

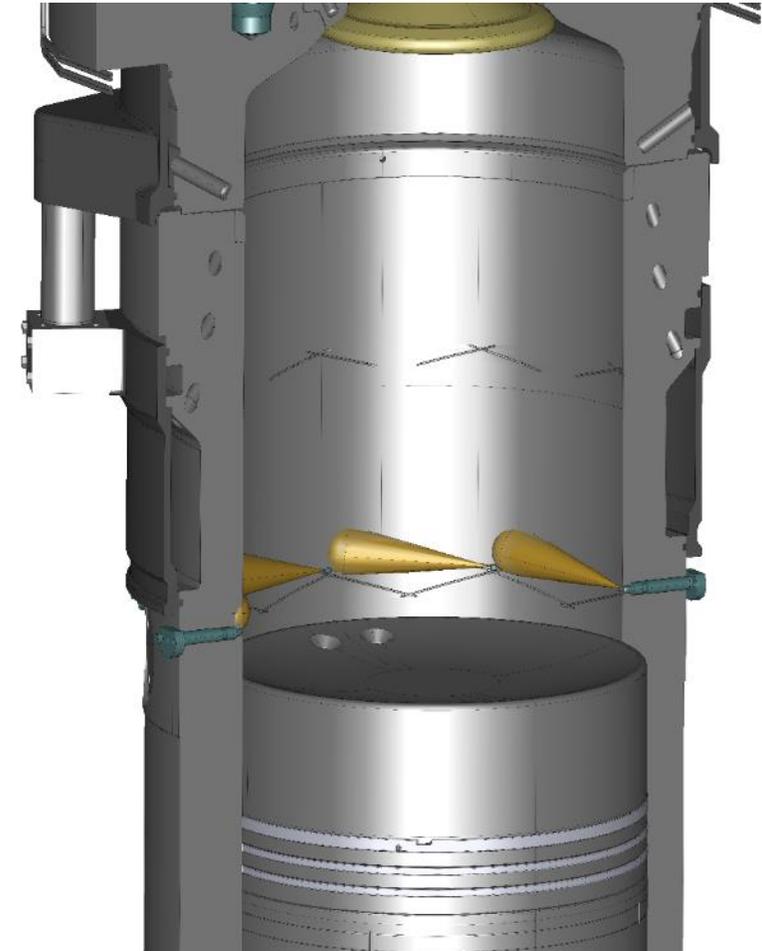
# X- and X-DF cylinder lubrication system

R.Wettstein, GM Marketing & Application, October 16, 2018

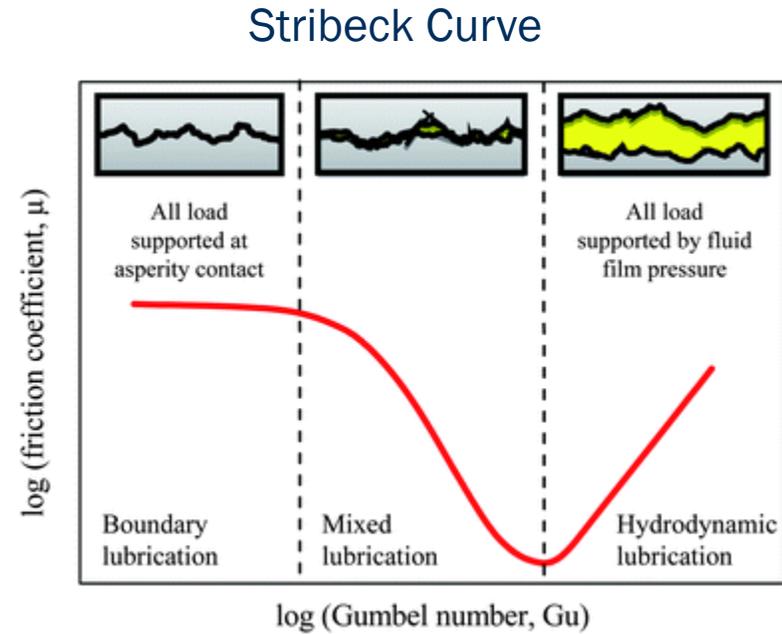
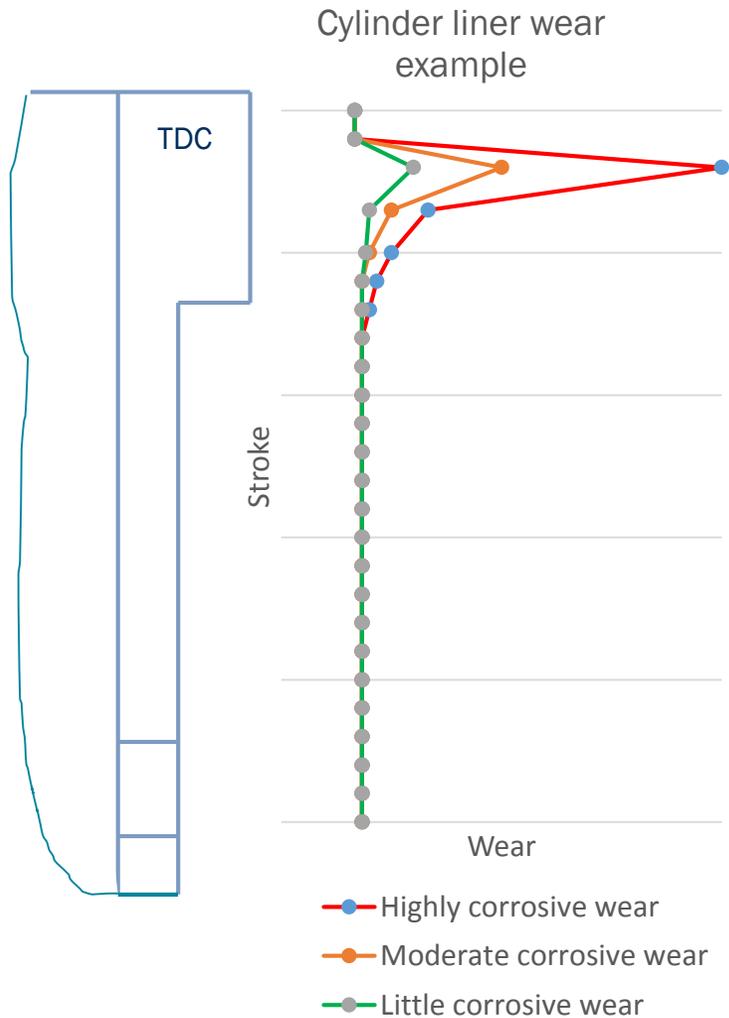
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# Impacts on combustion chamber components

- 1) Fuel properties, sulphuric acid, abrasive residues  
→ cold corrosion, wear
- 2) Component design, material selection  
→ speed of wear, other damages)
- 3) Combustion pressure / gradient  
→ impact on acid dew point, heat impact, cold corrosion, lubricant degradation, wear
- 4) Wear status of combustion chamber components  
→ deposits, blow by, wear)
- 5) Other impacts, ambient, operation related etc.



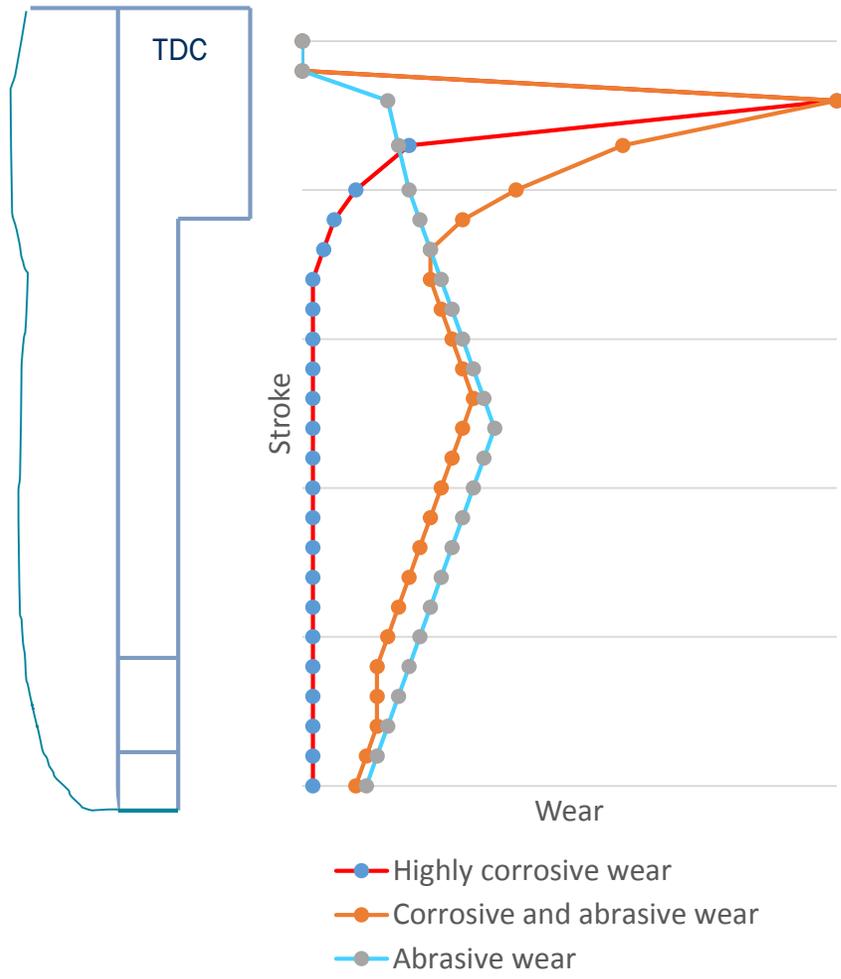
# Corrosion-induced component wear



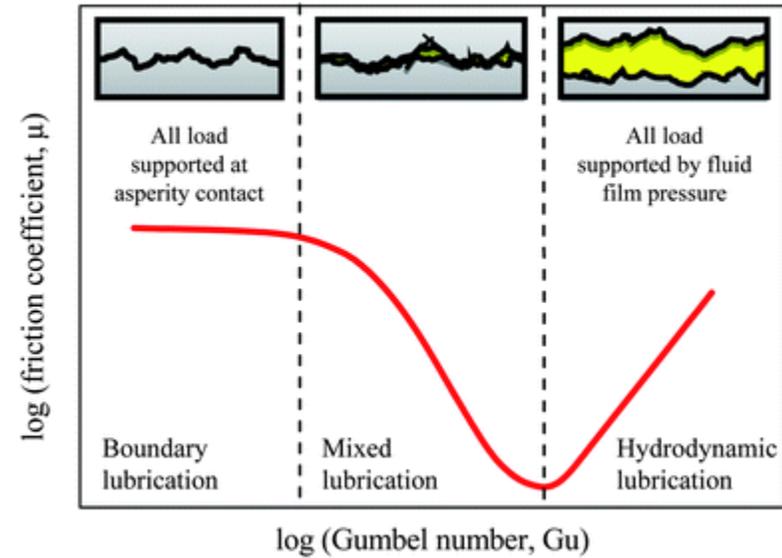
Source RSC publishing

# Corrosion- & Abrasion-induced comp. wear

Cylinder liner wear example



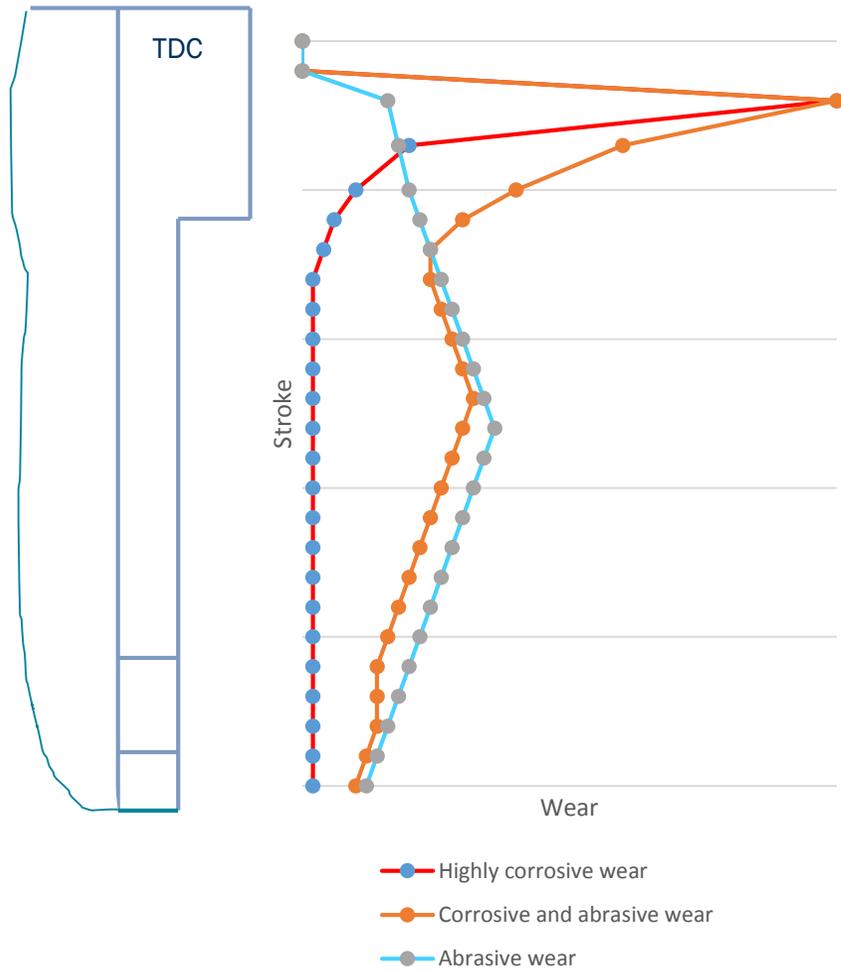
Stribeck Curve



Source RSC publishing

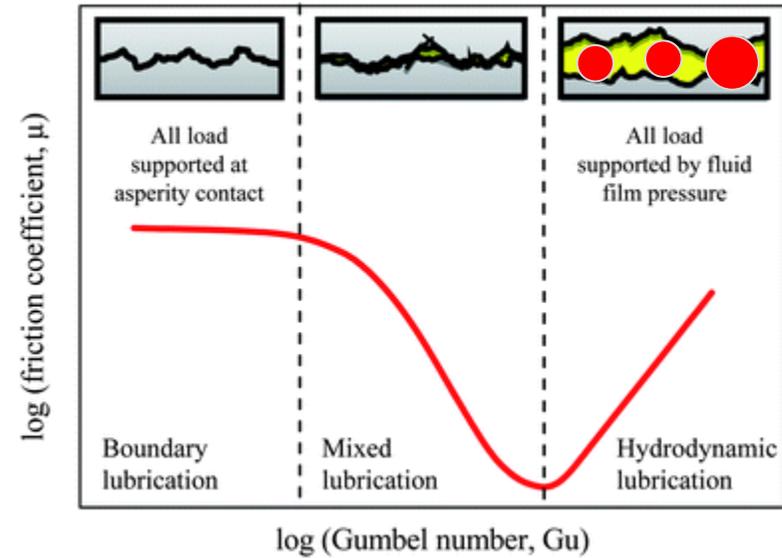
# Corrosion- & Abrasion-induced comp. wear

Cylinder liner wear example



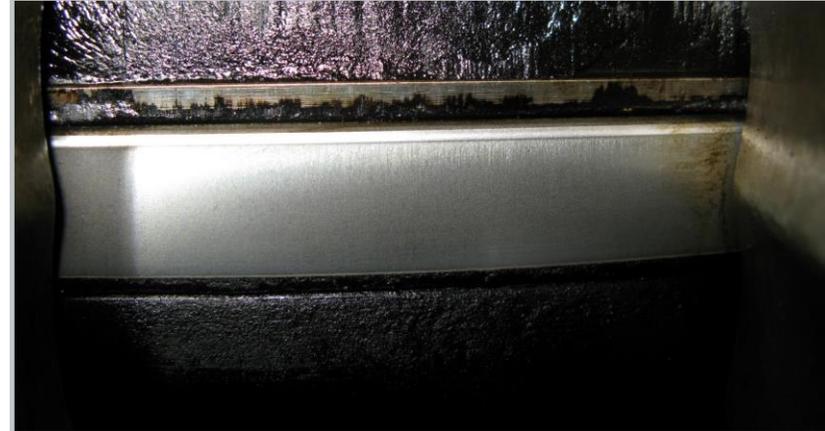
Worst case: Catfines etc.

Stribeck Curve



Source RSC publishing

# Impacts on combustion chamber components

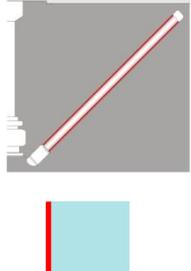


# Piston / Cylinder Liner design

Lifetimes X82 components	
Cyl.liner	>90,000 h
Exhaust valve	108,000 h
FAST nozzle tip	18,000 h
Piston rings	36,000 h
Bearings	90,000 h

Optimized liner wall temperatures

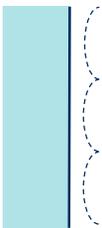
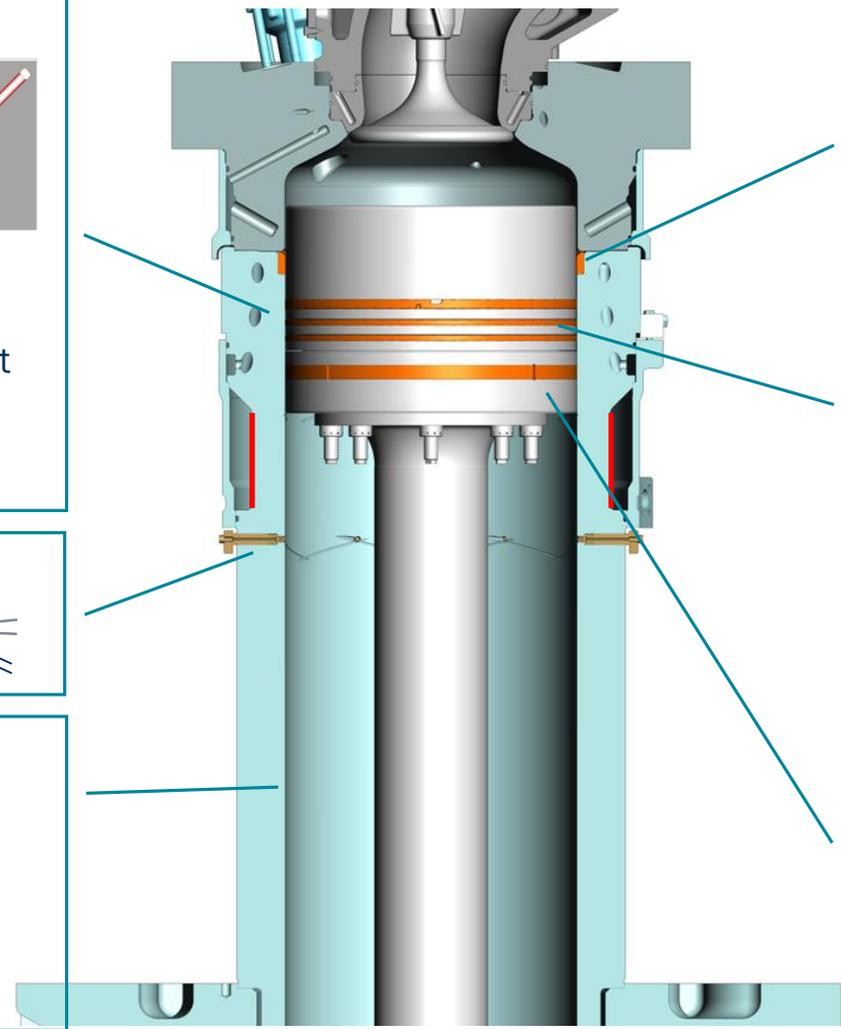
- Cooling bore insulation
- Mid-stroke insulation
- Shorter water guide jacket
- Adapted water cooling



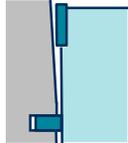
Pulse Lubricating System



Liner plateau honed

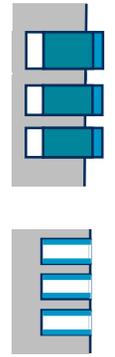
Anti-polishing ring



3 piston rings (2 rings on X52)

- Top ring gas-tight
- Cr-ceramic coated
- Pre-profiled

Piston ring grooves with thick chromium layer

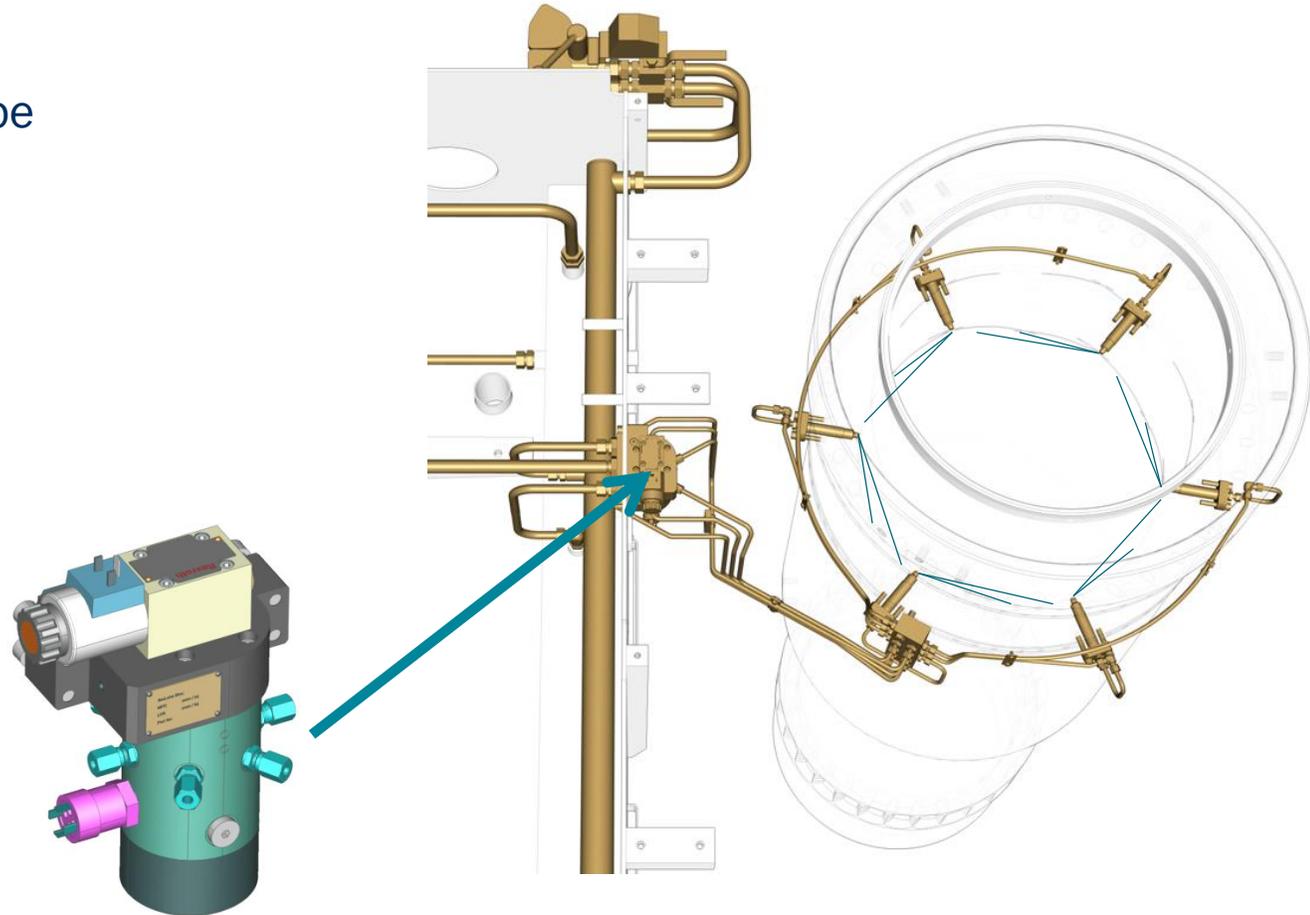


Piston skirt with bandage



# Pulse Jet Cylinder lubricating oil system

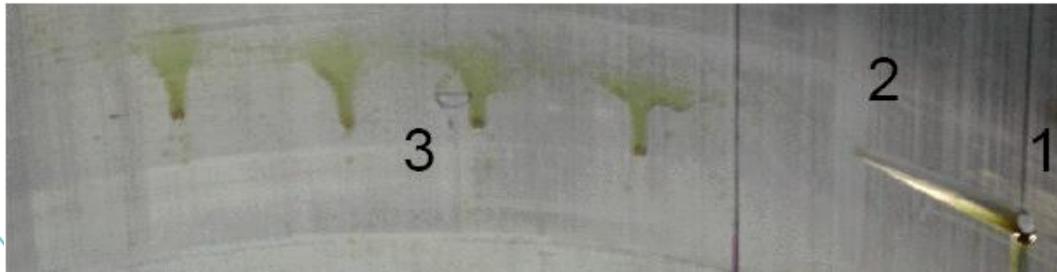
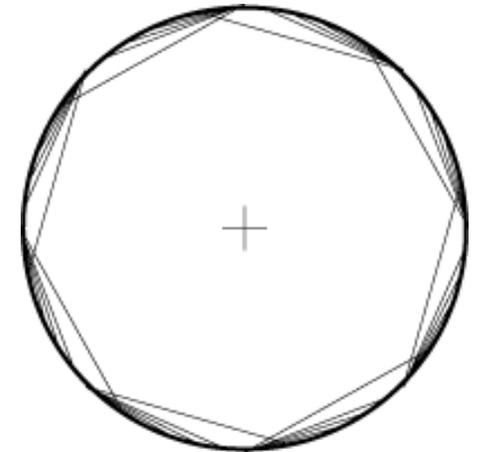
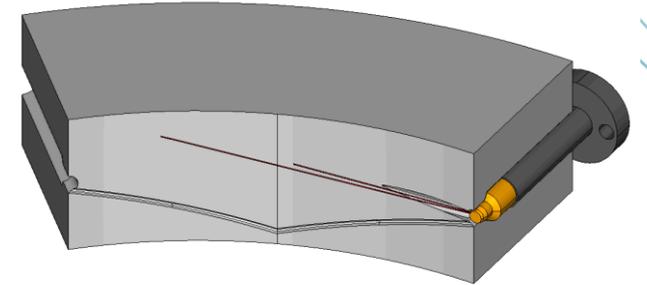
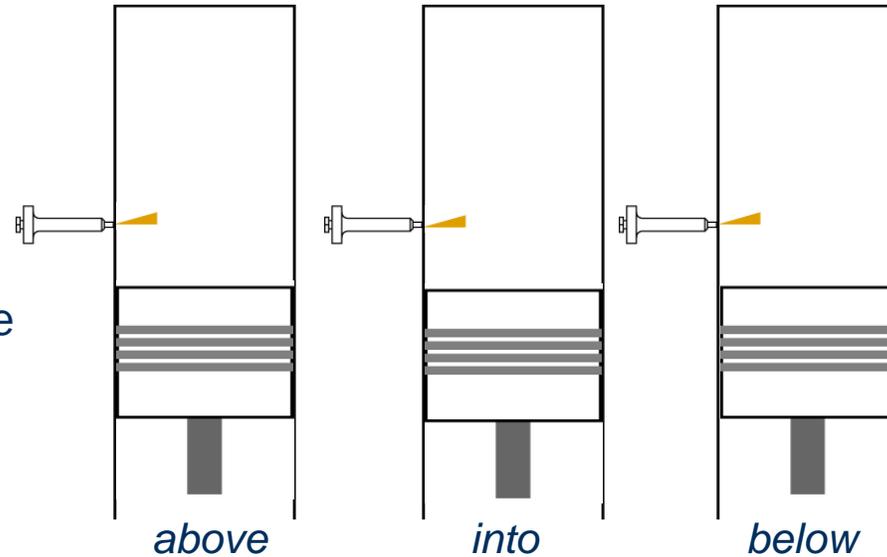
- The Pulse Jet Lubricating system will be applied on the new engines
- Servo oil driven lube oil pumps
- Electronic controlled, load dependent
- Sulphur dependent



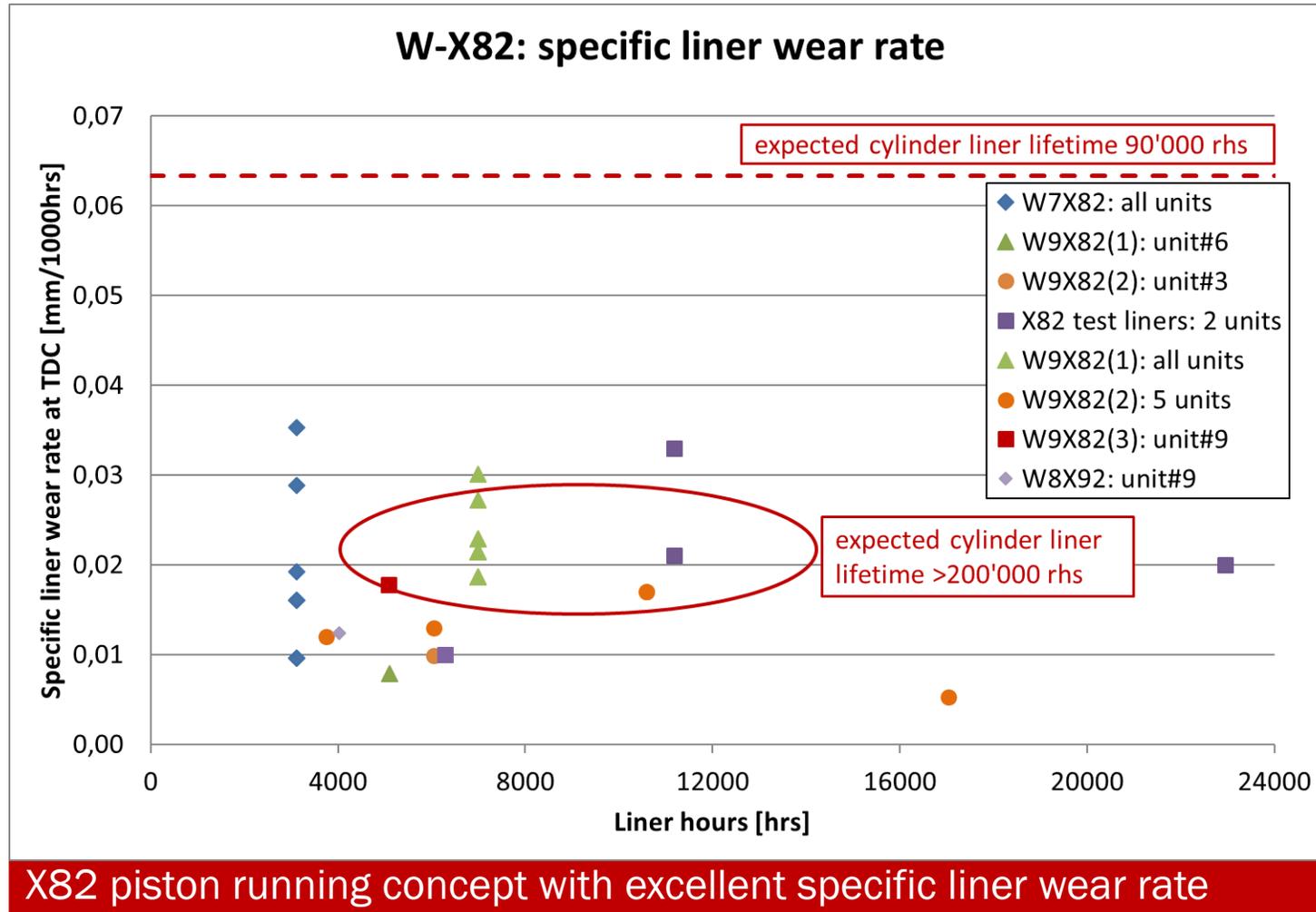
# Pulse Jet Cylinder lubricating oil system

## Maximum fuel flexibility

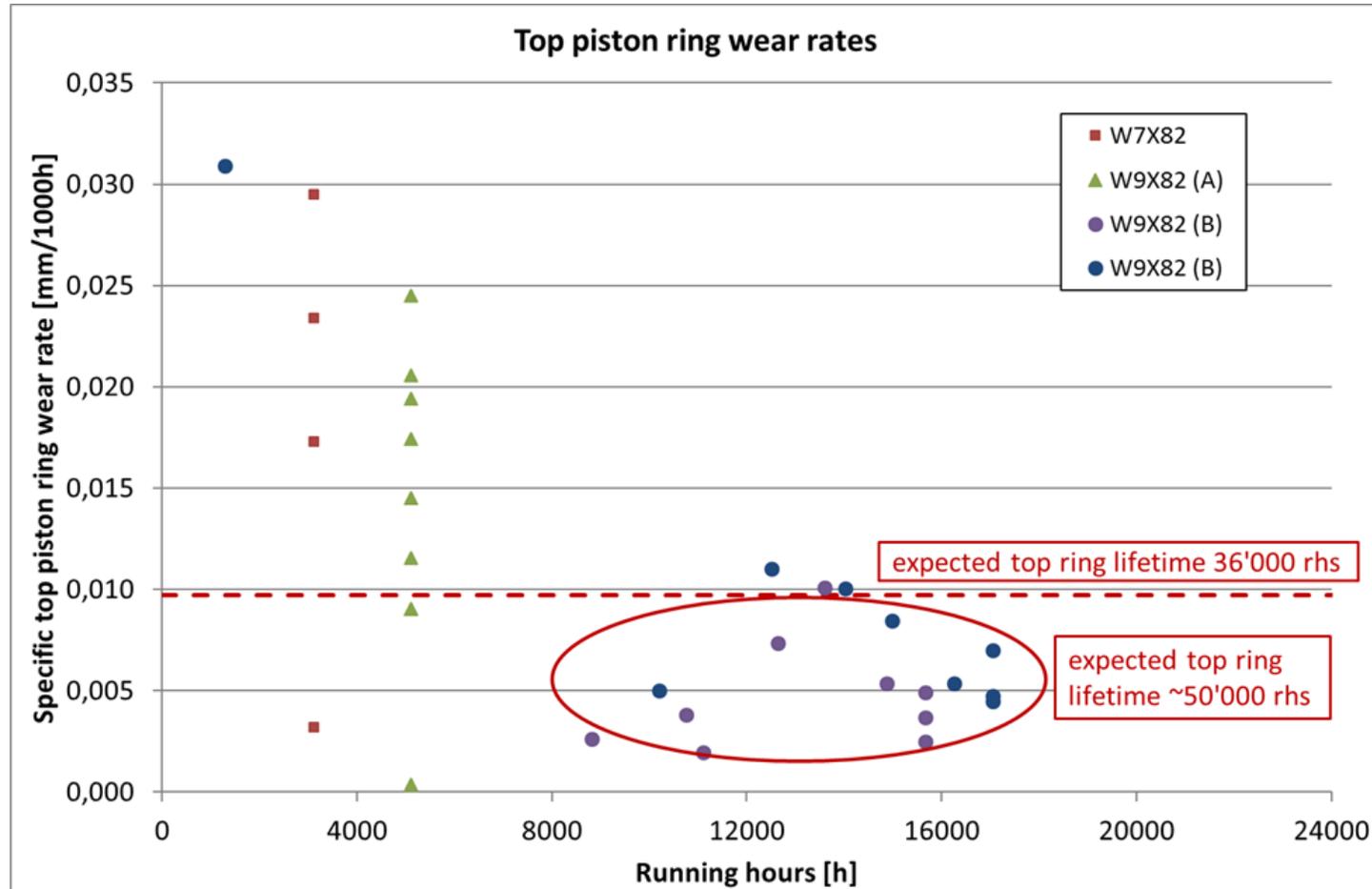
- Lube oil distribution into, above and below piston ring packet
- Cylinder liner with oil grooves
- Software: New injection algorithm, significant for slow steaming
- 4 - 10 quills depending on bores size



# X82 service experience



# X82 service experience



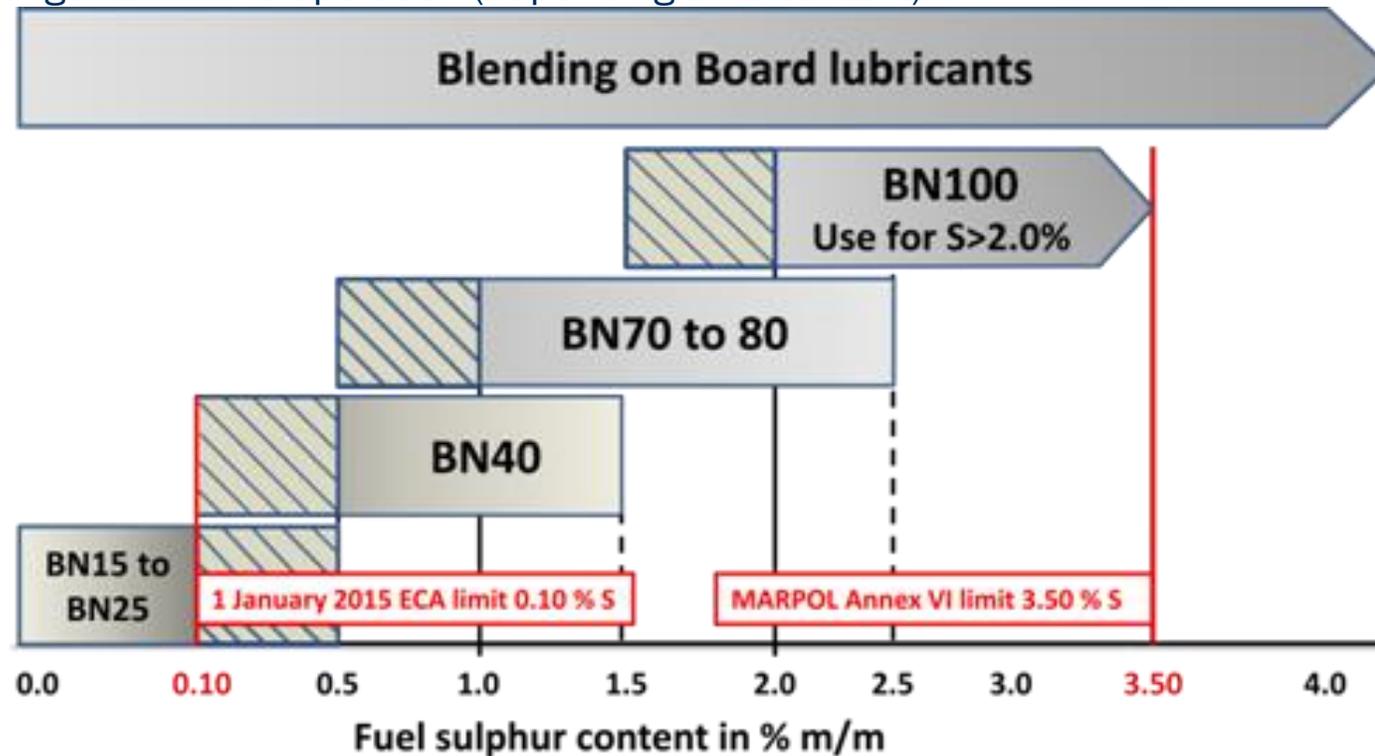
X82 piston running concept with excellent specific piston ring wear rate

# Cylinder lubrication

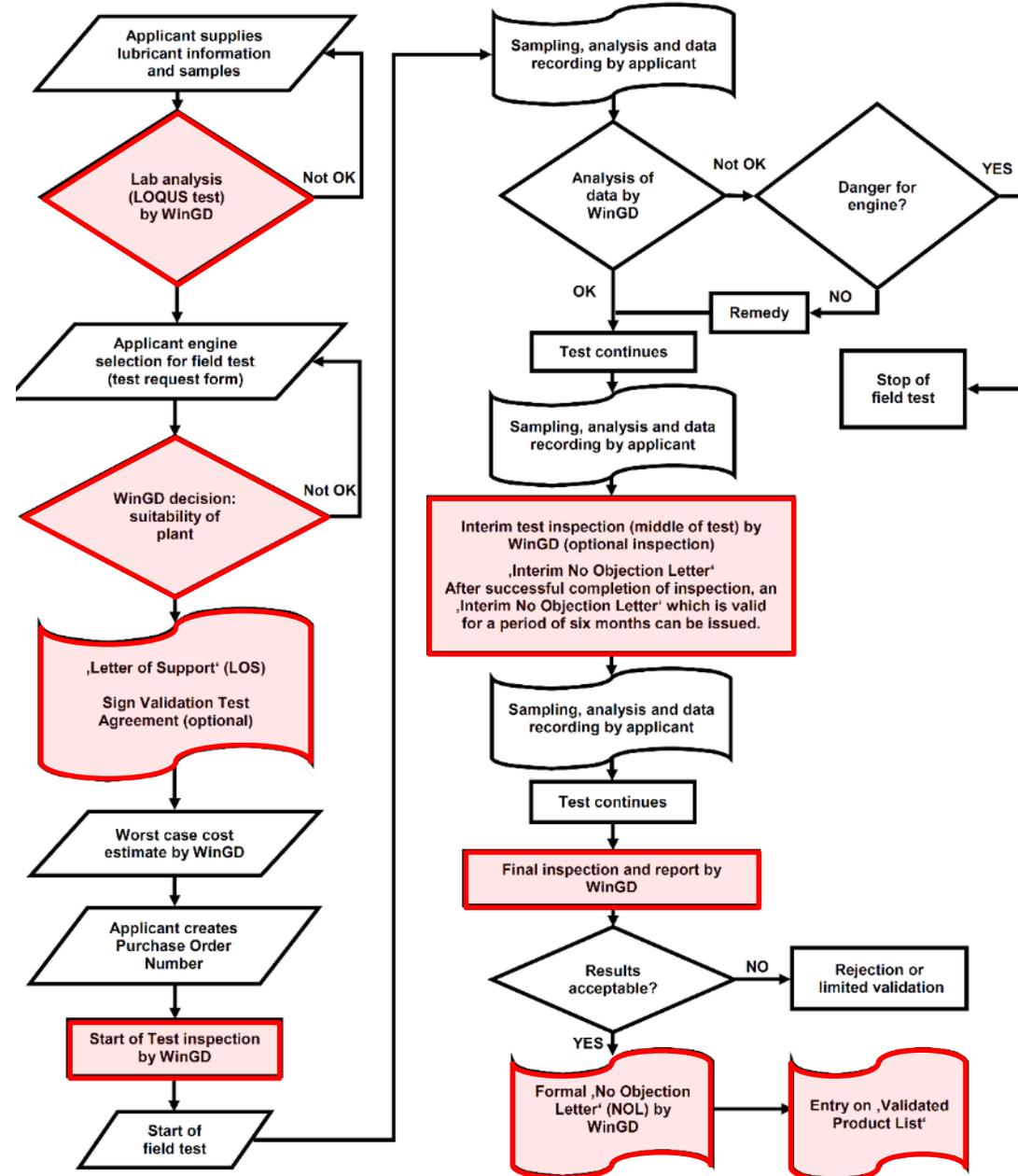
## Maximum fuel flexibility

Two lubricating oil types recommended:

- BN 15-25 for gas/MGO/MDO
- Higher BN oil for longer term HFO operation (depending on S-content)



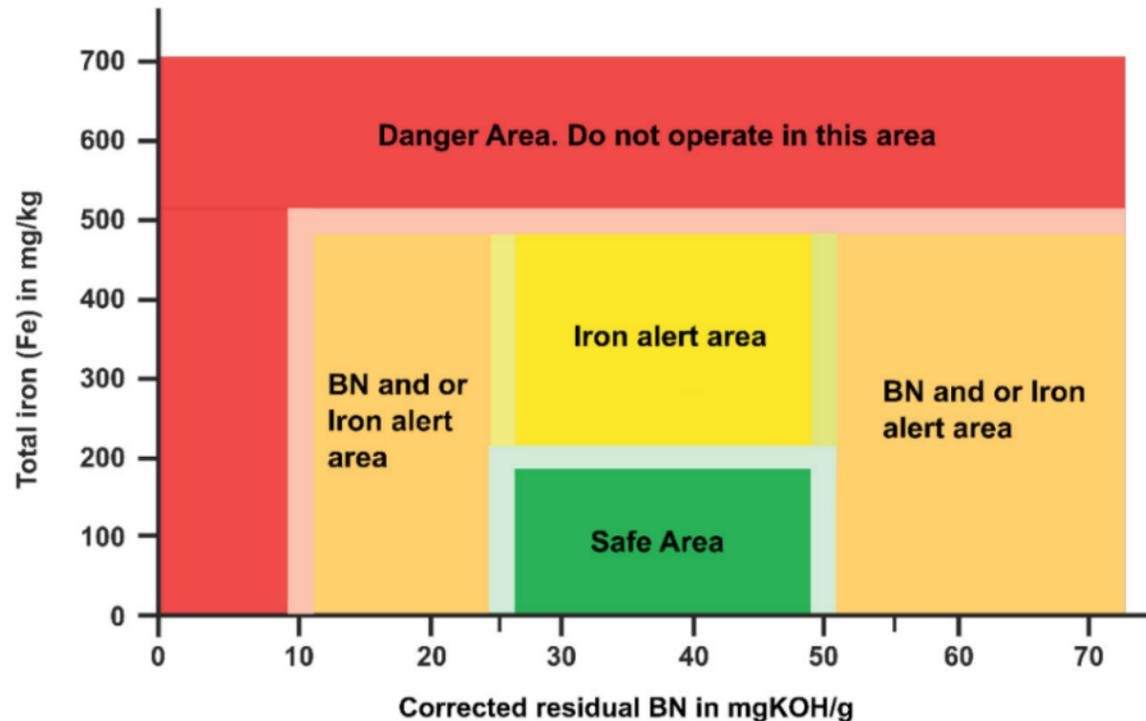
# Lubricant Validation Process



# Cylinder lubrication recommendations

## Feed rate / oil type selection process, Service Bulletin, RT 161.v2

*Fuel sulphur in the range  $0.5 < \text{Sulphur \%} < 3.5 \text{ m/m}$  and cylinder oil with  $40 < \text{BN} < 100$*



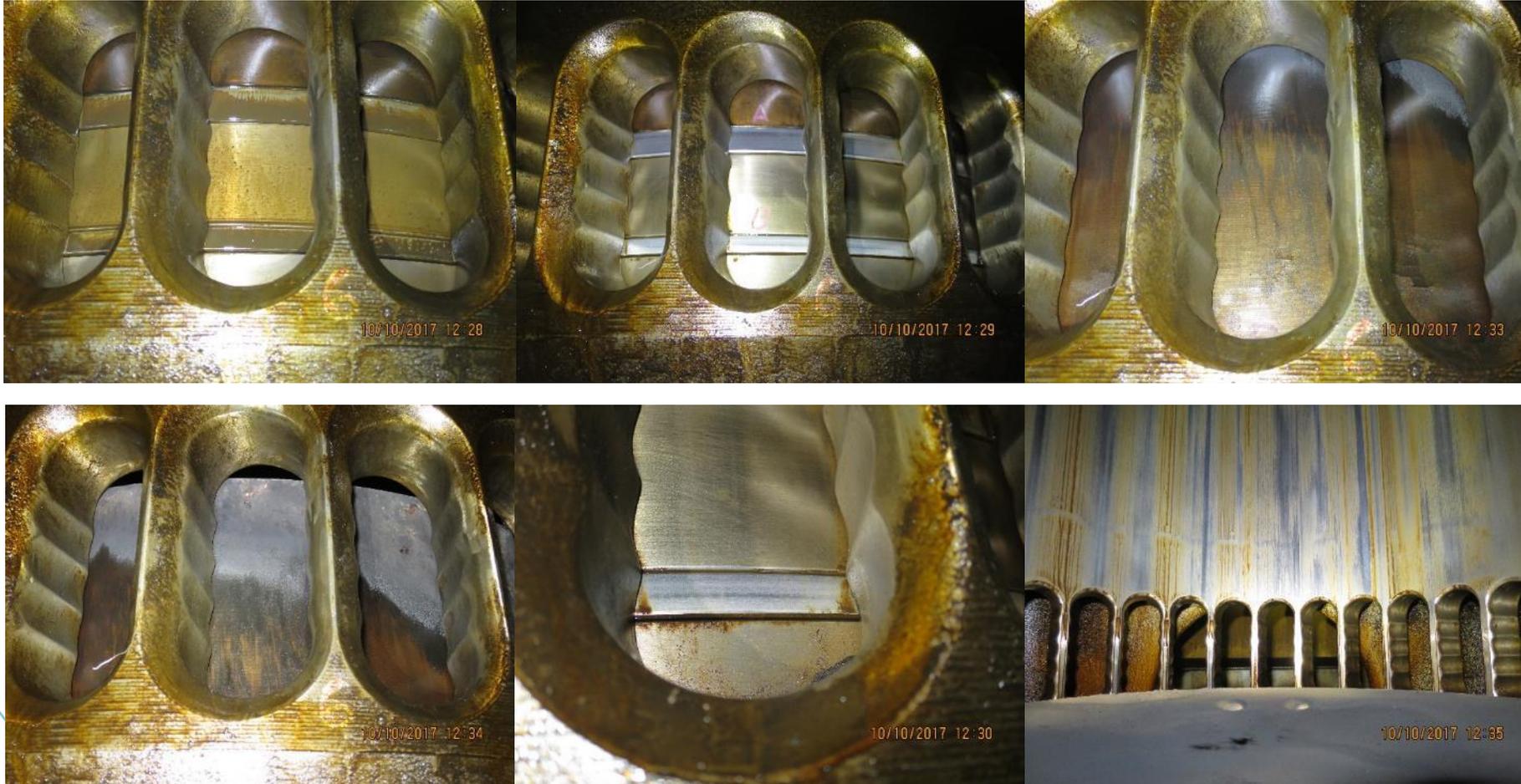
**Figure 5: Piston Underside (PUS) drain oil residual BN and iron (Fe)**

**NOTE:**

There are smooth transitions between the various areas as shown in Figure 5.

# Latest specification piston ring pack

X72, Two-ring Validation Piston, 6200h + (one of several tests)



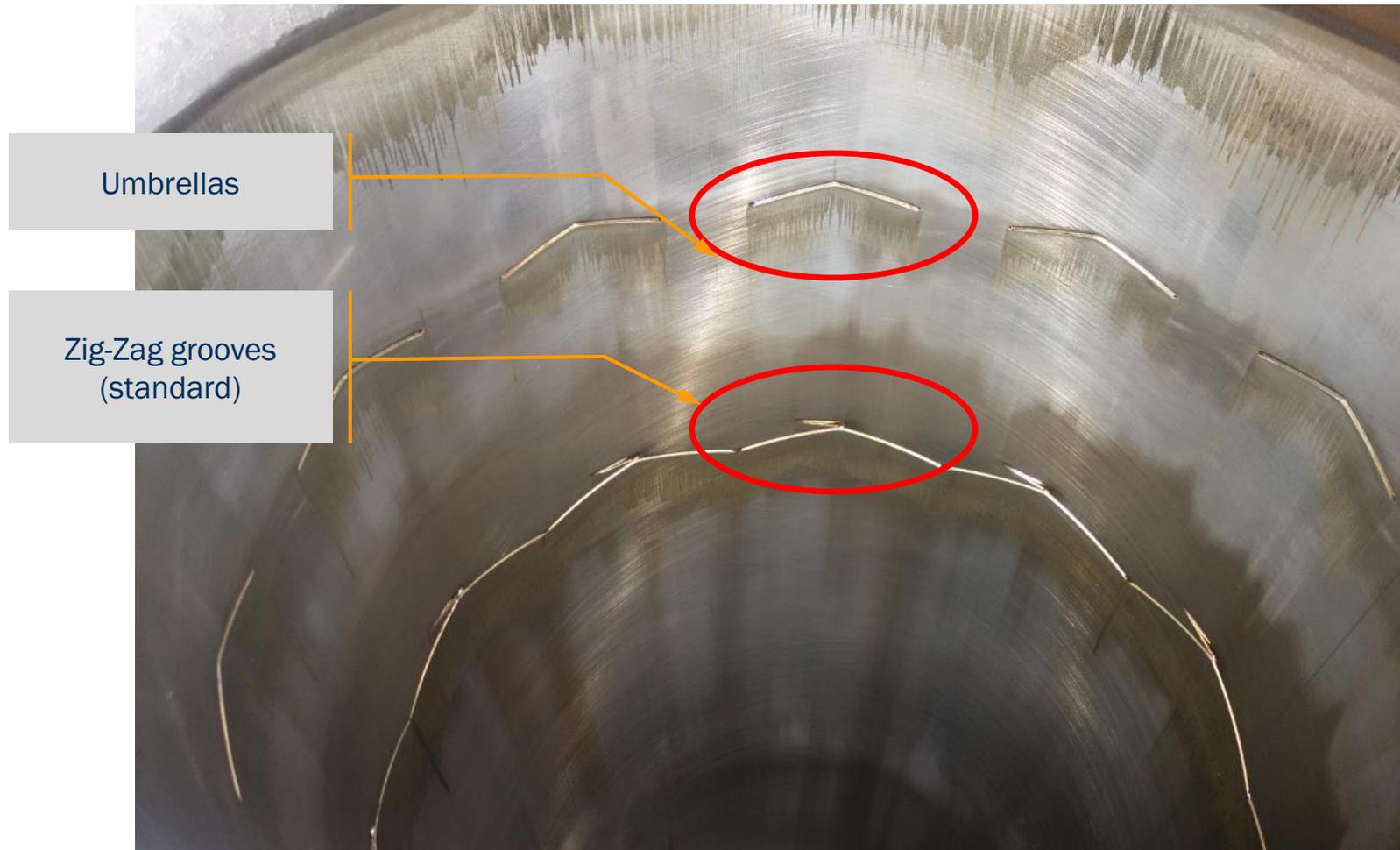
- MV KS
- 6X72
- 21585hr
- 10.10.17
- BN100
- 3.1%S
- 0.9g/kWh

# Latest specification piston ring pack

6X52 HP SCR, after shop test

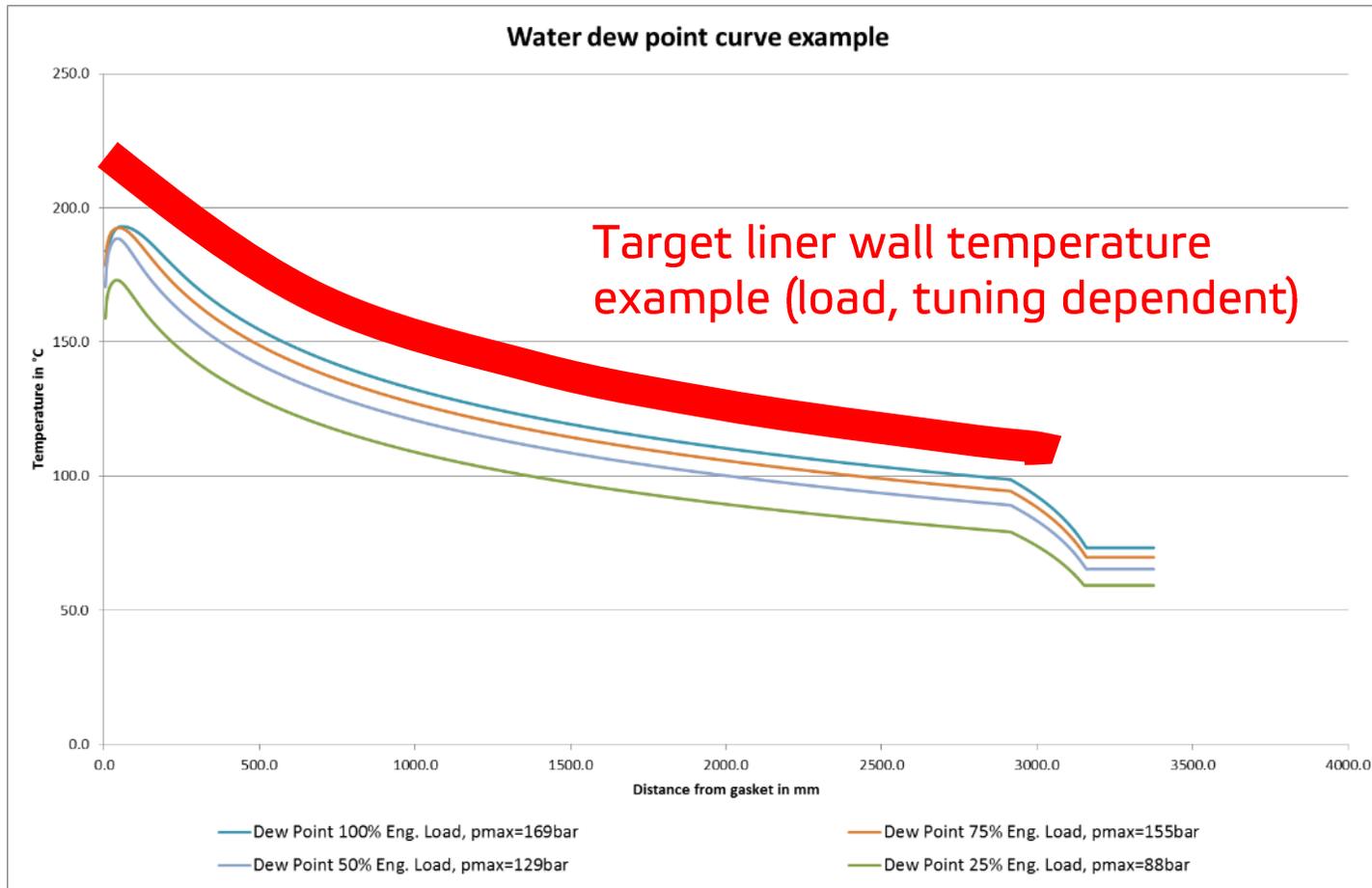


# Multi level lube oil groove design



- X92
- Cylinder liner 4000 hrs
- BN100, low wear rates <math><0.01\text{mm}/1000\text{h}</math> max. diametral

# Cylinder liner wall temperature



Liner wall temperatures need to be higher than dew point of water to avoid condensation, i.e. sulphuric acid formation on liner wall



**Thank you**

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