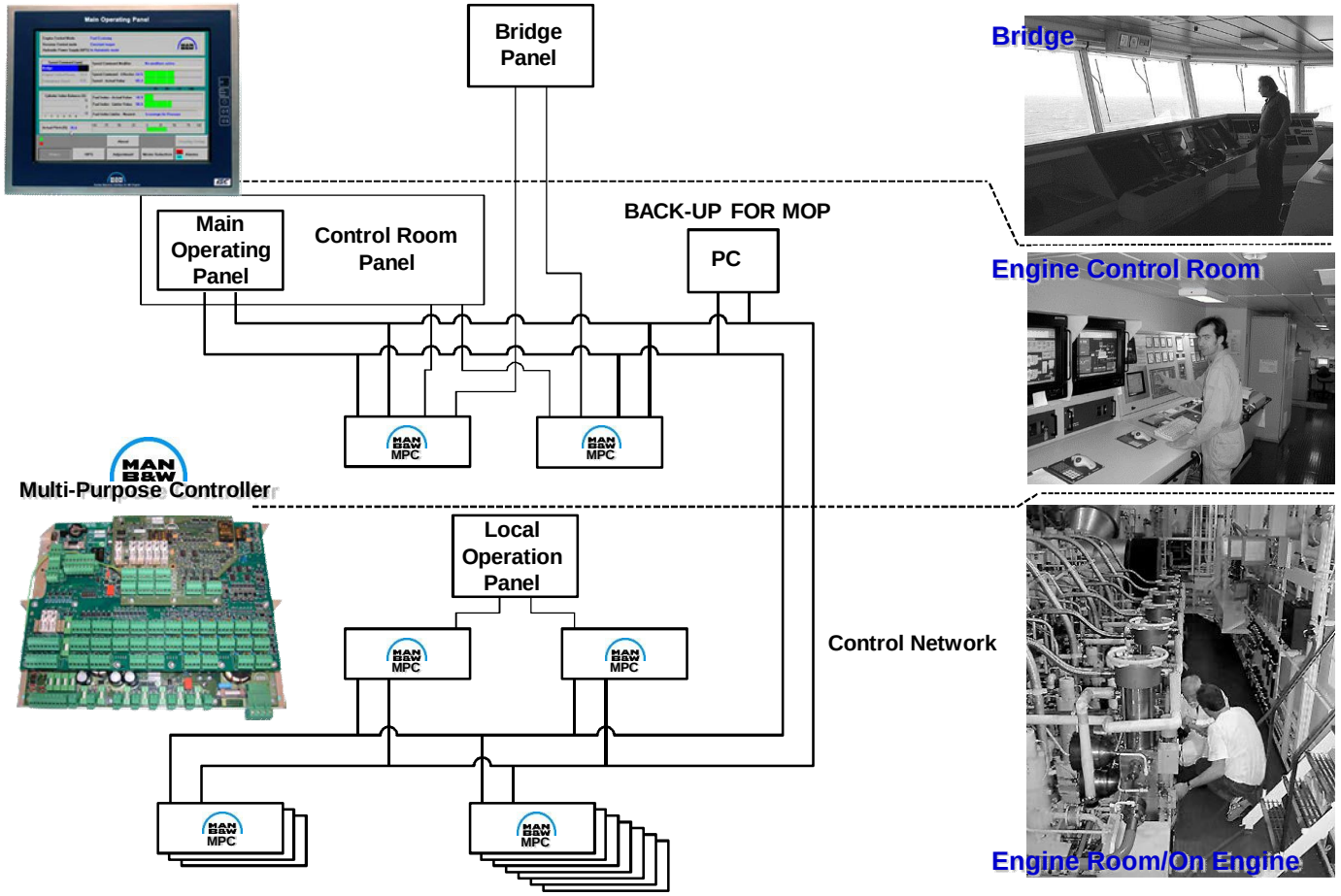
EXH gas Scrubber leak in service.

EXH Scrubber insert of plastic type.

Improved documentation of engine parameters are logged onbard.



ME Engine Control System

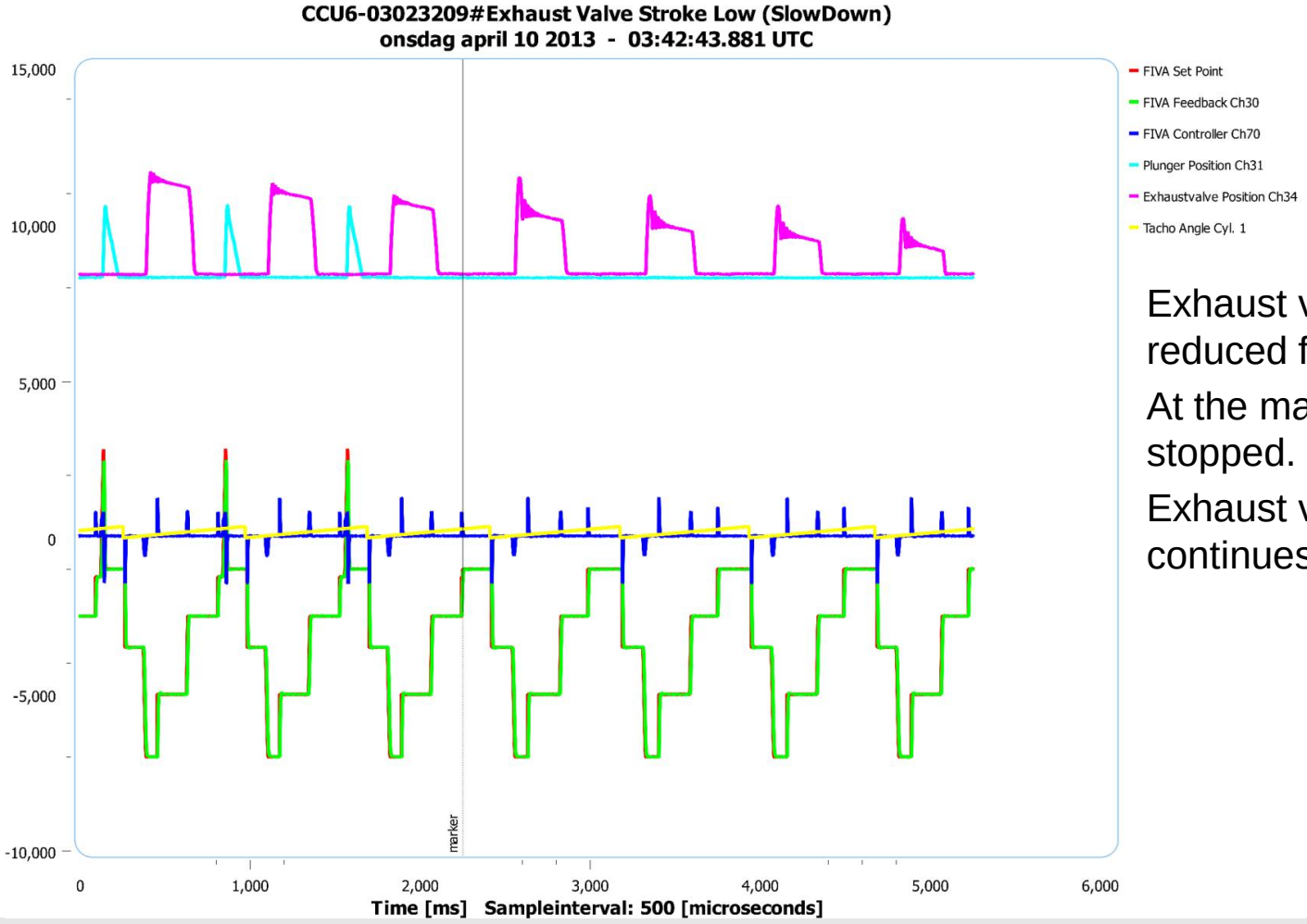


ME-ECS-SW-1903-2 introduces Improvements:

- **o ECU**: Send fuel telegram offset angle
- **o CCU**: Extend profile injection length
- **o ACOS**: Timer controlled force high-BN oil
- o ME Lube Adjustment to be dependent of min. feed rate
- o **PIV**: Deactivate reduced lift functionality if pressure fails
- o Fuel index margin signal for RCS filtered
- o Governor enhancements
- o Adaptive Cylinder Control (ACCo)
- **o SCSU**: Add supervision of gas sensor reset output
- **o LGIP**: Design maturing
- **o LGIP + LGIM**: Master SF valve enables support
- **o OMCU** node and functionality feature complete
- **o LDCL:** Circulation pump operation behaviour updated
- **o LDCL**: Exercise function for 3-way valve
- **o SCU**: Updated EGB calibration requirement

HCU events from service

Exhaust valve stroke low.

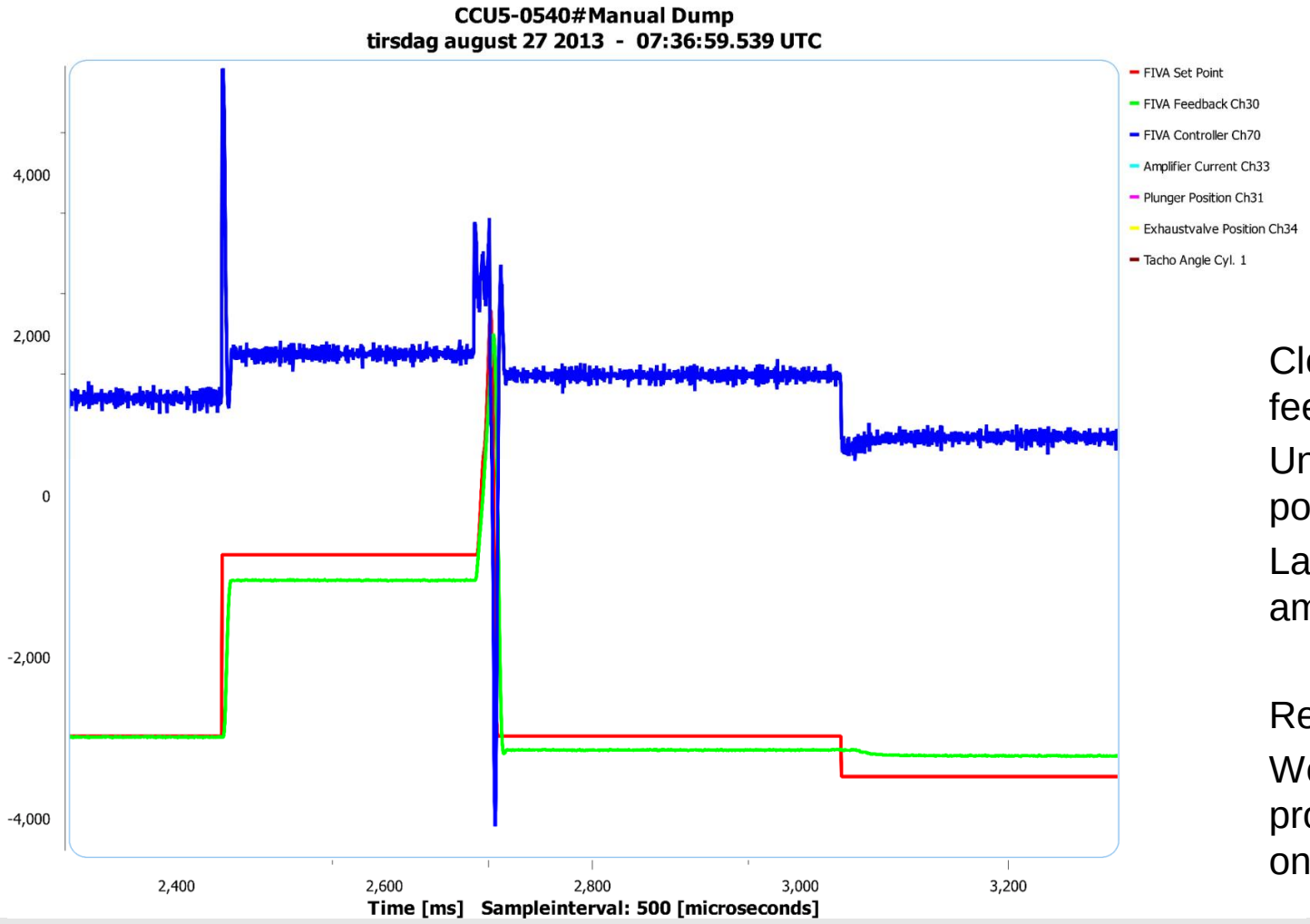


Exhaust valve stroke is reduced for each revolution.

At the marker the fuel is stopped.

Exhaust valve activation continues.

HCU events from service. **FIVA position** **Feed back signal delayed. Reason Worn Fiva proportional valve.**



Closer look at feedback.

Unable to follow set point.

Large Control signal amplitude.

Reason:

Worn out proportional valve on FIVA.

MAN B&W Two-Stroke, Dual Fuel engines ->> Multi fuel Engines

Historical timeline

2011 — Engine delivery for TOTE Maritime

2012 — Engine delivery for TEEKAY LNG

2013 — ME-GI retrofit for Nakilat

2014 — 1st sea trial on methanol

2015 — 1st sea trial on ethane

2016 — First order of MAN B&W 6G60ME-LGIP engines by Exmar

2017 — 4 x MAN B&W ME-LGIP Retrofit orders for BW LPG. Dry dock 2020

2018 — Hapaq Lloyd 9S90ME-C ME-GI retrofit. Dry dock 2020

2011 — ME-GI test at RCC, Copenhagen

2012 — Demonstration test at HHI

2013 — Demonstration test at MES

2014 — Development of ME-LGI

2015 — Ethane development

2016 — ME-GI/E PVU at RRC

2017 — LPG testrig at RCC

2018 — LPG tightness- & function test at RCC

2019 — LGIP cylinder installed on research engine at RCC

2020 — ME-GA test at RCC, Copenhagen

The Dual Fuel..

An overview

World's first LNG driven ocean going ship

Owner: TOTE
Ship type: Container ship
Capacity: 3,100 Teu

Dual Fuel engine type: 8L70ME-C8.2-**GI**

World's first Methanol driven ocean going ship

Owner: MOL
Ship type: Methanol carrier
Capacity: 50,000 dwt

Dual fuel engine type: 7S50ME-B9.3-**LGIM**

World's first Ethane driven ocean going ship

Owner: Hartmann Gas Carriers
Ship type: LEG Carrier
Capacity: 36,000 M³

Dual Fuel engine type: 7G50ME-**GIE**

World's first LPG driven ocean going ship (soon to be)

Owner: Exmar
Ship type: VLGC Capacity: 80,000 M³

Dual Fuel engine type: 6G60ME-**LGIP**

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Capacity: 50,000 dwt

Dual fuel engine type: 7S50ME-B9.3-**LGIM**

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Owner: Hartmann Gas Carriers
Ship type: LEG Carrier
Capacity: 36,000 M³

Dual Fuel engine type: 7G50ME-**GIE**

World's first LPG driven ocean going ship (soon to be)

Owner: Exmar
Ship type: VLGC Capacity: 80,000 M³

Dual Fuel engine type: 6G60ME-**LGIP**

MAN Energy Solutions
Future in the making

The MAN-ES Dual Fuel engine

½ Million

MAN Energy Solutions
Future in the making

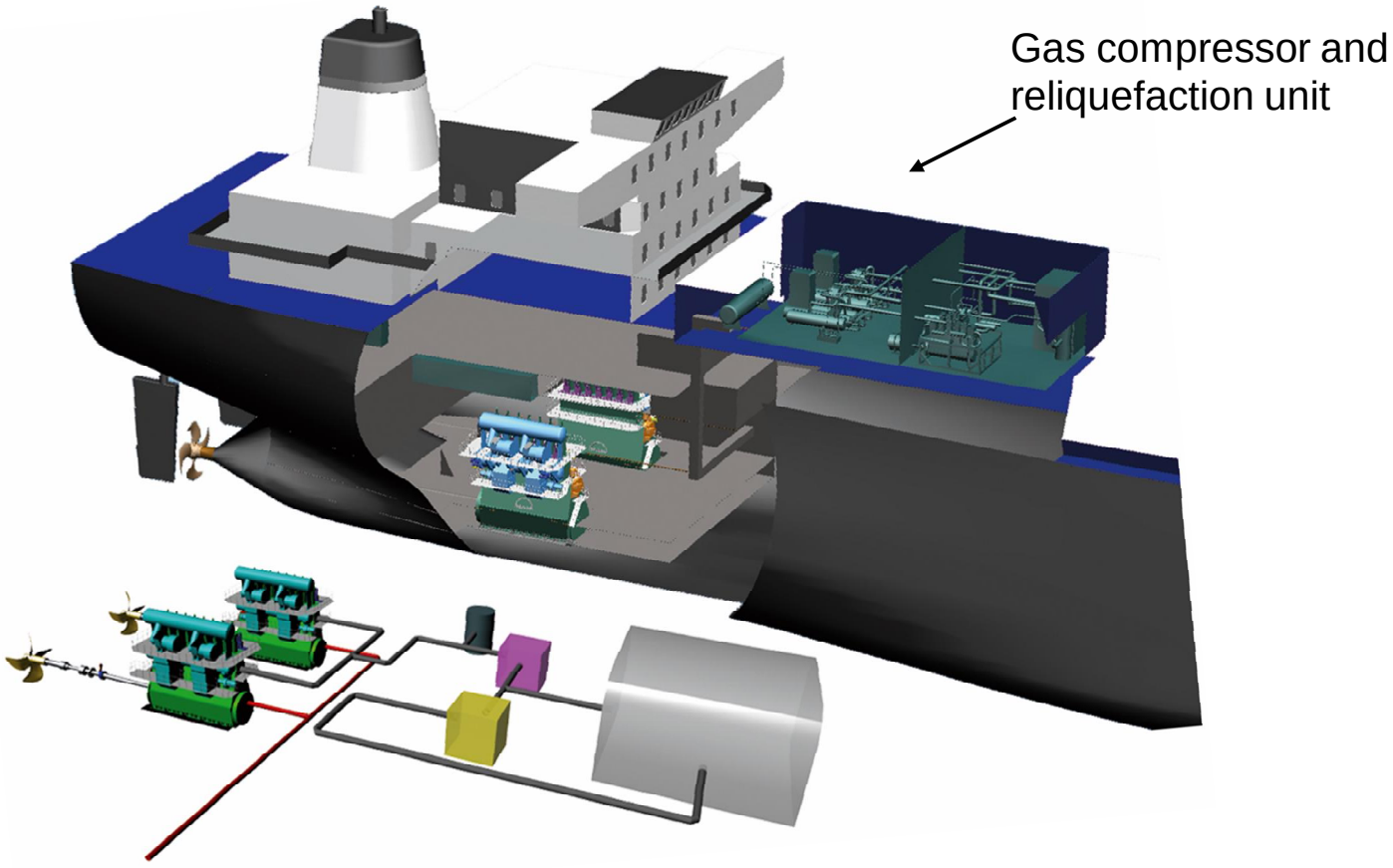
>65.000

MAN Energy Solutions
Future in the making

>30.000

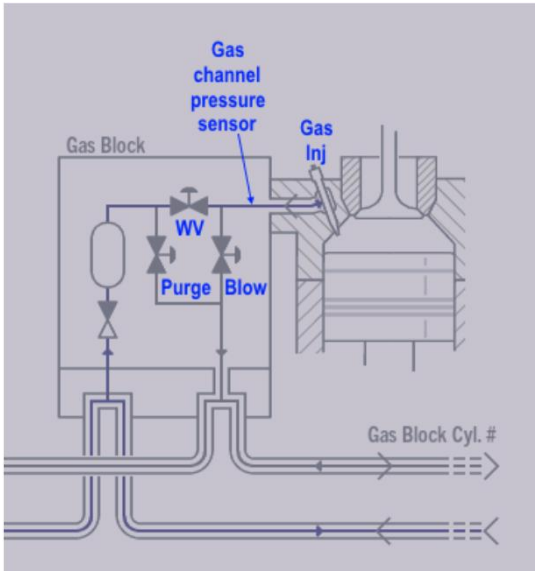
Peter C Quaade ï ©2019

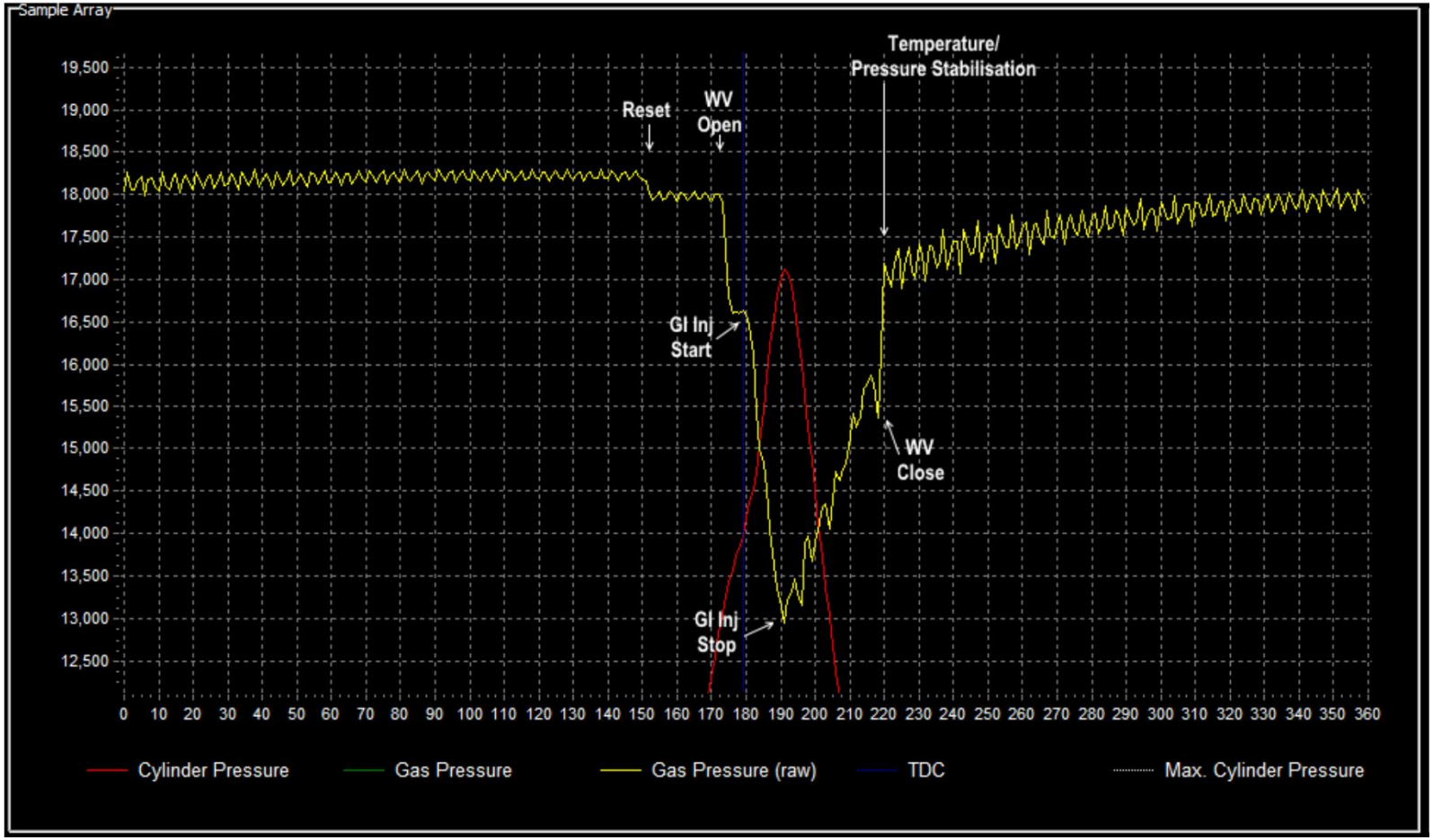
ME-GI Engine with High-pressure Gas Compressor and Reliquefaction



Safety system for dual fuel injection systems

LNG-Methanol-LPG-Ethane-Ammonia.





– HAZID analyse of LNG gas leaking in engine room

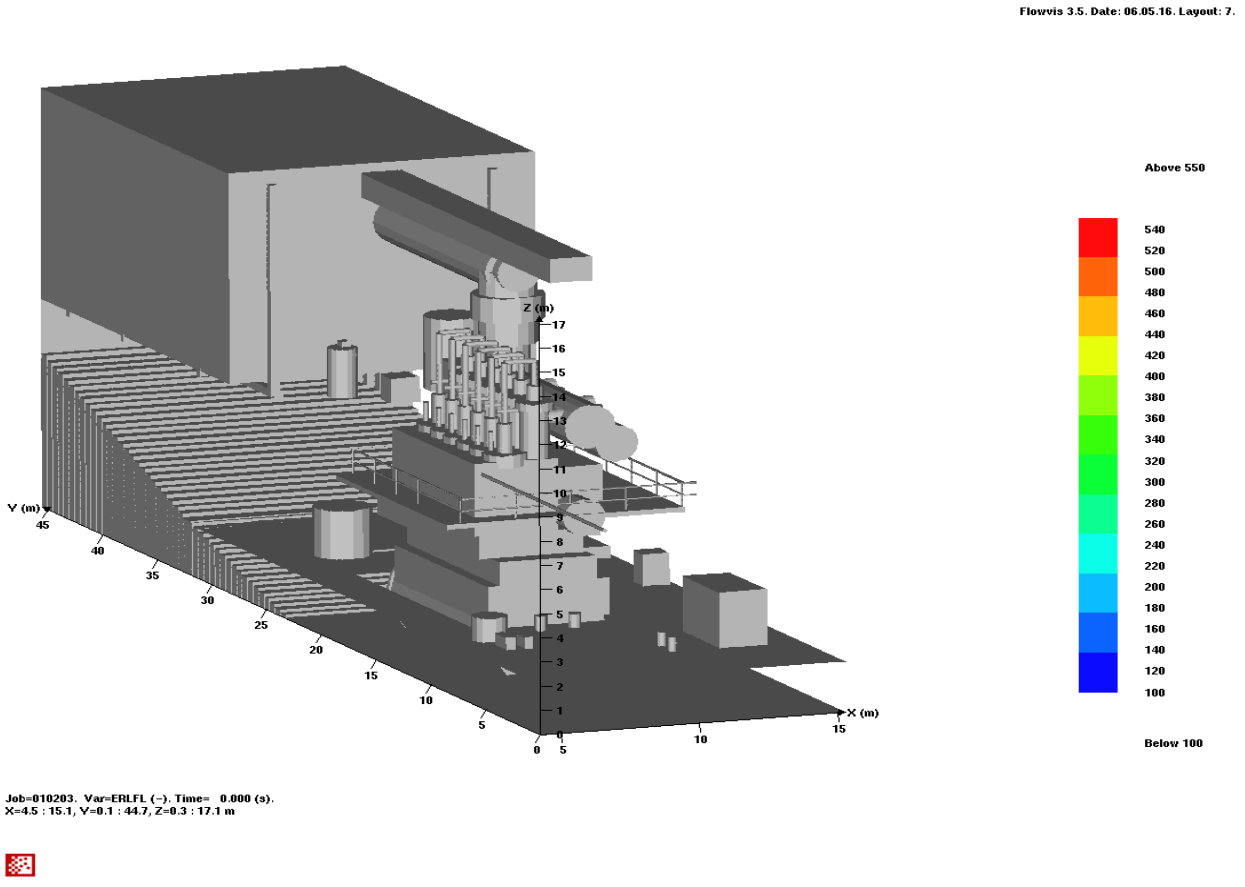
Table 1-1 Main results from explosion analysis. ESD valve is located on Main deck (22 kg gas in the segment) and 20 seconds ESD closure time, except for full bore rupture case. Explosion frequency is the frequency of reaching pressures which can be intolerable to humans (0.1-0.2 barg).

Hole diameter [mm]	Size/ ESD failure mode	Initial leak rate [kg/s]	Gas cloud size [m^3]	Max explosion pressure [barg]	Frequency of explosion (per year)	Comments
39 (full bore rupture)	Full bore/no failures	53	947**	1.1	4.7E-06	Max cloud size obtained from simulations. No failure of structure
8.5	Medium/no failures	2.5	500	0.47	2.0E-06	No failure of structure
3.8 and smaller	Small/no failures	0.5 and smaller	8 and smaller	Negligible	0	No failure of structure
39 (full bore rupture)	Full bore/failure of shut down	53	1000 to 1500*	1.1 to 1.7	5.8E-08	Can cause restrictions on girder
8.5	Medium/failure of shut down	2.5	1000 to 1500*	1.1 to 1.7	2.4E-08	Can cause restrictions on girder
3.8 and smaller	Small/failure of shut down	0.5 and smaller	500*	0.5	5.7E-07	No failure of structure

*Assumed

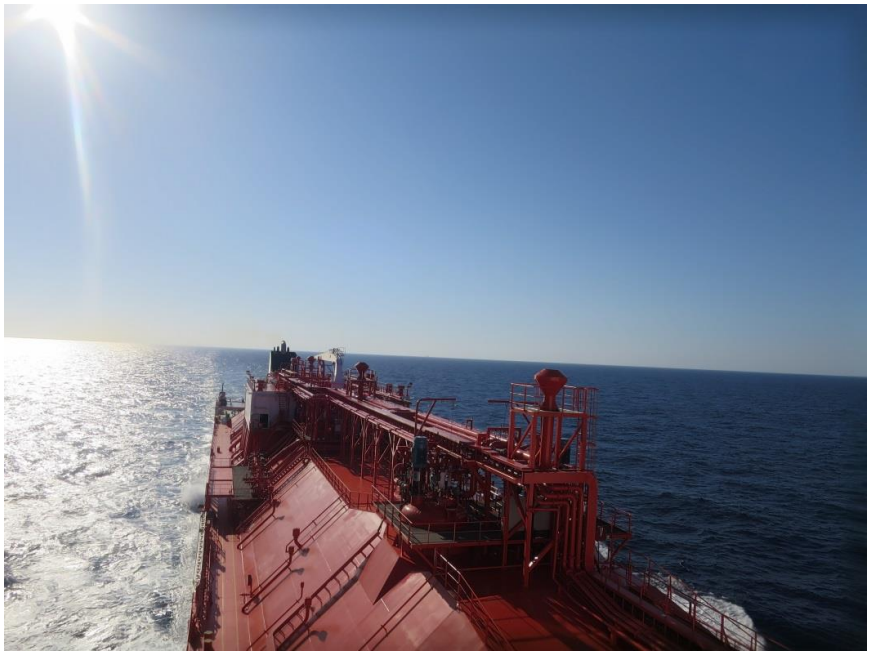
** Note that in this case only is applied ESD valve located just outside engine room and 5 seconds ESD closure time.

Safety study - Fires and Explosion Analysis by DNV: Engine Room Gas Dispersion for Full Bore Rupture 1000 m^3 Gas Cloud



The Dual Fuel..

An overview



- >280 Confirmed sales
  112 in service (8 LGIM / 3 GIE)
- LGIP engines
  Prototype test December 2019
- Retro Fit solutions
  tankers, CV (ME to ME-GI, ME-GI to ME-GIE, ME to LGIP)
- ME-GIE a new member of the family, G60 ME-GIE
  Gas atomizers for Methane and Ethane

– Diesel	GI-6
– HFO	GI-6
– Ethane	GIE-29
– Methane	GIE-29

While modern maintenance planning systems, digital services and trained personnel are undoubtedly important, the foundation for problem free machinery operations is set when the focus is put on basics. A well designed, thoroughly specified engine room combined with efforts made for superior supervision during the construction/commissioning period pays off later in the lifecycle of the machinery. For example, it may be hard to believe, but poor cleaning of piping during construction still remains one of the main reasons behind fuel equipment/bearing issues today.

Also, consistency in engine room manning has an impact. The 'Same Crew Same Vessel' concept creates a 'my ship' attitude where the crew takes ownership over installation. Problems are fixed immediately as they occur, even the smallest ones, which enables condition monitoring and leaves no opportunity for gradual deterioration of the installation.

Prudent engineering practices should not be underestimated. Following manuals, bulletins and other instructions published by the manufacturer is key to avoiding errors in machinery operations and maintenance activities. Assembly mistakes can remain hidden and cause disturbances at a later date, greatly affecting the engine's reliability.

Maintaining a detailed engine room logbook constructs a historical data timeline which can be used to identify focus areas, and aid learning from past experiences.

Proper trending of Cooling Water, Lubrication Oil and Fuel Oil analyses creates an understanding of the overall condition of the machinery and assists in calibrating maintenance needs as well as component lifetimes.

100

Service centers worldwide

MAN Energy Solutions
Future in the making

Thank you!
Do you have any questions?