MAN-B&W 6S70 ME-C diesel engines concept, specifics of maintenance and repair in service.

Subject presentation will briefly include the following:

- General concept and advantages of ME-C towards other MC-/ME-B series of diesel engines

- Maintenance and operational experience gained on ME-C series for 7 years handling the Q-Flex LNG Fleet

- Commonly encountered failures experienced at sea and implemented countermeasures to avoid reoccurrence.

General concept and advantages of ME-C towards other MC-/ME-B series of diesel engines

MAN Diesel & Turbo initially introduced electronic, fuel injection control on its large bore, ME-C engines, which are a more compact form of their ME-B counterparts. The ME-C range's electronic controls bring a whole host of advantages to the table and are characterized by:

- Fully integrated electronic control
- Low SFOC
- Superior performance parameters
- Appropriate fuel injection pressure and rate shaping at any load
- Improved emission characteristics
- Smokeless operation at any load
- Lower NOx on command.

These advantages are gained by the use of variable, electronically-controlled timing of fuel injection and exhaust valves during operation. Additionally, all software and hardware are upgradable for the lifetime of the engine.

Elements of the ME Engine.

The mechanical difference between an MC-C engine and its electronically controlled counterpart, the ME-C engine, constitutes a number of mechanical parts that are made redundant and replaced by hydraulic and mechatronic parts with enhanced functions.

The following parts are omitted:

- **Chain drive Chain wheel frame**
- **Chain box on frame box Camshaft with cams**
- **Roller guides for fuel pumps and exhaust valves**
- **Fuel injection pumps**
- **Exhaust valve actuators**
- **Starting air distributor**
- **Governor**
- **Regulating shaft**
- **Mechanical cylinder lubricator**
- **Local control stand**

The above-mentioned parts are replaced by:

- **Hydraulic Power Supply (HPS)**
- **Hydraulic Cylinder Units (HCU)**
- **Engine Control System (ECS),**
- **Crankshaft position sensing system**
- **Electronically controlled Alpha Lubricator;**
- **Local Operating Panel (LOP)**

Fig. 6 shows how the necessary power for fuel injection and exhaust valve operation – previously provided via the chain drive – is now provided from a Hydraulic Power Supply (HPS) unit located at the front of the engine at bedplate level.

The main components of the Hydraulic Power Supply unit are the following:

- **Self cleaning filter with 10-micron filter mesh**
- **Redundancy filter with 25-micron filter mesh**
- **Start-up pumps: Electrically driven pumps with supply pressure of 175 bar**
- **Engine driven axial piston pumps supplying high pressure oil to the Hydraulic Cylinder Unit with oil pressures up to 250 bar**

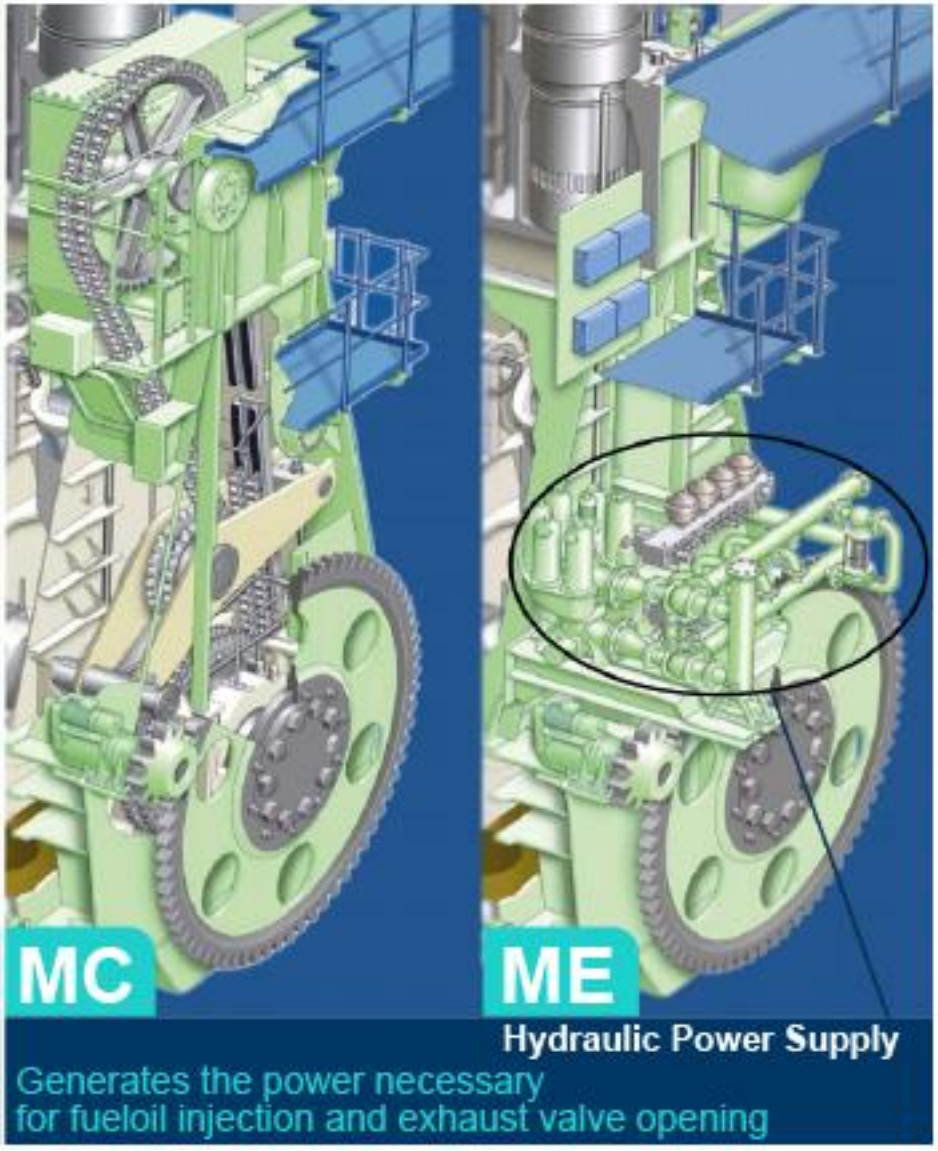


Fig. 6: Hydraulic Power Supply (HPS)

The ME version of this engine has now logged about **30,000** running hours and it has, throughout this period, been used to fine-tune the ME technology.

The main objectives for the ME-technology are:

- **Improved fuel economy at all load point, Fig. 2**
- **Flexibility with respect to present as well as future emission requirements, Fig. 3**

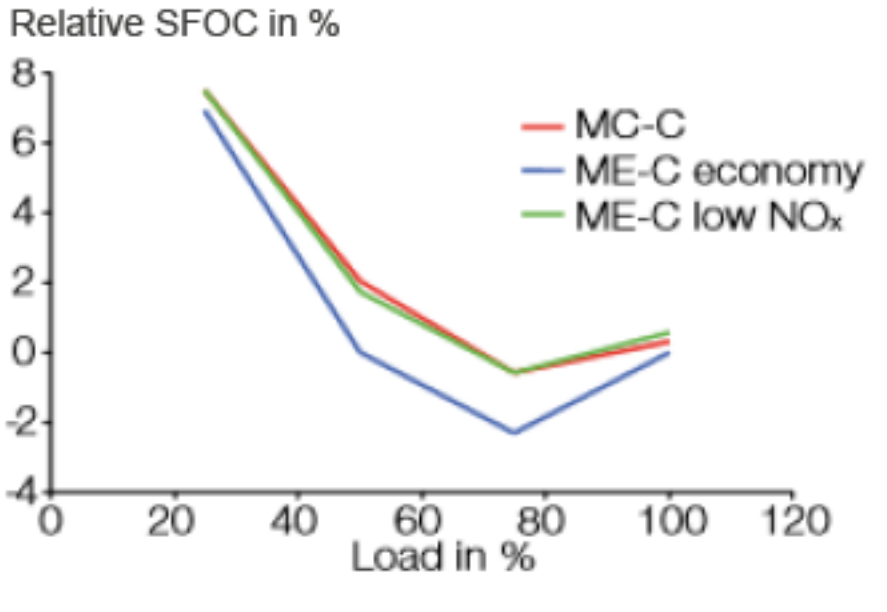


Fig. 2: Improve fuel economy at all load point

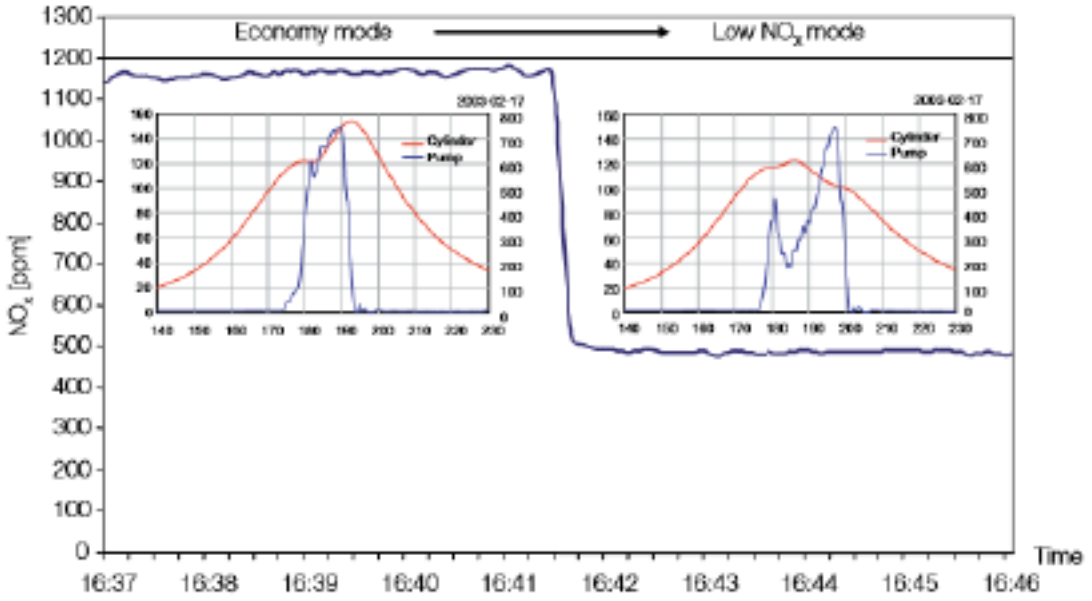


Fig. 3: Flexibility with respect to emission

- **Easy engine balancing/adjustability, Fig. 4**
- **System integration (example, Fig. 5: Alpha Lubricator fully integrated in the ME-system)**
- **Smokeless operation**
- **Stable running at very low load**

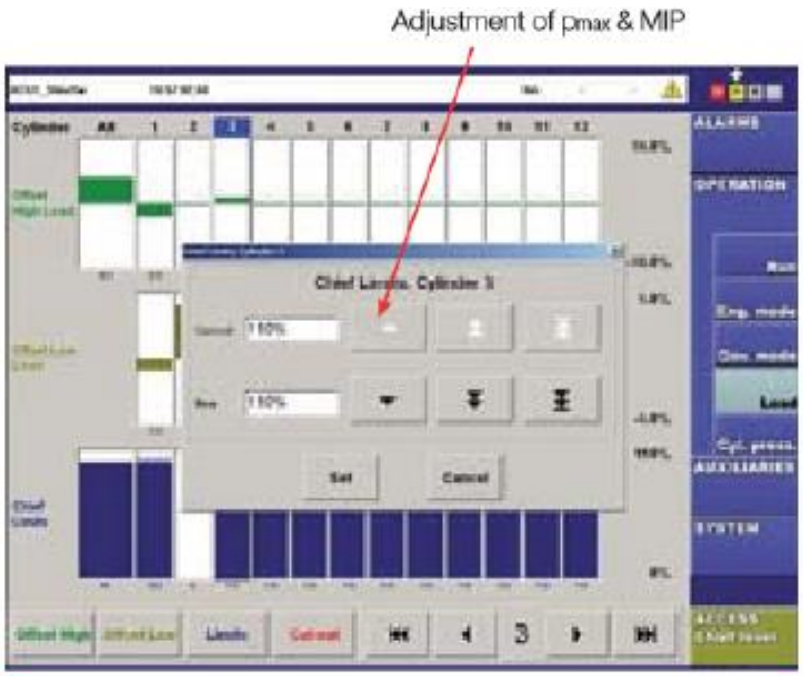


Fig. 4: Easy engine balancing/adjustability

Fig. 5A: System integration example: Alpha Lubricator

Future updates and fine tuning with new releases of the control software further enhance advantages of the ME concept.

Other ME features realized are:

- Real camless operation with either engine driven or electrically driven standard industrial pumps for the hydraulic power supply
- Standard flexibility with respect to changing between HFO and MDO operation
- Simplicity is kept by low number of components (e.g. only one NC valve per cylinder)
- Furthermore the number of assembly points are kept low by having only one high pressure oil system
- Cylinder control computers are kept away from areas with high heat exposure in order to limit thermal heating
- Apart from the ME-specific features like OROS combustion chamber with slide fuel valves, nimonic exhaust valves with W-seat securing long time between overhaul and very satisfactory cylinder condition.

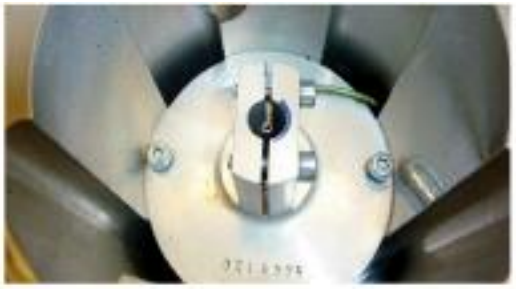
Maintenance and operational experience gained on ME-C series for 7 years handling the Q-Flex LNG Fleet:

- **Main diesel engine 6S70 ME-C single unit overhauling, cleaning and measuring process carried out by crew:**

- **Moment compensator and chain drive inspection, chain tightened hydraulic torque adjustment:**

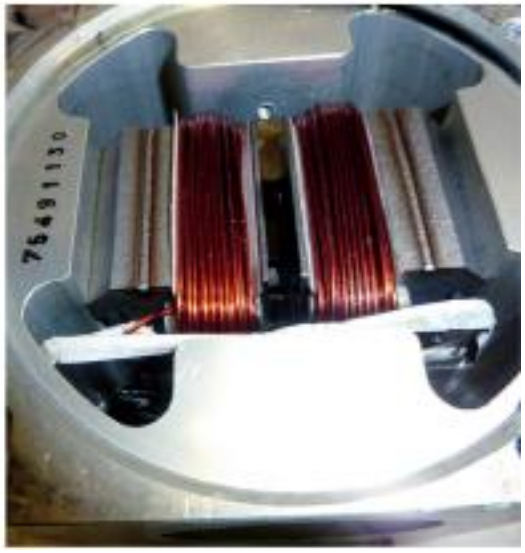
- **FIVA Valve proper handling:**









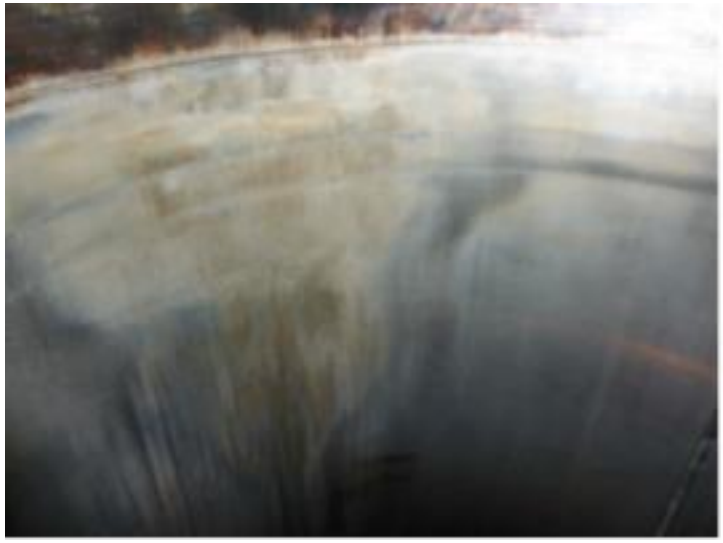


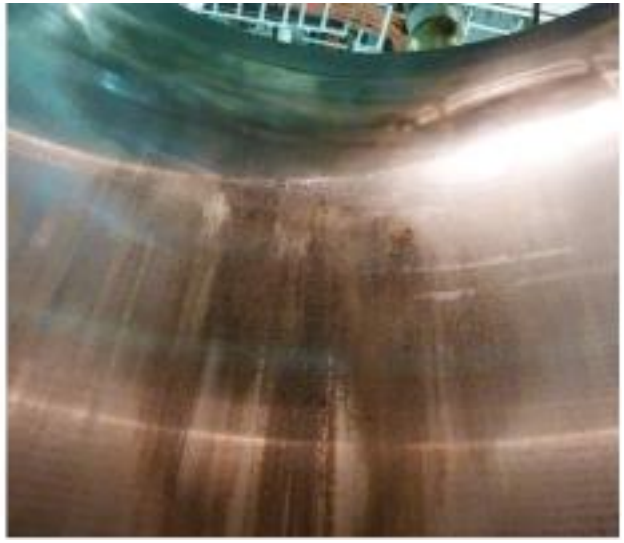
The internal liner cooling is to be lowered:

The new spare liners onboard should be modified by replacing 10 of the existing 24 cooling pipes with insulated cooling pipes.

The insulated pipes should be positioned with 5 pipes in the exhaust side and 5 pipes in the maneuvering side. New produced liners will be modified with a reduced number of cooling bores, going from 24 to 20 bores. When increasing the temperature level to 90°C we have in a few cases experienced problems with hardening of the O-rings and subsequent water leakages from the sealing of the outside water connections between the cylinder liner and cylinder cover.

An investigation of such incidents has proved that this has been the result of use of O-rings of wrong material (nitrile rubber).



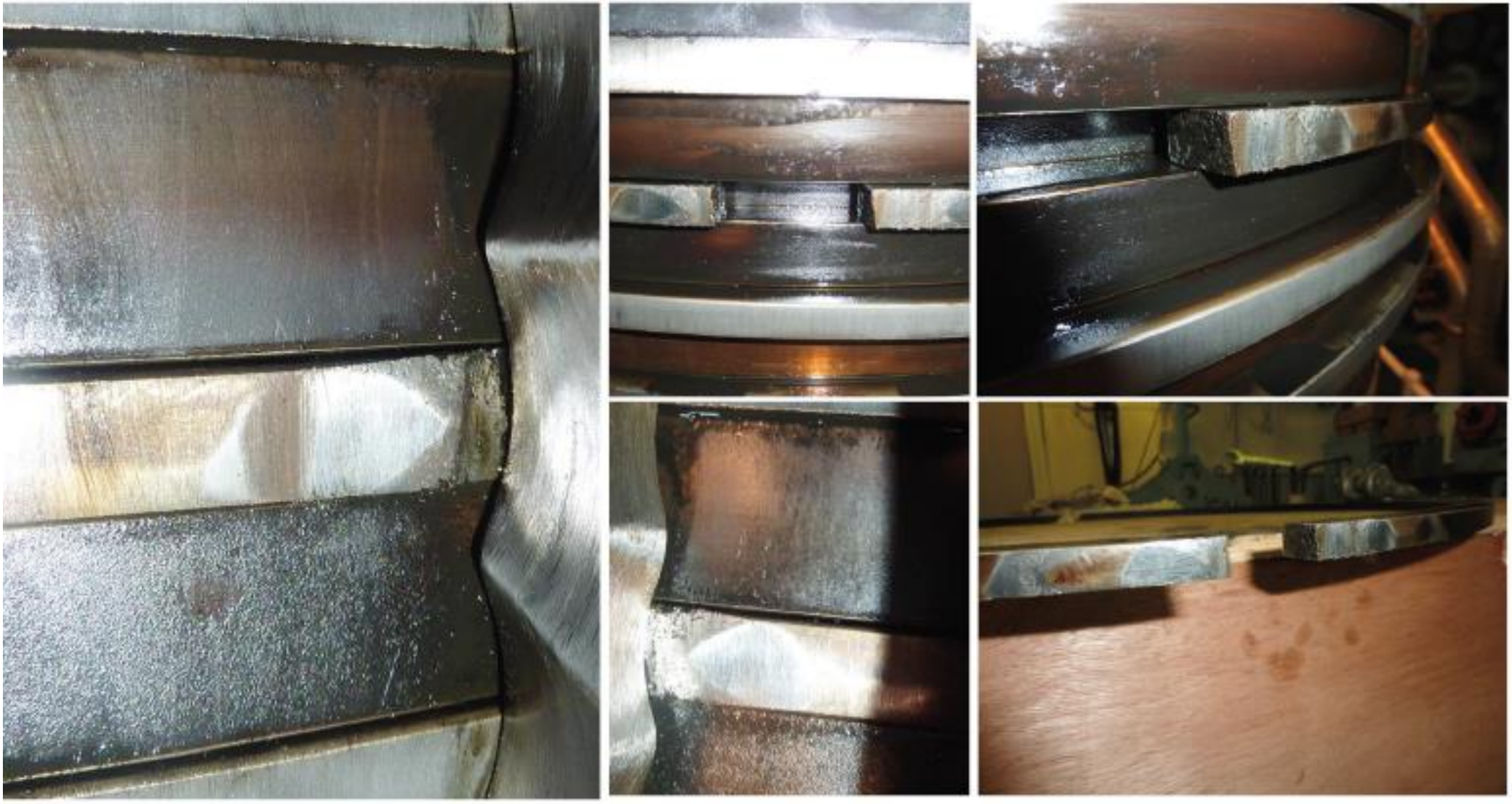


Lubricator shaft seizure

Corrective measures: lubricator replacement assy undertaken and failed shaft sent for reconditioning:

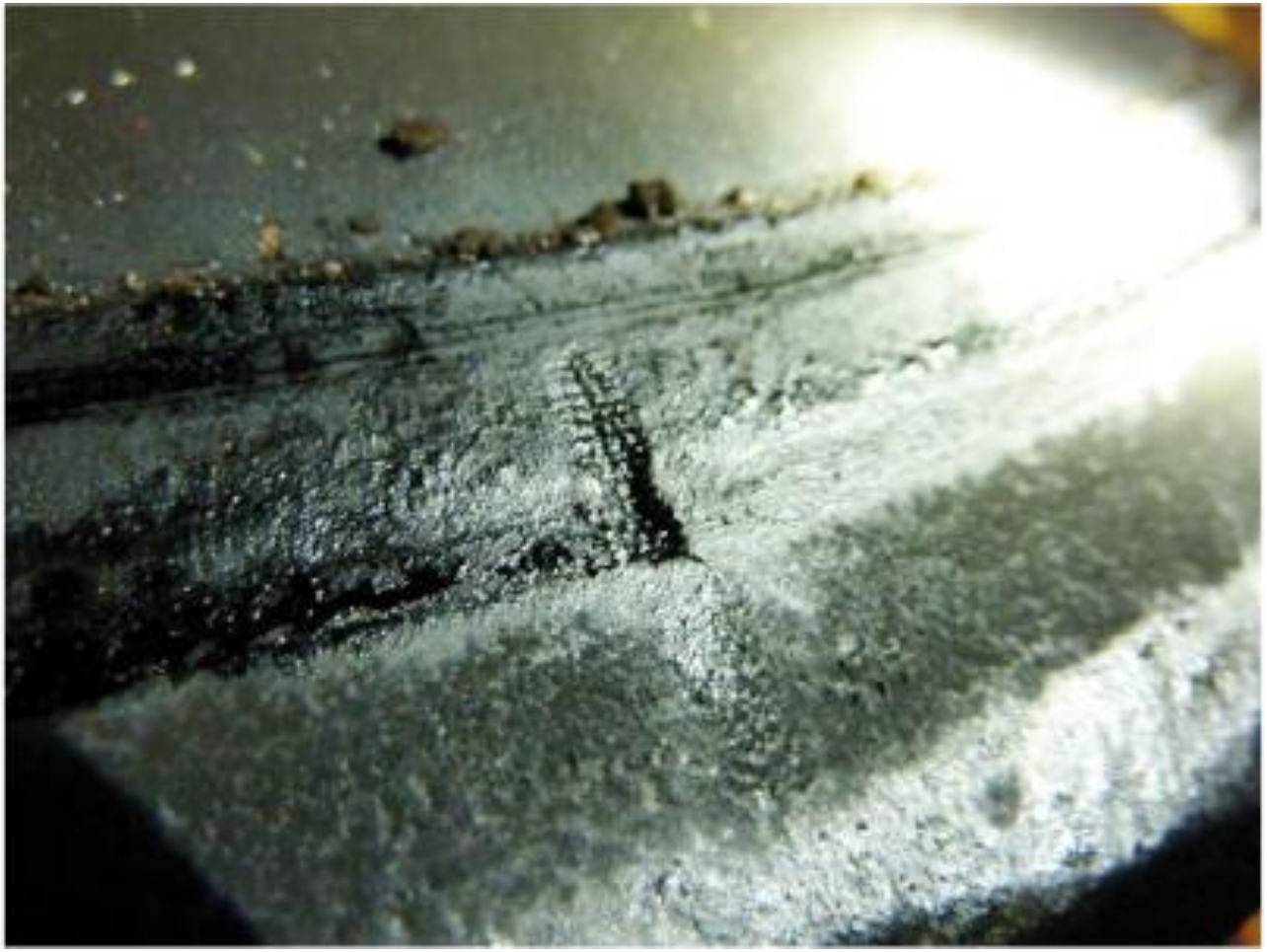
Piston 2nd ring breakage

Corrective measures: piston with broken ring withdrawn and new set of rings fitted:



Exhaust valve spindle blow-by

Corrective measures: Exhaust valve overhauled, new valve assy was fitted and failed component has been sent to MAN Dubai for reconditioning:

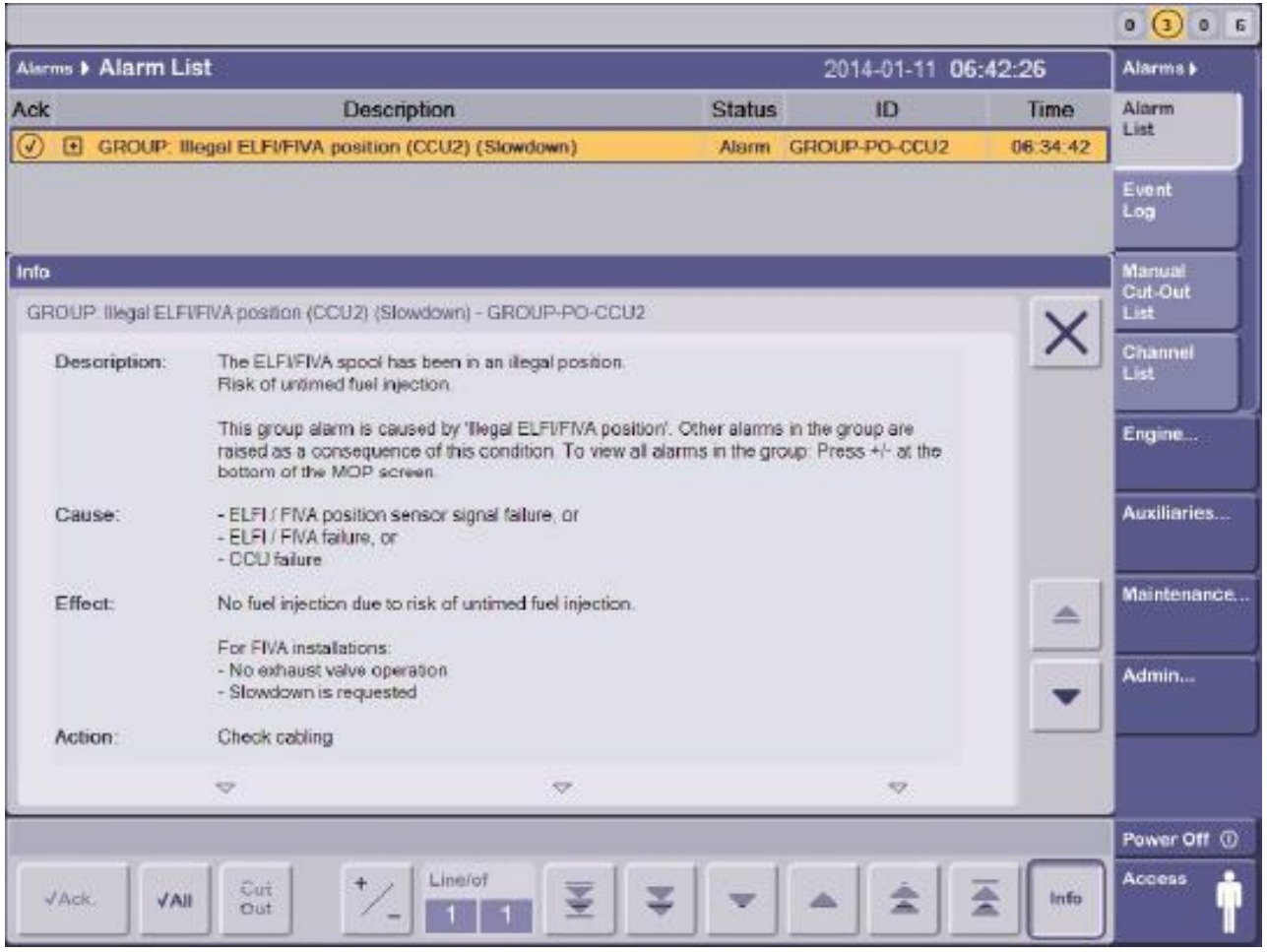


Main hydraulic pump swash plate amplifier failure

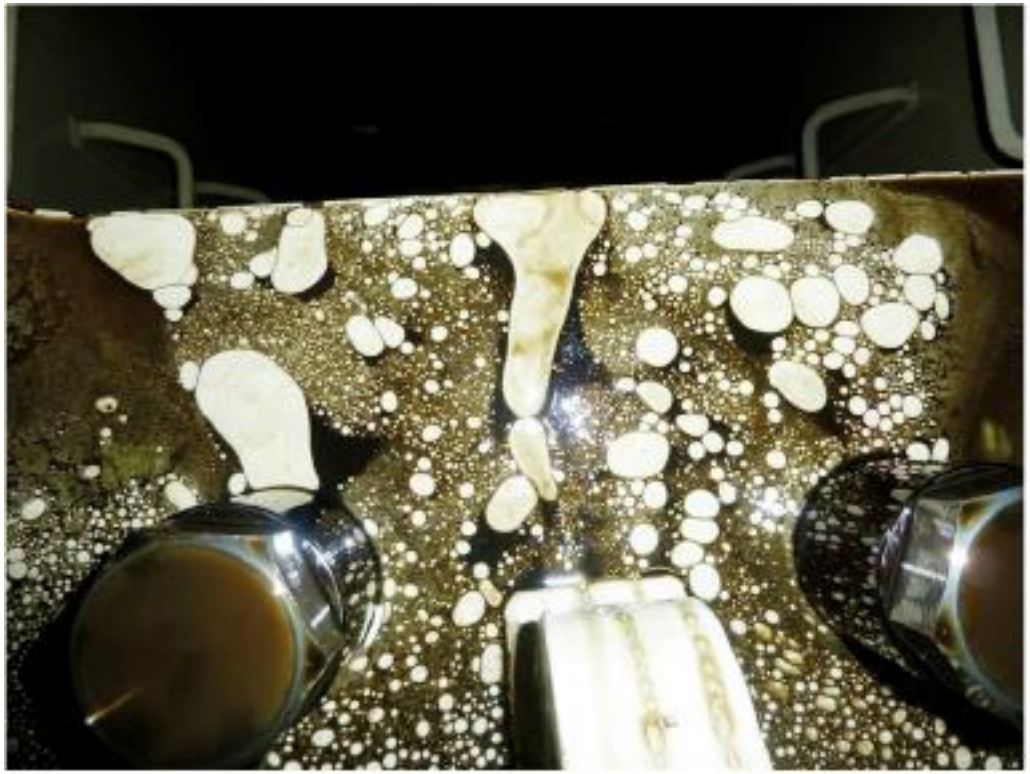
Corrective measures: identification on MOP screen, evaluation and ascertainment of root cause of failure. Swash plate amplifier renewed:

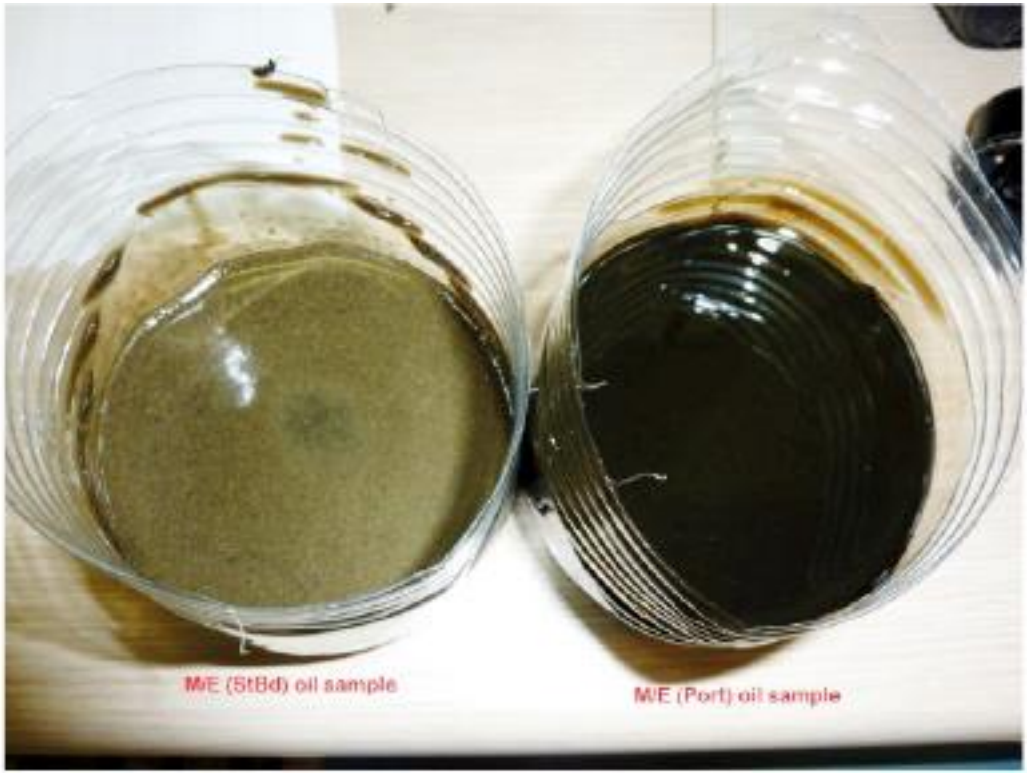
Main engine sump oil contaminated by water

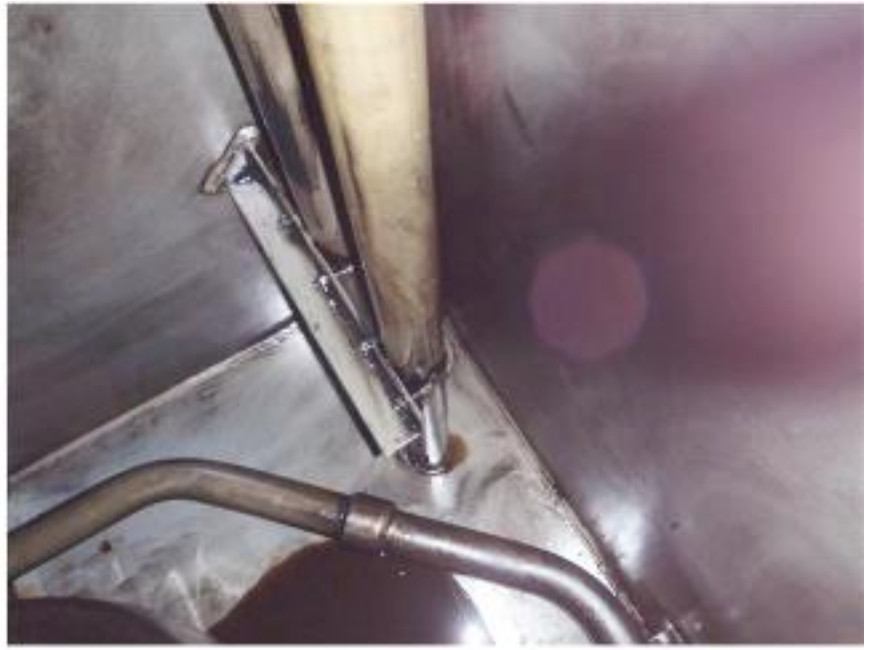
Indirect indication – ascertained on earlier stage: repetitive occurrence of '' ME (S) Illegal ELFI-FIVA position (CCU1-6) Slowdown'' alarm pop up on MOP screen: Frequent FIVA cleaning and overhauling did not bring positive effect



Direct indication – ascertained on later stage: water presence in oil abt. 0.48% what caused frequent FIVA malfunction and consequently engine slowdown. Corrective measures: immediate oil analysis for water presence on board and in laboratory has revealed excessive oil deterioration by water. After complete oil drain the source of contamination ascertained as damaged piece of steam heating coil where part of condensate penetrated inside sump tank via pin hole caused by heavy friction of coil against U-clamp. Coil repaired, sump tank was cleaned. Eventually complete system oil was replaced with fresh one.






Thank You!