MAN Energy Solutions
Future in the making

Operational update:

Methanol and Ethane fueled two-stroke engines

Peter H. Kirkeby
Technical promotion and customer support
MAN-ES

ME-GI and ME-LGI Gas Technologies

Dual Fuel Combustion Concept – different requirements for injection systems

Gas Oil
Nozzle diameter: 0.5 mm
Injection pressure: 891 bar

Methanol
Nozzle diameter: 0.8 mm
Injection pressure: 569 bar

Methane
Nozzle diameter: 1.0 mm
Injection pressure: 301 bar

Ethane
Nozzle diameter: 0.8 mm
Injection pressure: 280 bar

KYUSHU UNIVERSITY

Alternative fuels

Properties and practicalities

Energy Storage Type	Specific Energy MJ/kg	Energy Density MJ/L	Required Tank Volume m^3. [1]	Supply Pressure Bar	Injection Pressure Bar	Emmision Reduction Compared To HFO Tier II			
HFO	40,5	35	1000	7-8	950	SO_x	NO_x	CO2	PM
Liquefied natural gas (LNG -162 °C)	50	22	1590	300 METHANE	300 METHANE	90-99%	20-30%	24%	90%
				380 ETHANE	380 ETHANE	90-97%	30-50%	15%	90%
LPG (including Propane / Butane)	42	26	1346	50	600-700	90-100%	10-15%	13-18%	90%
Methanol	18	15	2333	10	500	90-97%	30-50%	5%	90%
Ethanol	26	21	1750	10	500				
Ammonia* (liquid -33 °C)	18,6	12,5	2800	50	600-700				
Hydrogen (liquid -253 °C)	142	10	3500						
Marine battery market leader Corvus battery rack	0,29	0,33	106.060						
Tesla model 3 battery Cell 2170*. [2]	0,8	2.5	14000						

- *1: Given a 1000 m^3 tank for HFO. Additional space for insulation is not calculated for in above diagram. All pressure values given a high pressure Diesel injection principle.*
- *2: Values for Tesla battery doesn't contain energy/mass obtained for cooling/safety/classification . https://insideevs.com/tesla-model-3-2170-energy-density-compared-bolt-p100d/*

1 Methanol – the MAN LGIM engine

MAN B&W Dual Fuel Methanol Engine

Waterfront Shipping Company Ltd., Marinvest/Skagerack Invest (Marinvest), IINO Kaiun Kaisha, Ltd. (IINO), Mitsui & Co., Ltd. (Mitsui), and the NYK Group (NYK) are proud to announce their investment to build four new ocean-going vessels powered by clean-burning methanol fuel using the MAN B&W 6G50ME-LGIM

All 7 Methanol-fueled vessels entered service in 2016

ME-LGI Technology

ME-LGI-Methanol - Development Milestones

LGI demonstration event at MDT 4T50ME-X

Test at MDT 4T50ME-X

Test at MES 4S50ME-T9

Test at MES 7S50ME-B9.3

Celebration at MES

Test at HHI 7G50ME-B9.3

TAT at MES 4S50ME-T9

Sea trial MNS *Taranaki Sun*

Sea trial HMD *Lindanger*

Sea trial HMD *Mari Jone*

Sea trial HMD *Leikanger*

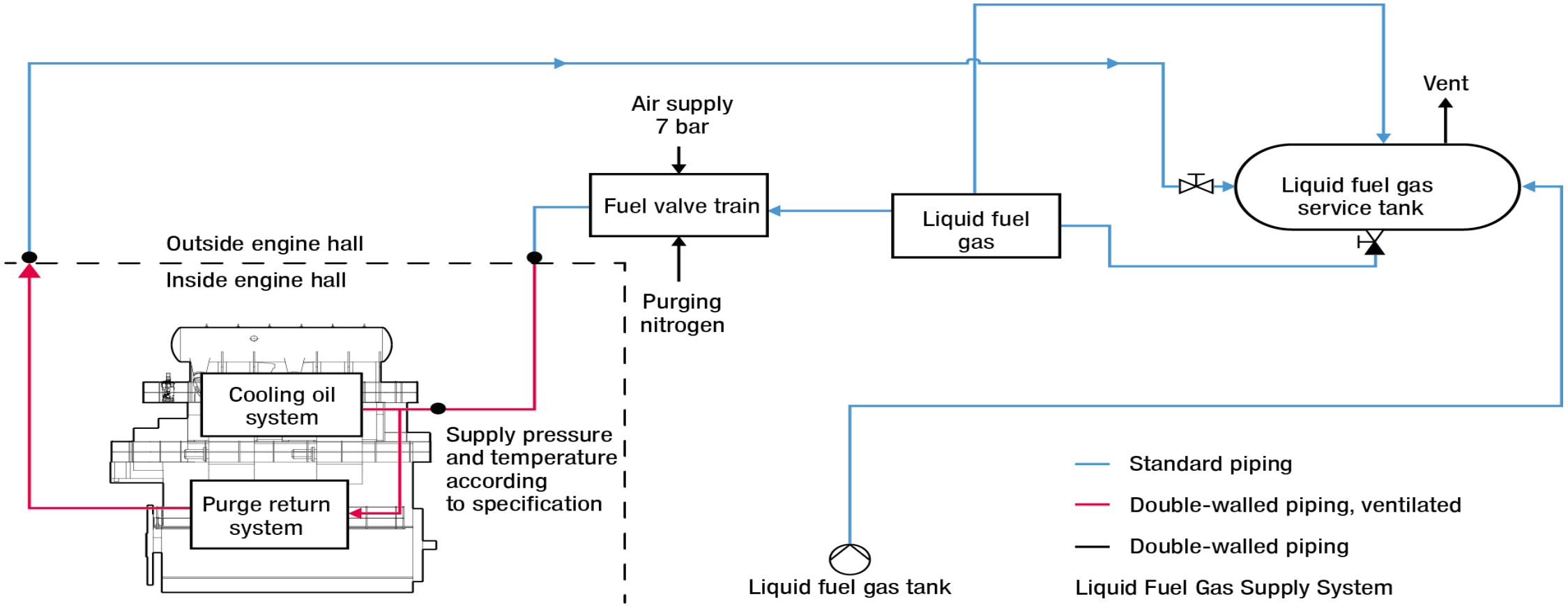
Sea trial M752

The 3rd tier III option: Water in Methanol

2015 2016 2017 2018

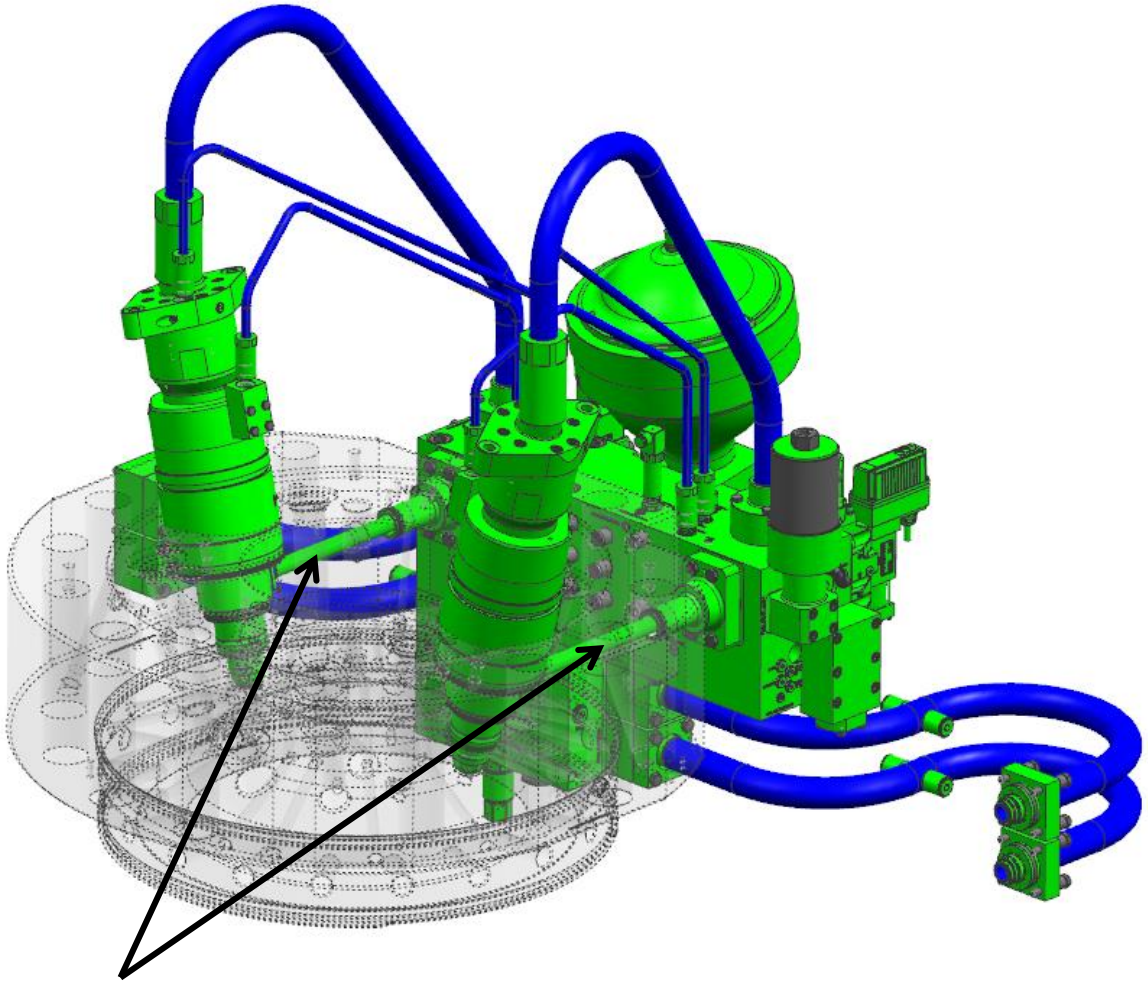
ME-LGIM System Overview

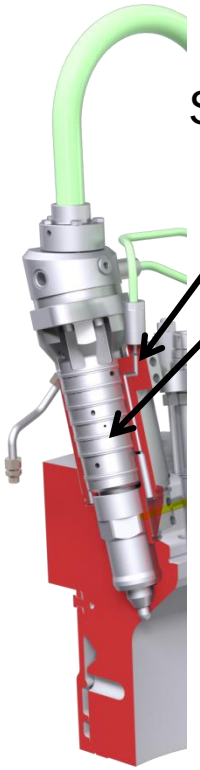
Low pressure supply system



LGIM injection equipment

Current design

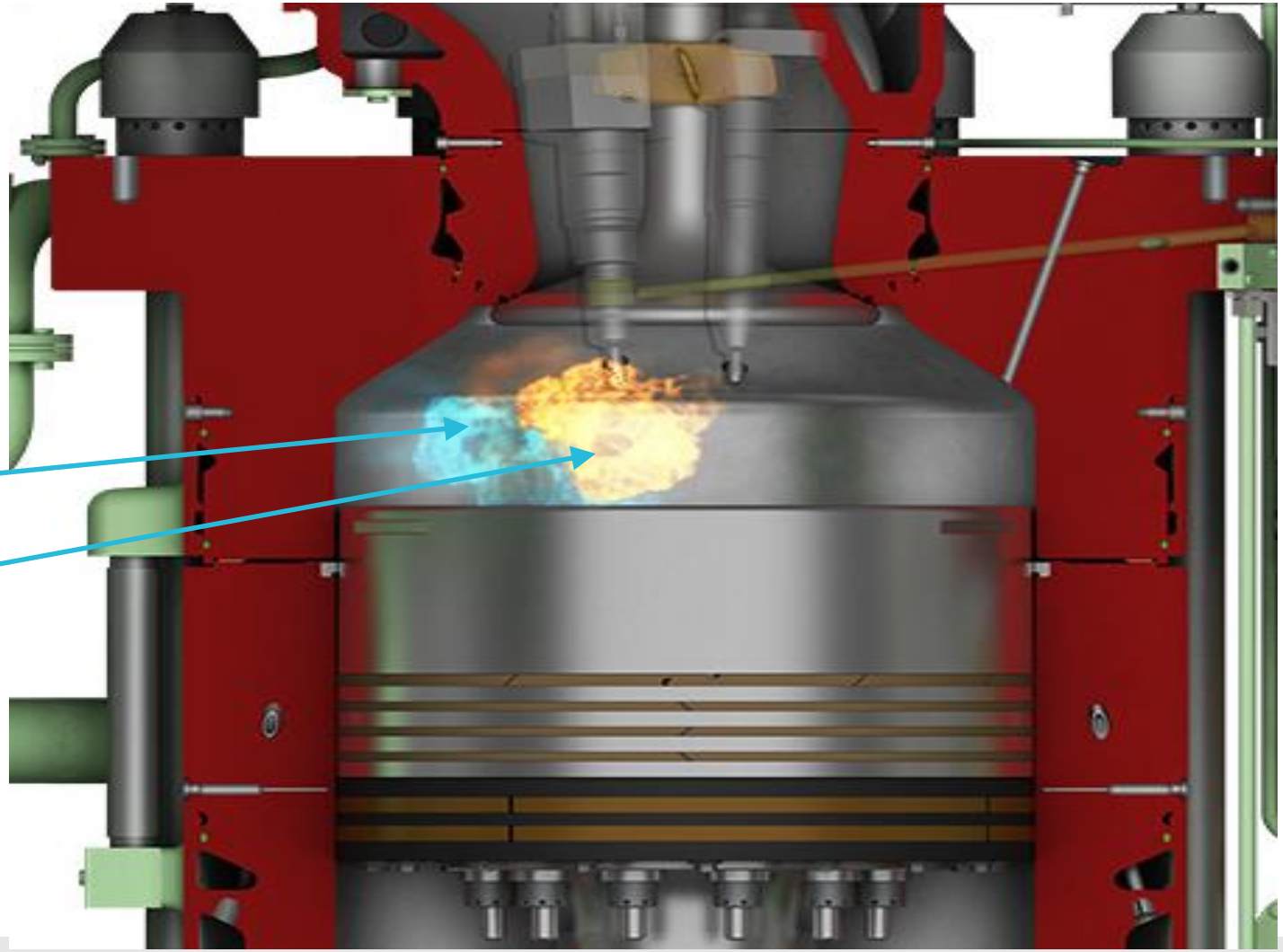




Methanol supplied by lance-design (internal pipes) through cylinder cover

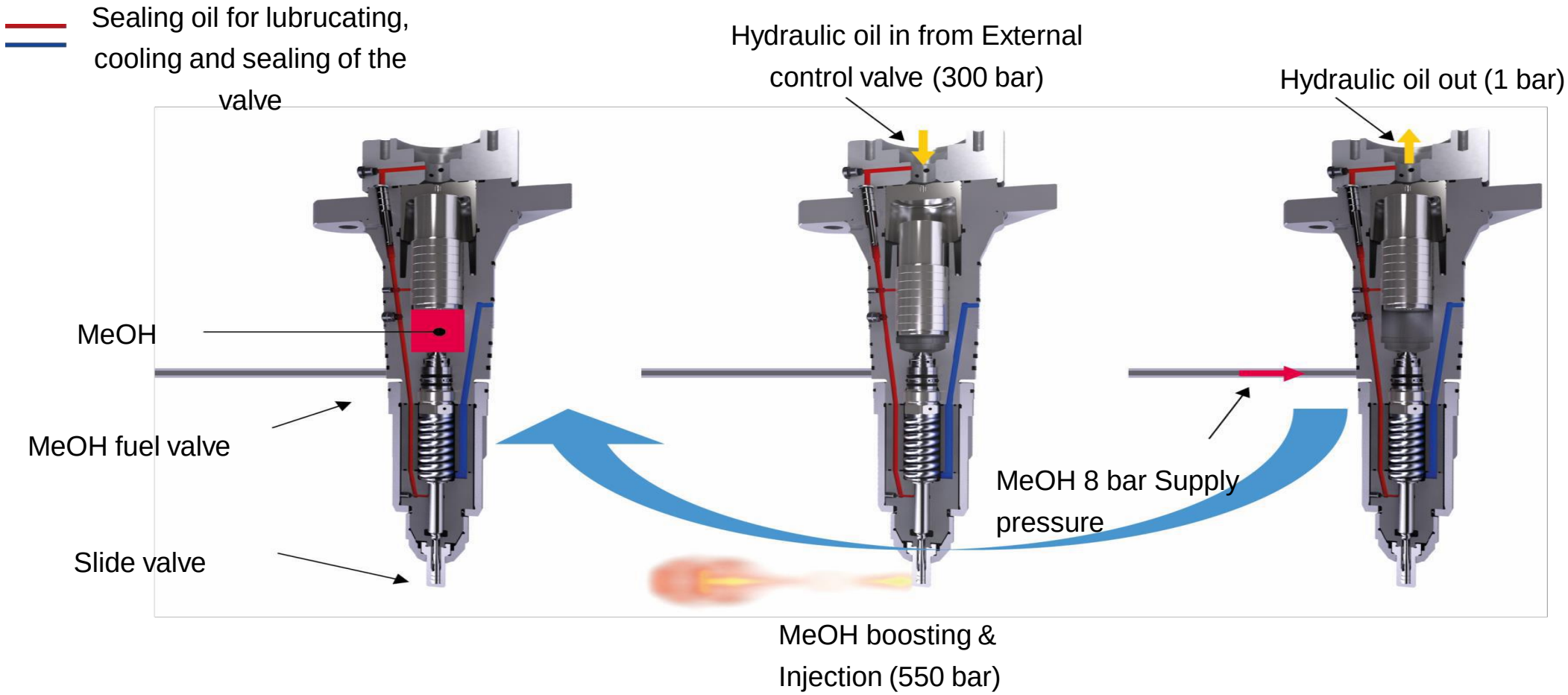
ME-LGIM Combustion Principle

- The ME-LGIM engine is a dual fuel engine
- Diesel combustion process →
- High effciency



The Fuel Booster Injection Valve

Principle of the FBIV – Fuel Booster Injection Valve



ME-LGIM Technology

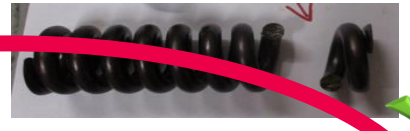
ME-LGI G50 and S50 Methanol Engines: Service Experience

Service status:

- 4 vessels from HHI in service
- 3 vessel from MES in service
- Currently more than 38.000 service hours are obtained
- First start up of MeOH operation was carried out by the crew alone
- Extensive follow-up carried out to ensure service experience is collected by MAN

Challenges:

- Broken springs in fuel diesel fuel valves:



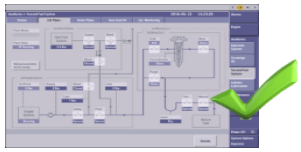
- Broken cut-off shafts I FBIV:

- Micro cracks observed in FBIV atomizers:

- Damage of sealing rings in FBIV suction valves:

- Unstable HC sensors:

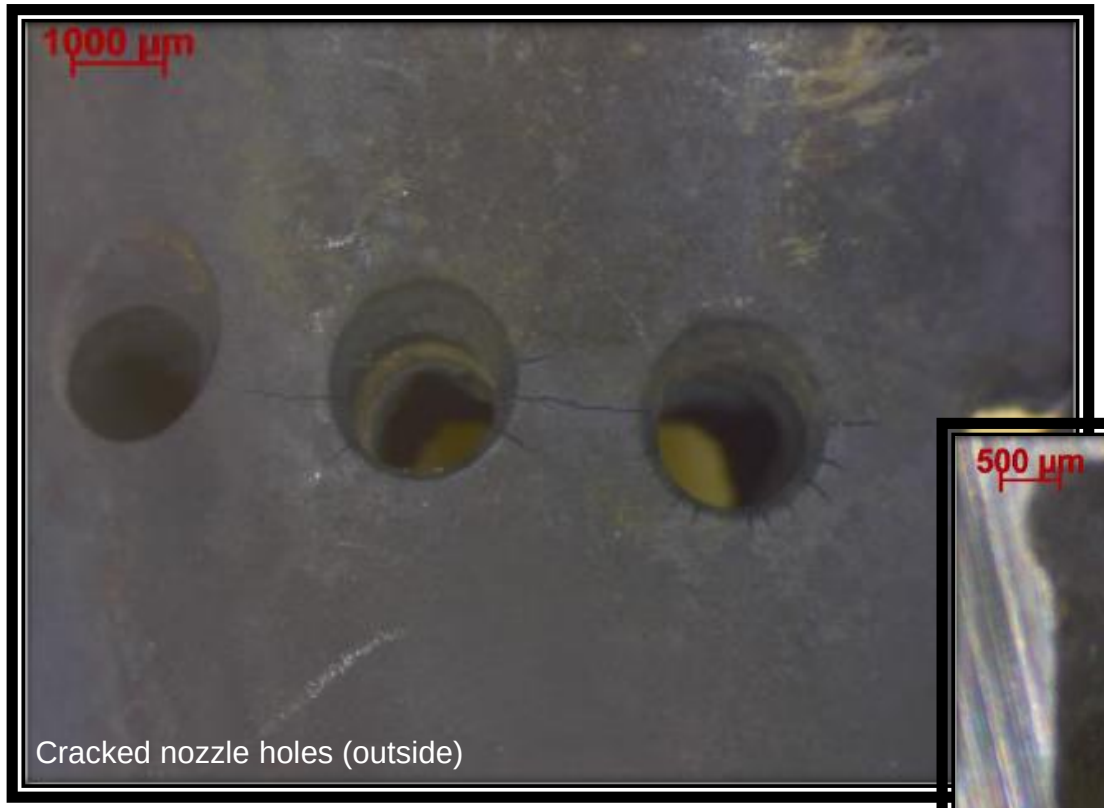
- Several SW bugs have disturbed operation:



- N2 leaking MeOH accumulators resulting in damage of membrane:

ME-LGIM

Corrosion and cracked nozzles in the first tests



Cracked nozzle holes (outside)

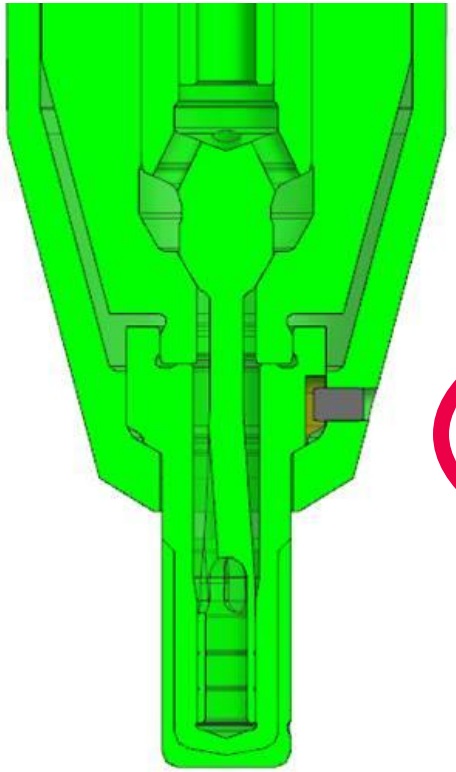
Corroded nozzle holes (inside)

Initally our standard material for fuel nozzles was used.

ME-LGIM

Corrosion and cracked nozzles - remedy

Test stopped and X90CrMoV nozzles mounted and still running



Atomizer test on Lindanger:

Status:

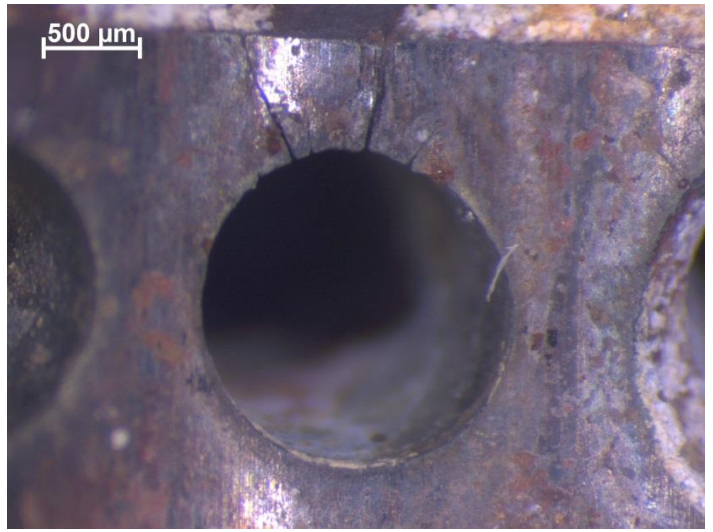
Cyl 1 : 27H (DSA) - 67 RH
Cyl 2 : X90CrMoV no coat - 166 RH
Cyl 5 : 27N (DSA w. coat) - 86 RH
Cyl 6 : X90CrMoV w. coat – Running

X90CrMoV type was removed in Japan and sent to Copenhagen for analysis
Total RH 720

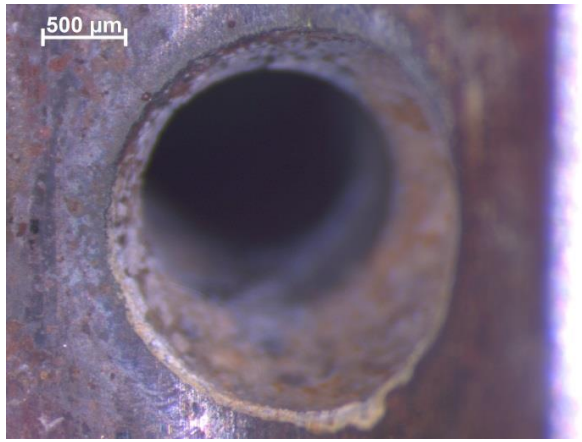
ME-LGIM

Investigation of nozzle X90CrMoV after 720 hrs
Significant improvement and further lessons learned

6Aft: no cracks outside



6Aft: inside cracks on drilled hole



6Aft: No corrosion inside- no cracks

6Fwd: No Corrosion- small cracks

ME-LGIM

Spindle and cut-off shafts

Diamond-Like Carbon coating intact

ME-LGIM - The next generation

- Declining anglex of Methanol inlet/outlet pipes has been omitted.

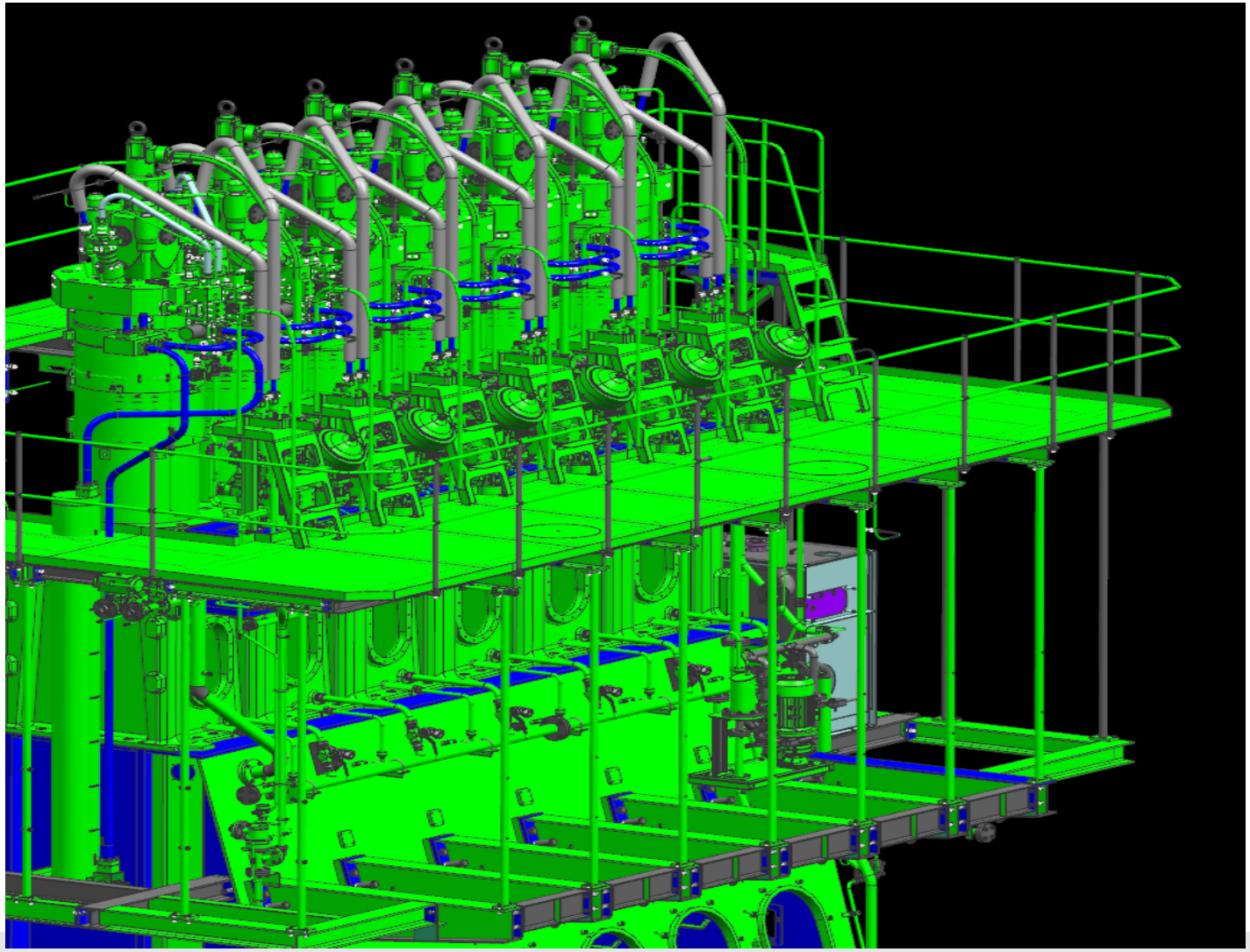
- Methanol connection to engine is one block at cylinder cover no. 1

- Methanol connection to FBIV is done through cylinder cover

- Methanol block is simplified in design and with standard components

- FBIV is simplified in design

- Cooling oil is omitted and sealing system is simplified



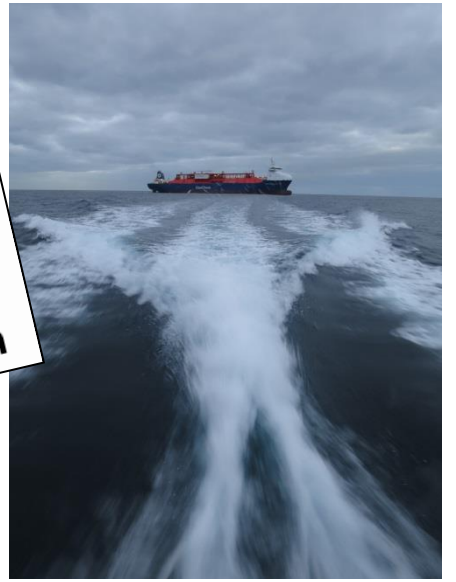
2 Ethane – the MAN ME-GIE engine

MAN B&W Dual fuel Ethane engine

- G50 Series, Hartmann projects. Two in service pr. July 2017
- G60 Series, Hartmann II. Shop Test at HHI completed in July / August 2017
- S50 Retrofit project, tests completed at KHI, Japan in July / August 2017

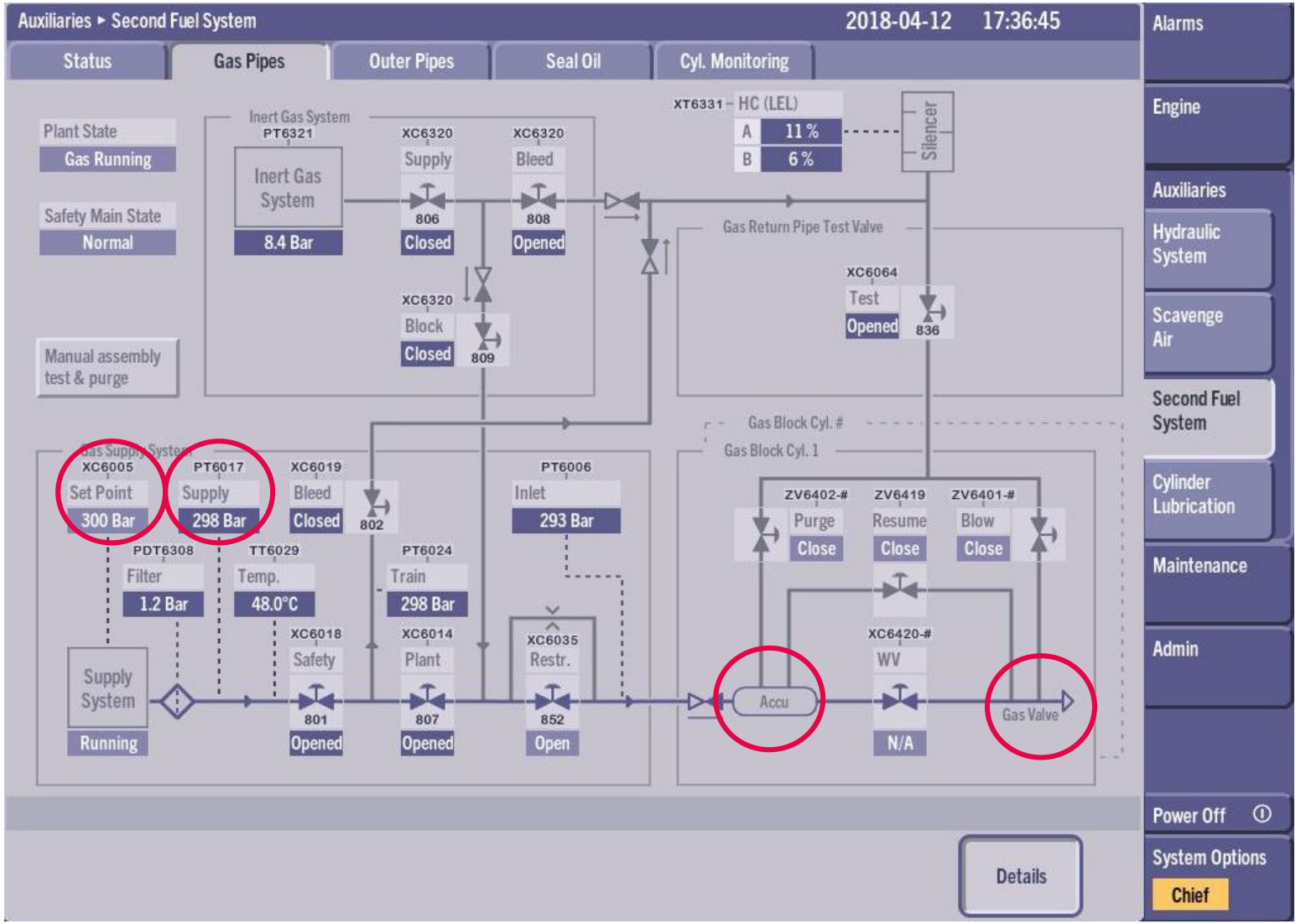
C_2H_6

Two-Stroke Propulsion



MAN B&W Dual fuel Ethane engine

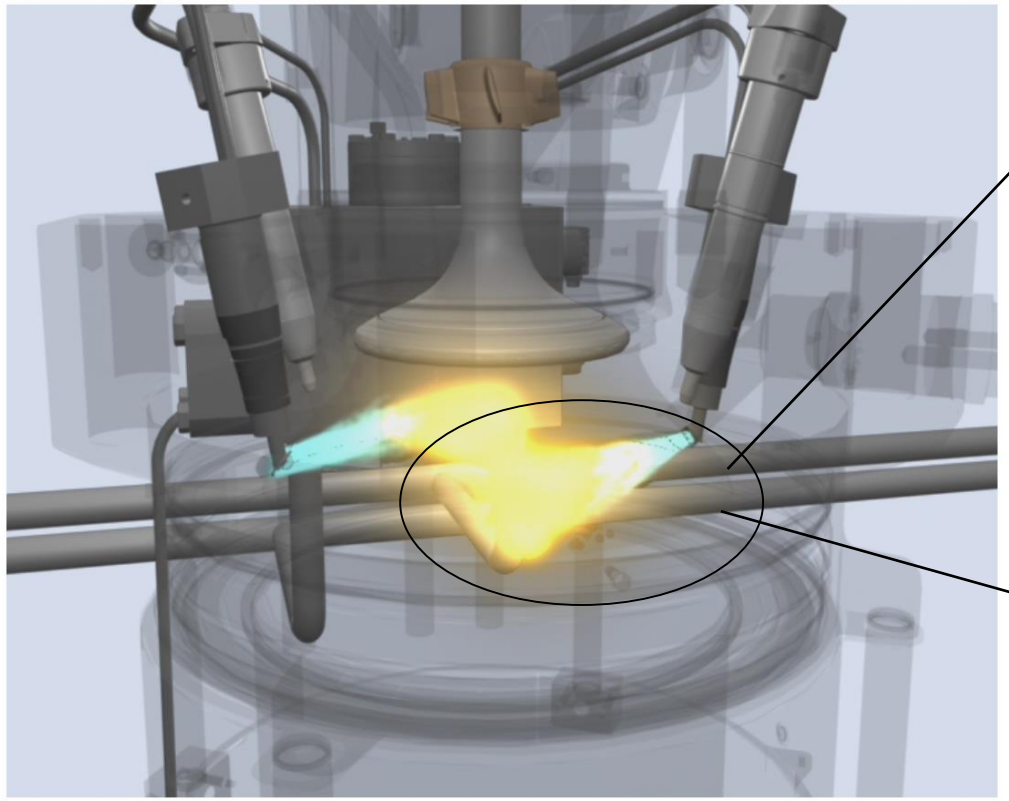
Fuel gas supply system and 300 bar concept



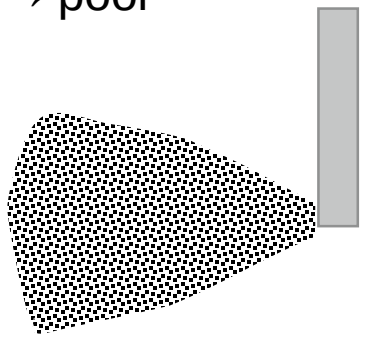
ME-GI for Ethane Design → ME-GIE

400 bar working pressure – ideal injection pressure 600 bar

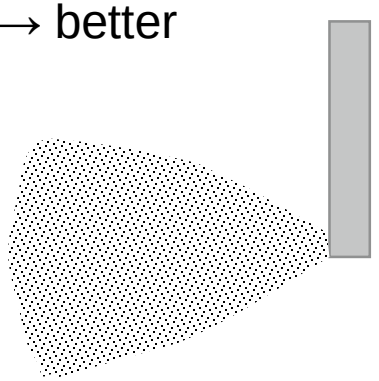
- Proper mix of gas and air, reference HFO injection.



- Ethane 300 bar → poor
  - Atomisation
  - Burning
  - Economy
- More soot



- Ethane 400 bar → better
  - Atomisation
  - Burning
  - Economy
- Less soot

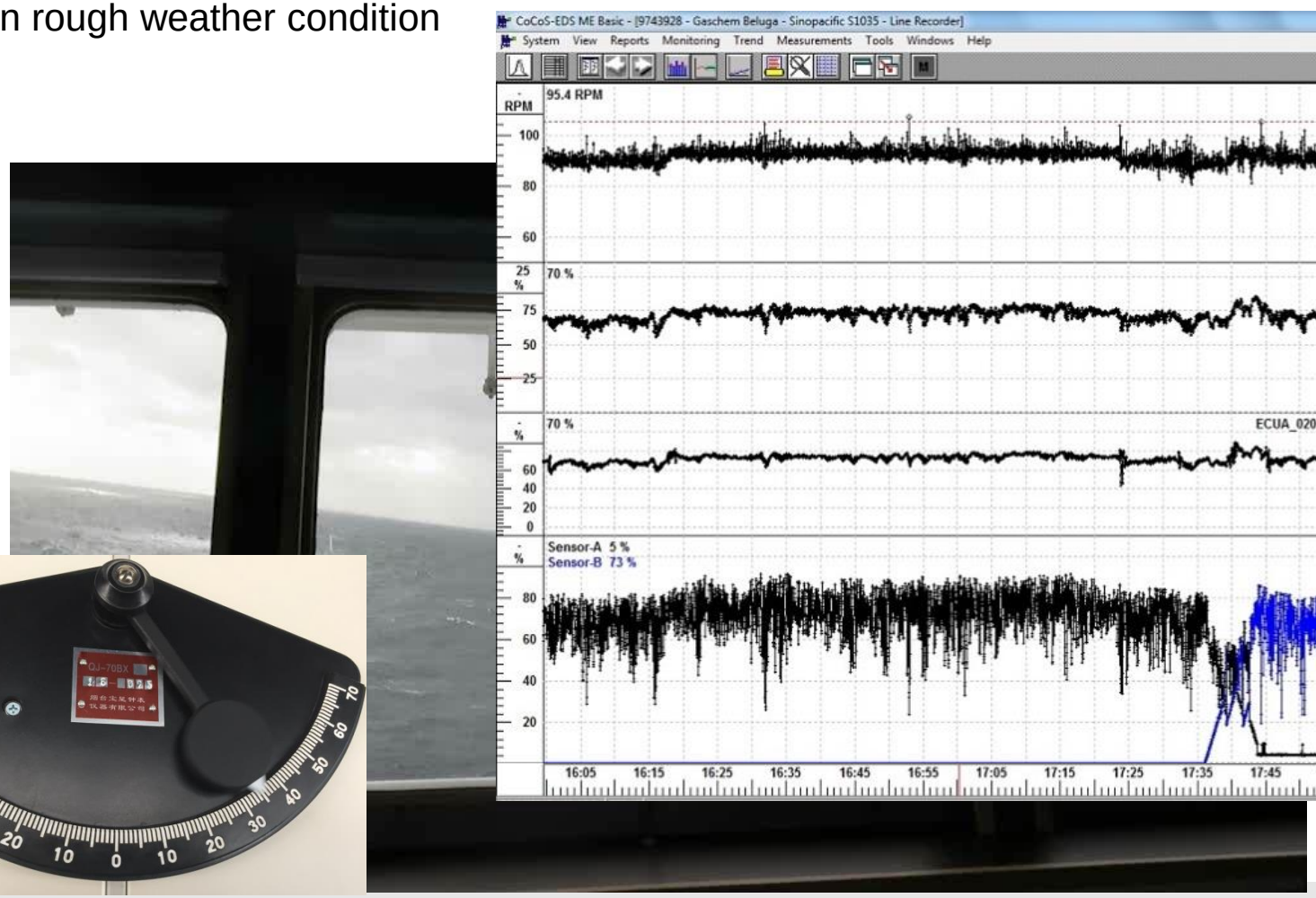


Higher Pressure → Higher Injection Velocity → Better Atomisation → Better Burning

MAN B&W Dual fuel Ethane engine

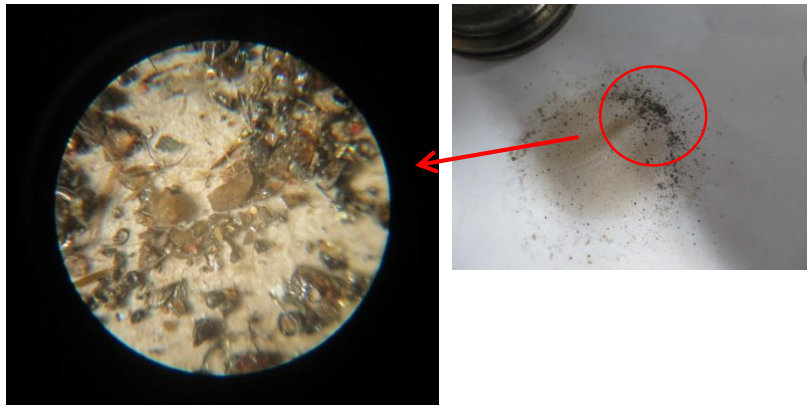
Change-over from diesel to Ethane

- GasChem Beluga and Orca experience rough weather in the Atlantic the past winter
- Perfect change over in rough weather condition

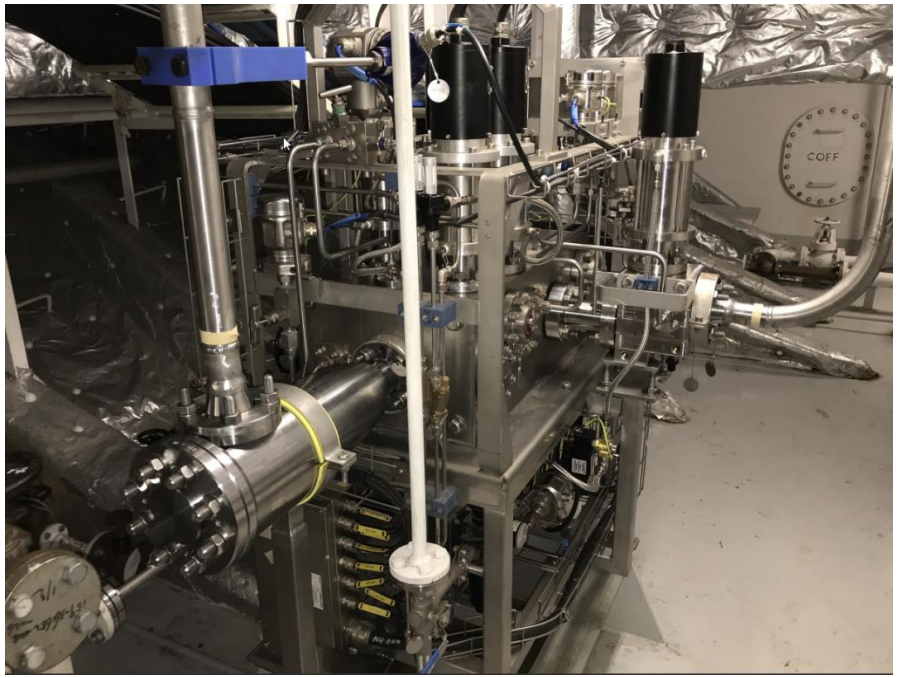


MAN B&W Dual fuel Ethane engine

Initial issues with availability traced to supply system

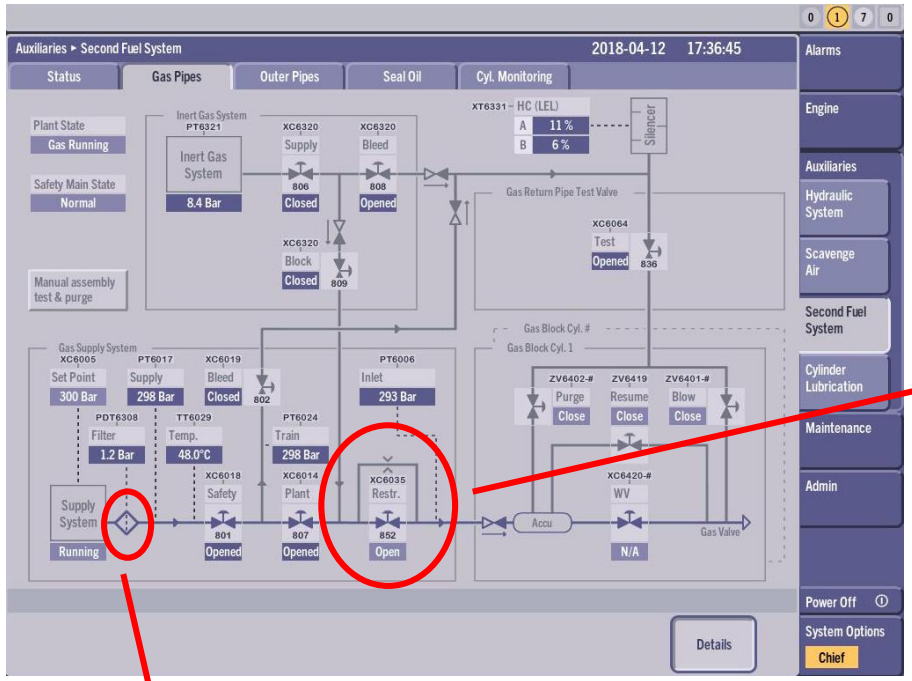


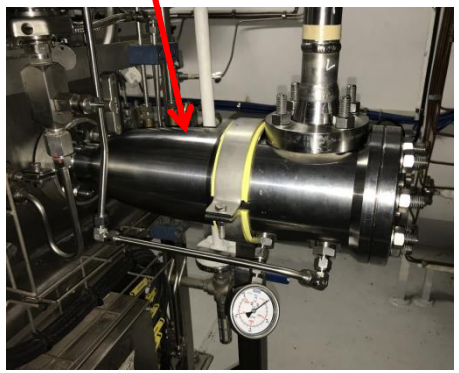
Updated GVT



MAN B&W Dual fuel Ethane engine

Initial issues solved with supply system



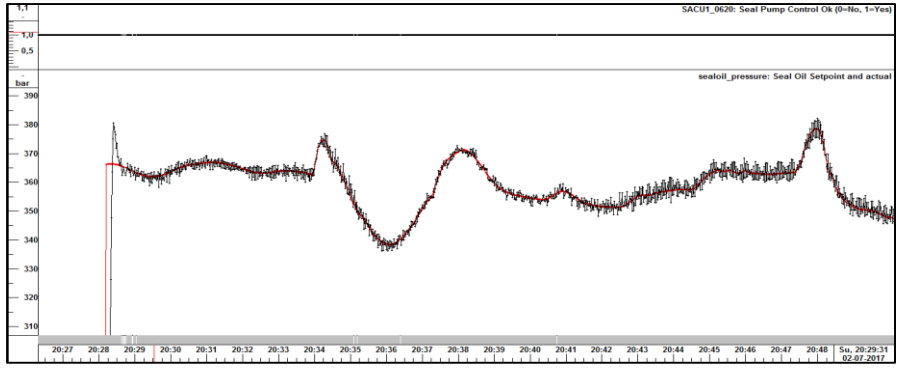


Increased stability, less dirt from gas and gas fuel tanks

MAN B&W Dual fuel Ethane engine

Initial issues on engine

- Seal Oil system
- PMI Sensors
- Window Valve seals



Betech seal	Trelleborg seal
	

MAN B&W Dual fuel Ethane engine

Conclusions

- ME-GI(E) common rail concept has proven that the diesel cycle provides very stable engine performance even under hard conditions
- Fuel gas system and fuel gas cleanliness is important, and it is important to keep these conditions in mind during the design phase
- Few issues identified on the engine in the first months of service, all relatively cured in cooperation with the crews and design departments

Disclaimer

All data provided in this document is non-binding.
This data serves informational purposes only and is especially not guaranteed in any way.
Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.

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Thank you very much!

Peter H. Kirkeby
Technical promotion and customer support
MAN Energy Solutions Copenhagen