

The logo for Winterthur Gas & Diesel, featuring the letters 'WIN' in a bold, sans-serif font, followed by 'GD' in a stylized, outlined font where the 'D' has a small hook at the bottom.

Winterthur Gas & Diesel

W-X92

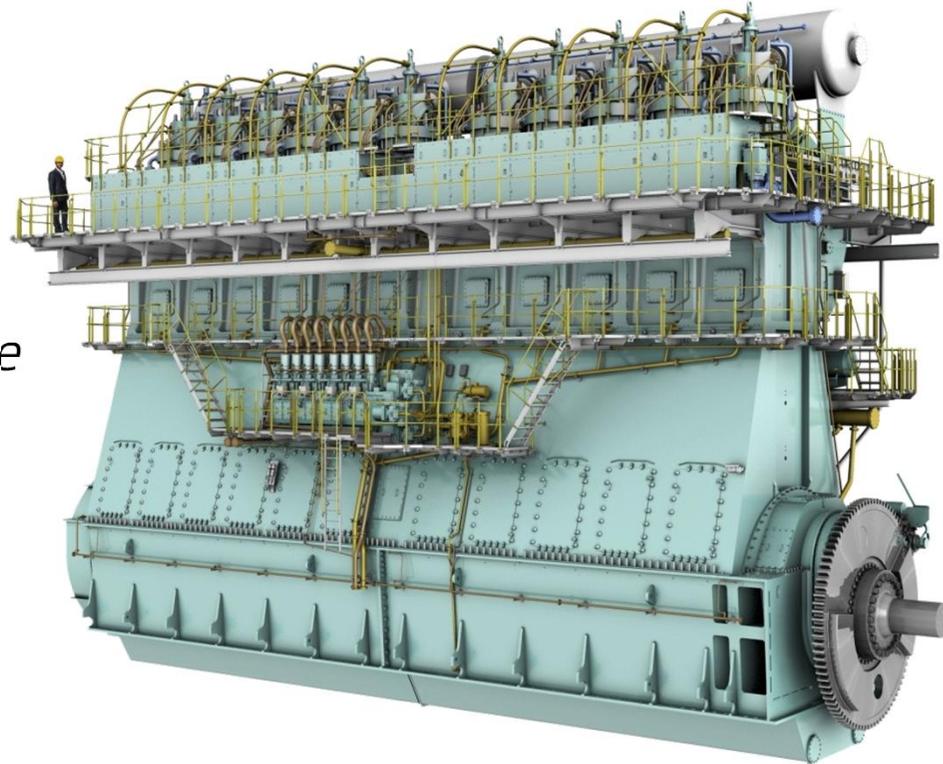
The most efficient Engine for large Container Vessels

W-X92, June 2016 / H. Brunner, J.-N. Constantin, L. Knipstrom

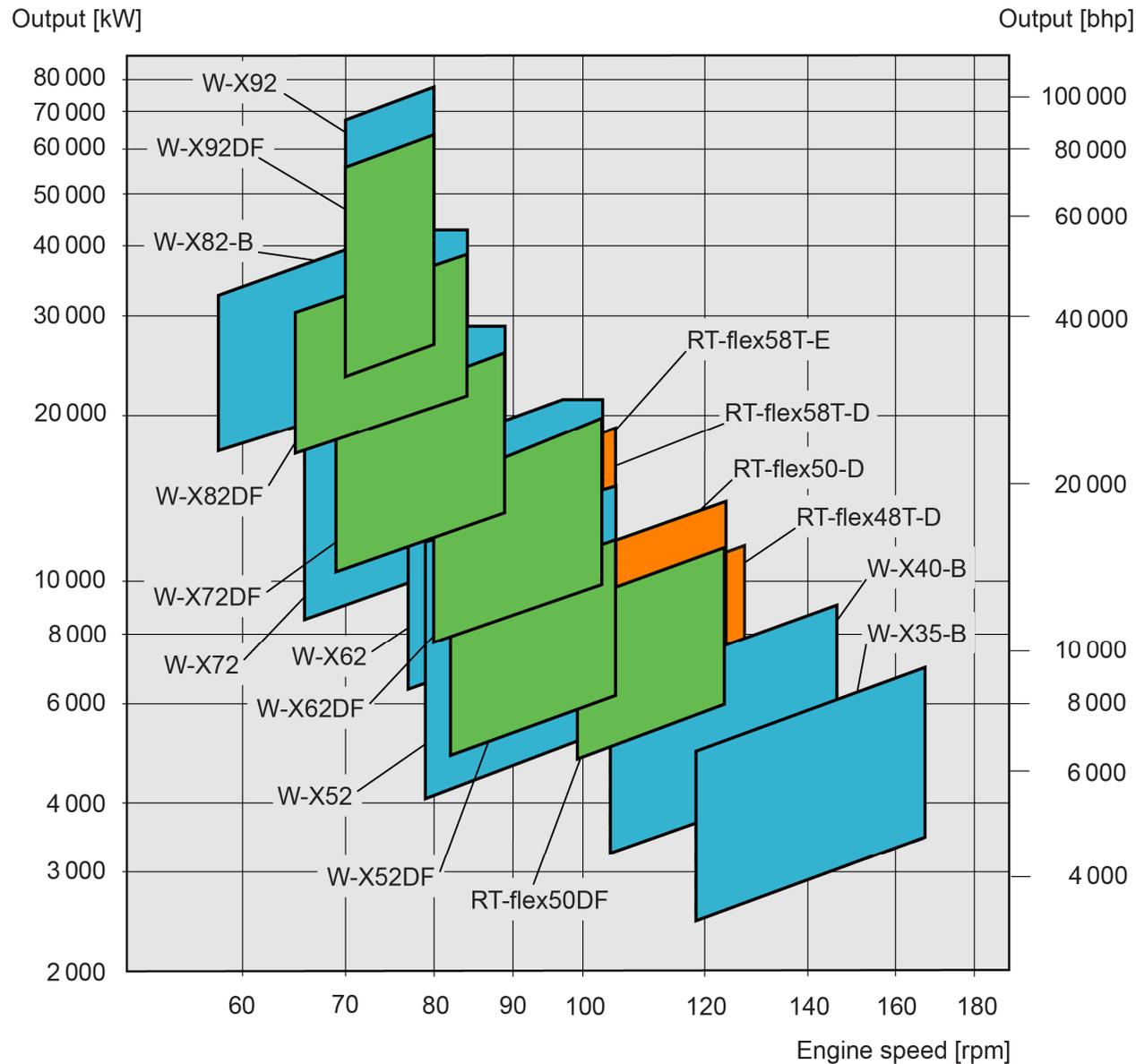
W-X92 - Contents

Contents

- *Engine Rating Field and Main Parameters*
- *Engine Design Features*
- *Engines on Order and in Service*
- *Service Experience with X92*
- *Conclusion*



W-X92 – Engine parameters



W-X92 Marketing Kit, June 2016 / H. Brunner, J.-N. Constantin, L. Knipstrom

For every application a Wärtsilä X Engine

Wärtsilä X35/40



Wärtsilä X52



Wärtsilä X62



Wärtsilä X72



Wärtsilä X82

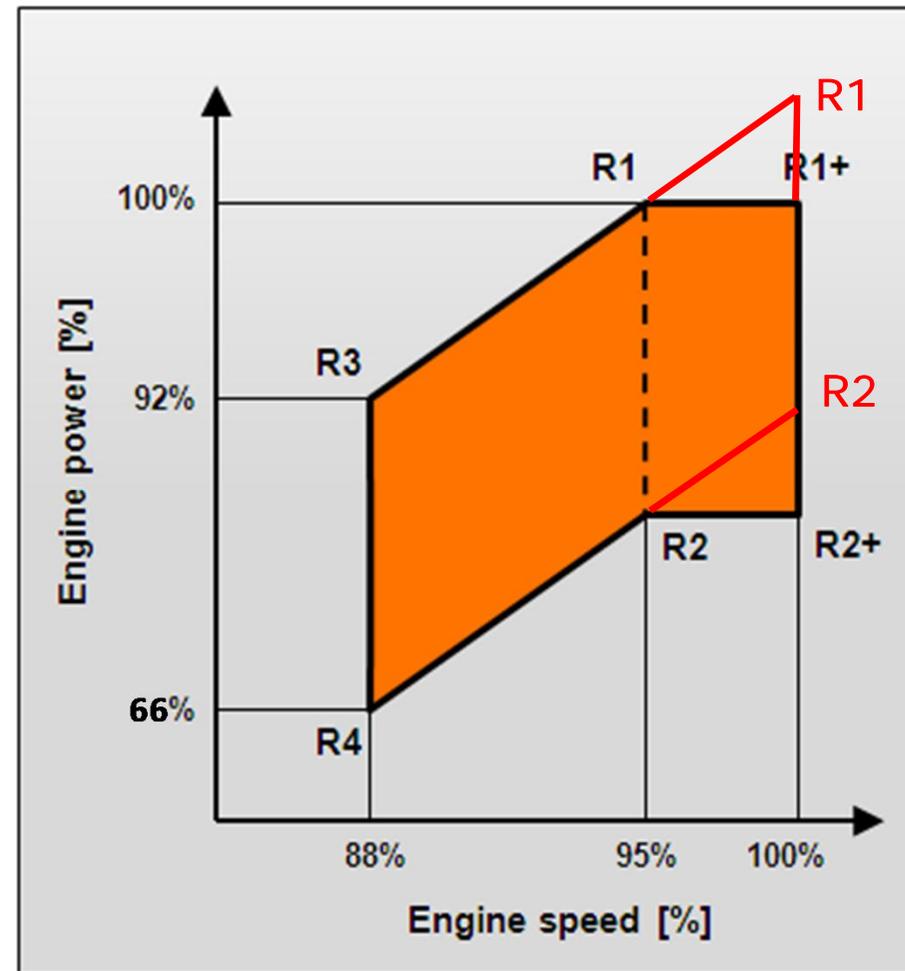


Wärtsilä X92



W-X92 – Engine parameters

	W-X92	W-X92 upgrade
Power/cyl. R1 (kW)	6130	6450
Power/cyl. R4	4070	4070
Speed R1 (rpm)	76	80
Speed R1+ (rpm)	80	
Speed R3/R4 (rpm)	70	70
Bore (mm)	920	920
Stroke (mm)	3468	3468
MEP Introduction (bar)	21	21
Cyl. Config.	6 – 12	6-12



W-X92 – Engine parameters

Wärtsilä X92	IMO Tier II/Tier III (SCR)
Cylinder bore	920 mm
Piston stroke	3468 mm
Speed	70–80 rpm
Mean effective pressure at R1	21.0
Stroke / bore	3.77

Rated power, principal dimensions and weights

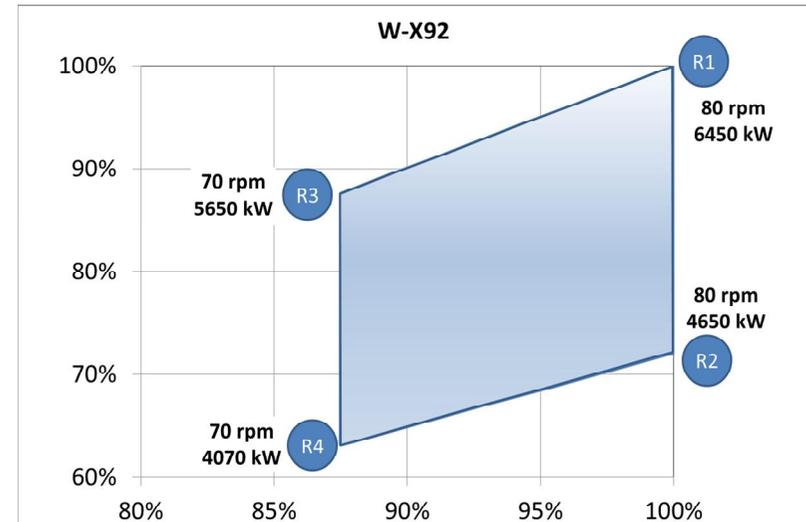
Cyl.	80 rpm		70 rpm		Length A mm	Weight tonnes
	R1	R2	R3	R4		
6	38 700	27 900	33 900	24 420	11 630	1 120
7	45 150	32 550	39 550	28 490	13 210	1 260
8	51 600	37 200	45 200	32 560	14 750	1 380
9	58 040	41 850	50 850	36 630	17 850	1 630
10	64 500	46 500	56 500	40 700	19 520	1 790
11	70 950	51 150	62 150	44 770	21 280	1 960
12	77 400	55 800	67 800	48 840	22 870	2 140

Dimensions (mm)	B	C	D	E
	5550	1900	12 950	6050
	F1	F2	F3	G
15 420	15 450	14 240	2930	

Brake specific fuel consumption (BSFC) in g/kWh

Full load					
Rating point		R1	R2	R3	R4
BMEP, bar		21.0	15.1	21.0	15.1
BSFC	Standard Tuning	166	159	166	159

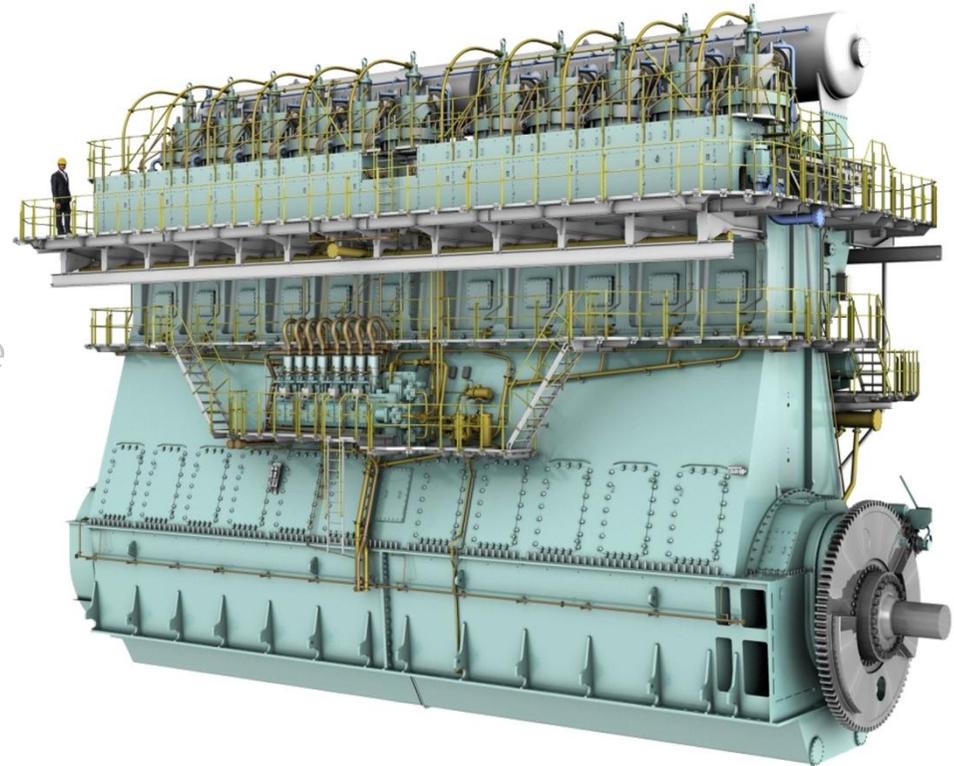
Part load, % of R1/R1+	85	70	85	70	65
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	162.2/161.2	161.8/160.8	161.5/160.5	160.3/159.3	155.6/154.8



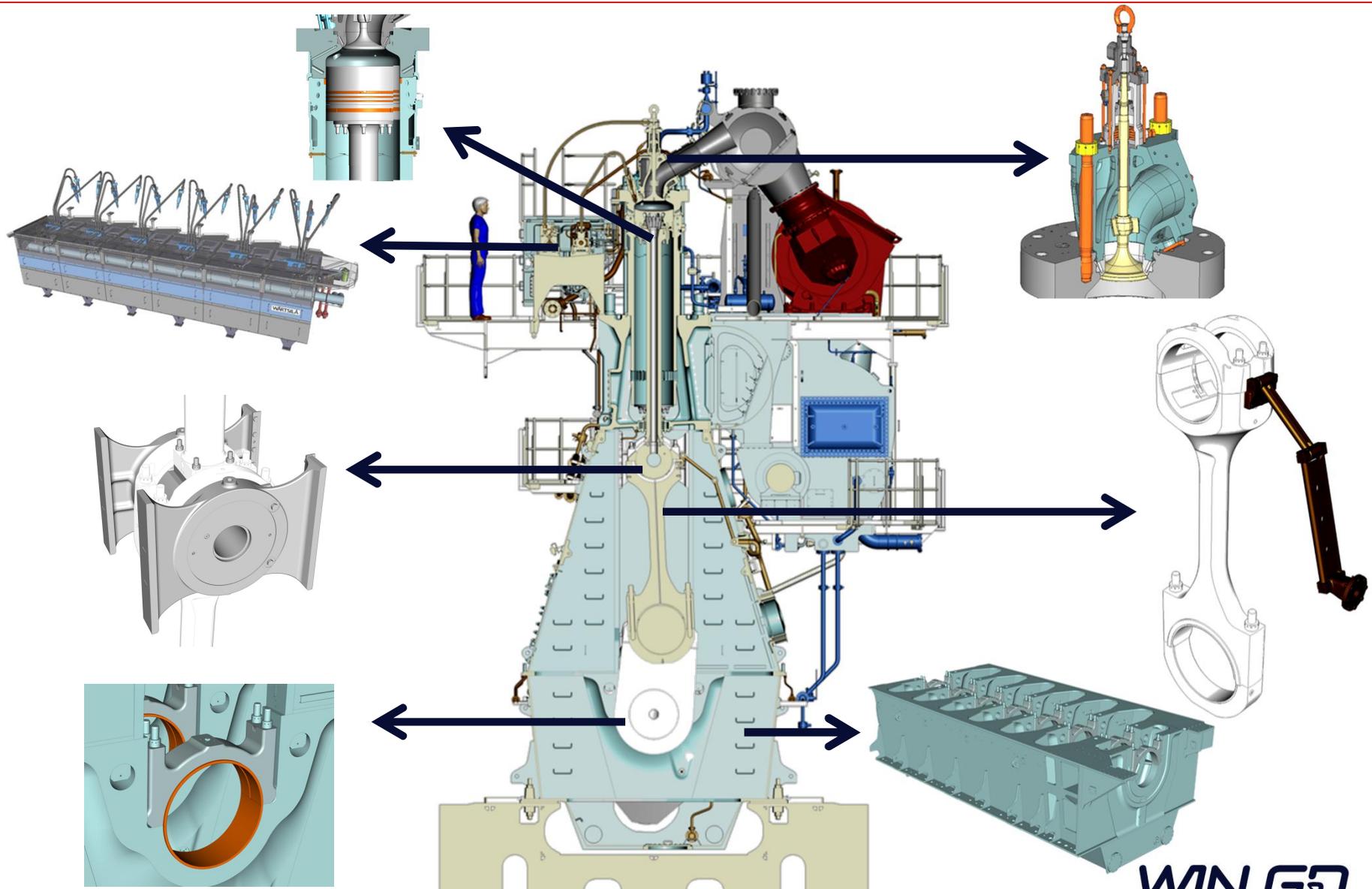
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W-X92 - Design Concept Overview



W-X92 Marketing Kit, June 2016 / H. Brunner, J.-N. Constantin, L. Knipstrom

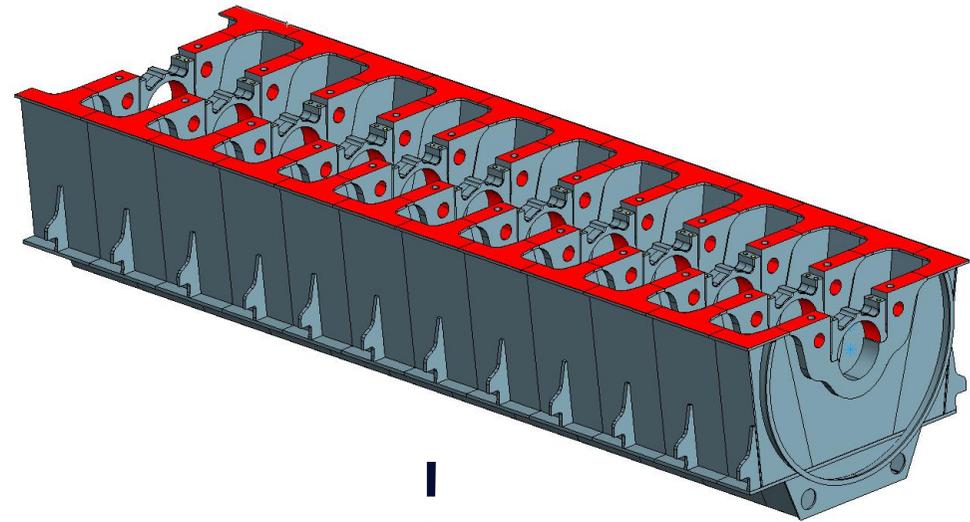
WIN G2
Winterthur Gas & Diesel

W-X92 – Bedplate

- *Bedplate*

*Compact single wall design,
Integrated thrust bearing*

- *Optimized for low deformations by propeller thrust force*



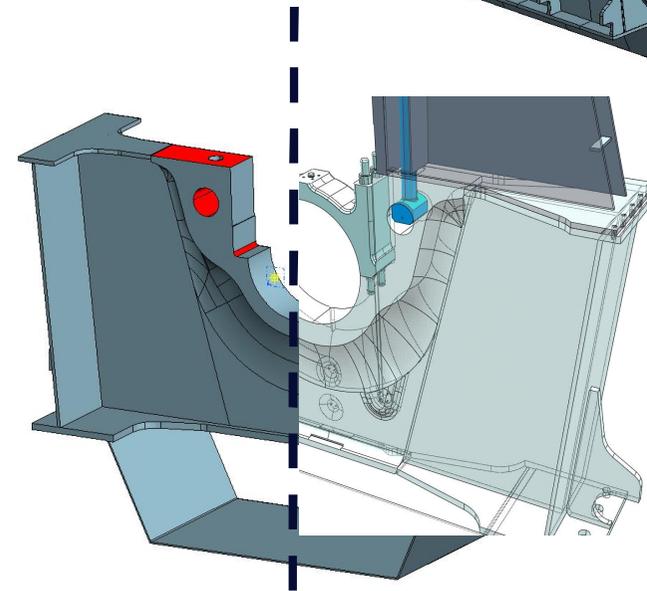
- *Main bearings*

*Two thin shell bearing design
with thick white metal layer*

Two bearing diameters (FE < DE)

Layout by Elasto Hydro

Dynamic calculation



W-X92 – Bedplate

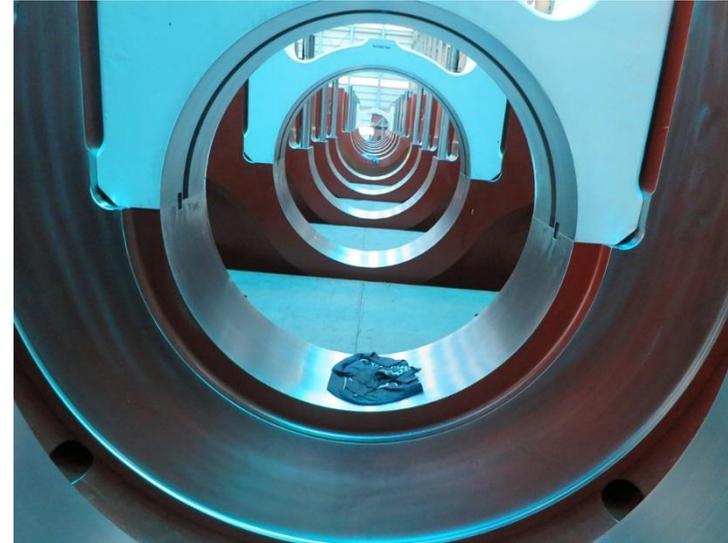


Driving End

Free End

W10X92 Bedplate

W-X92 – Main Bearing



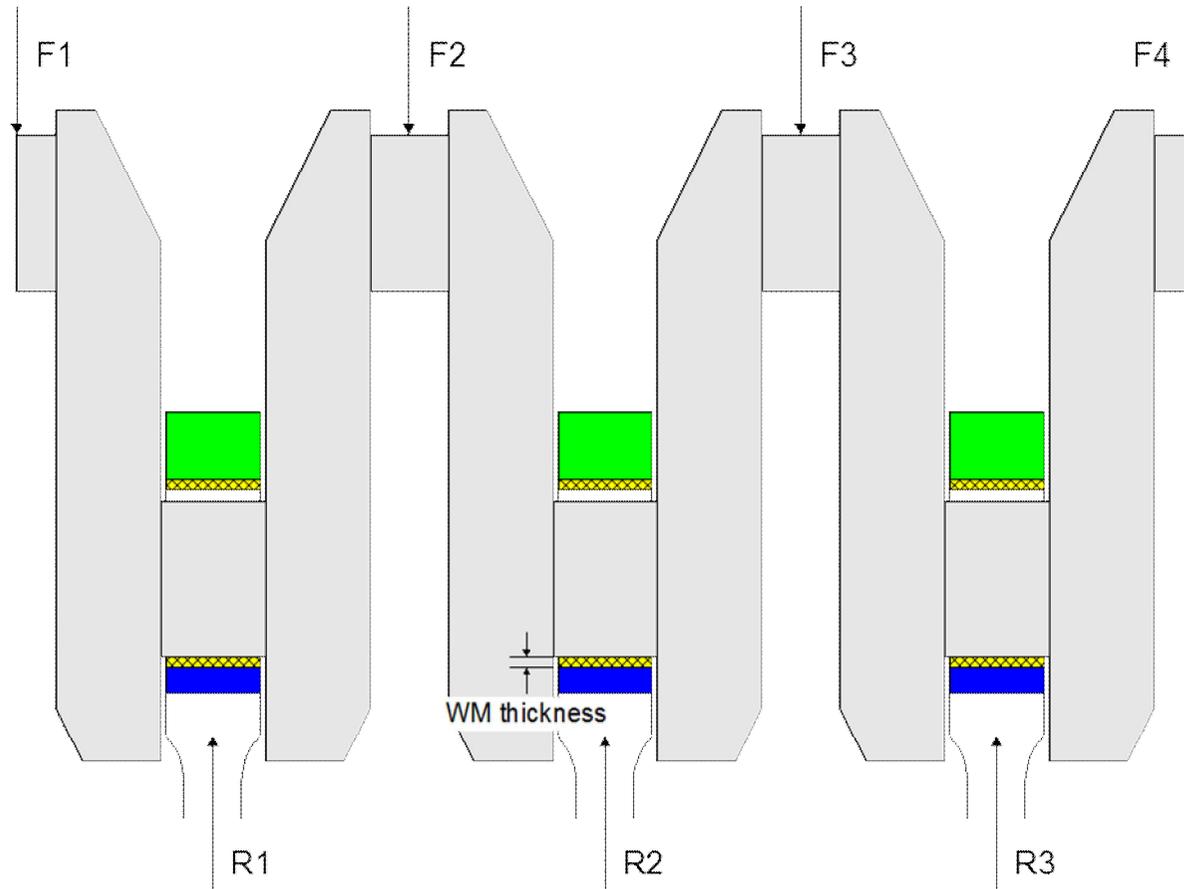
W-X92 – Main Bearing

Risk after a main bearing failure

- What should be avoided
 - Main engine breakdown
 - Contact between crankshaft and back metal of main bearing shell
- Preventive measure
 - White metal layer thicker than bending of crankshaft
- Service experience
 - No main engine breakdown after a main bearing failure in Wärtsilä engines
 - Extreme low risk to damage the crankshaft journal
 - Main bearing shell exchanged at next port and trip continued
 - Proven design

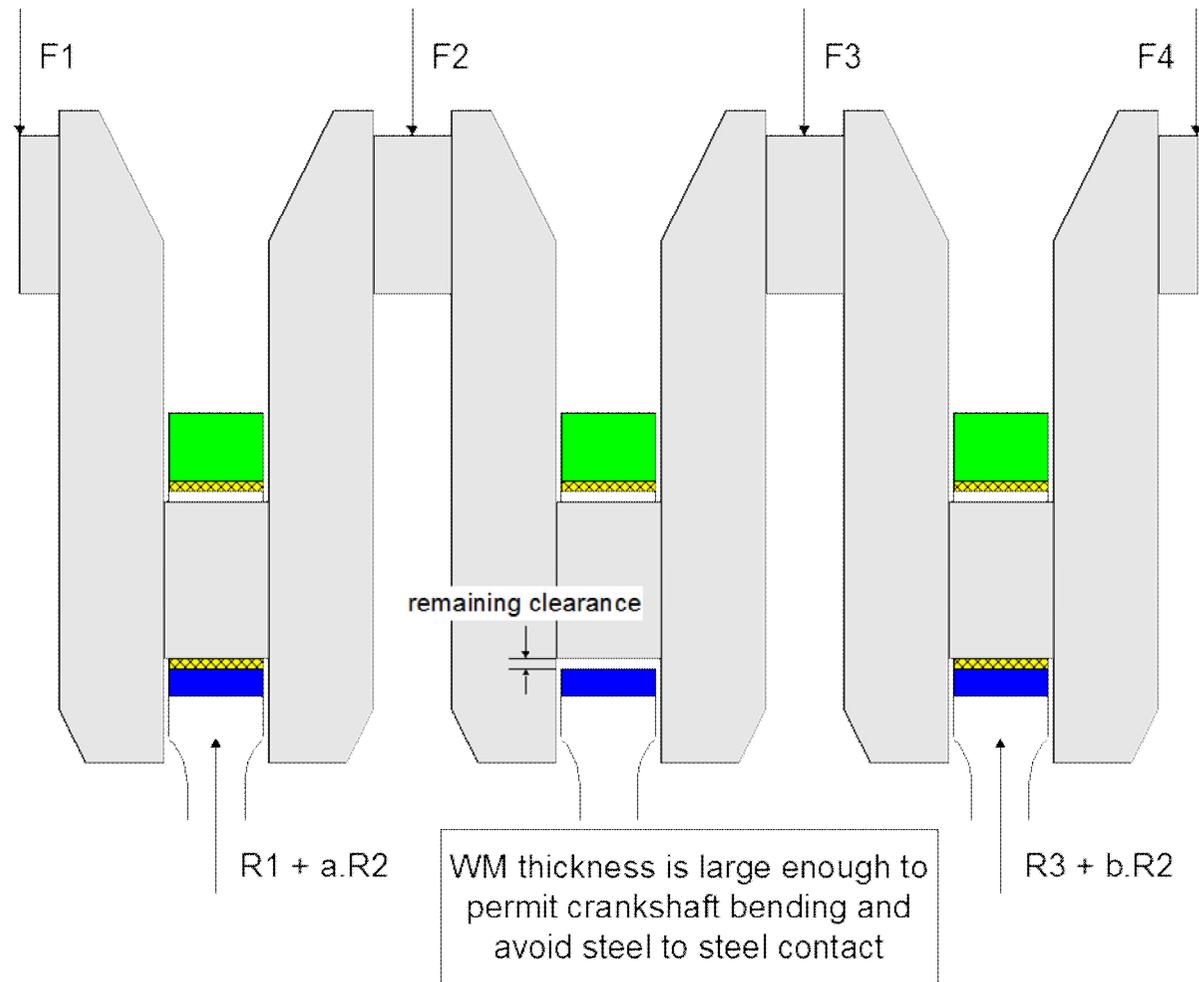
W-X92 – Main Bearing

Crankshaft with main bearings



W-X92 – Main Bearing

One main bearing shell without white metal



W-X92 – Column

- *Column*

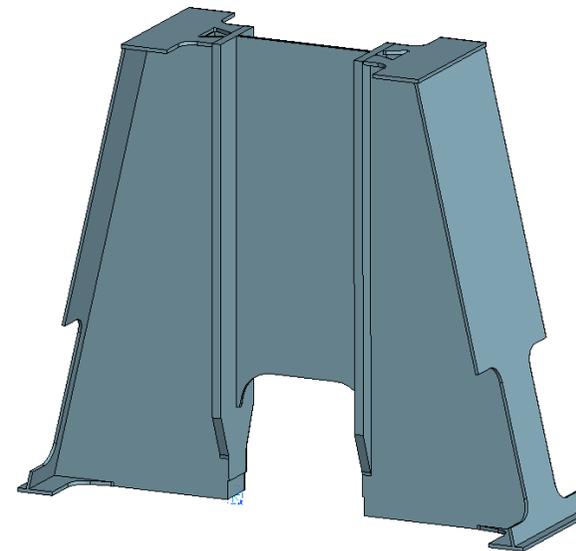
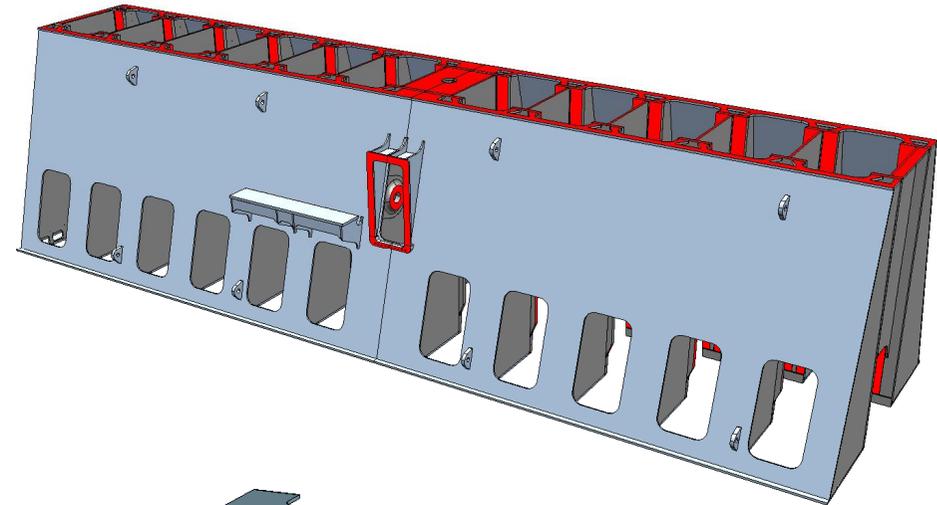
Sturdy double wall design

Same concept as on W-X62/72

Mid-sheets are executed as single walls

Thick guide rails to reduce deformation and stress under guide shoe forces

Design optimised for ease of manufacturing and allowing strong quality assurance



W-X92 – Column



Driving End

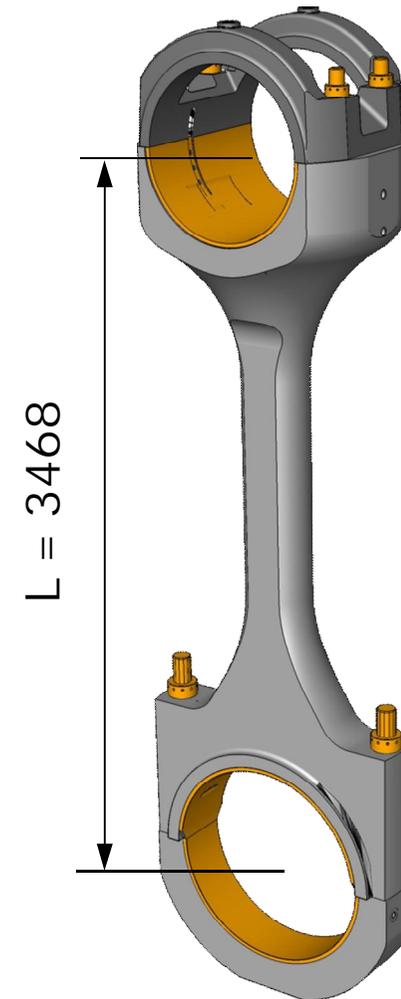


Free End

W10X92 Column

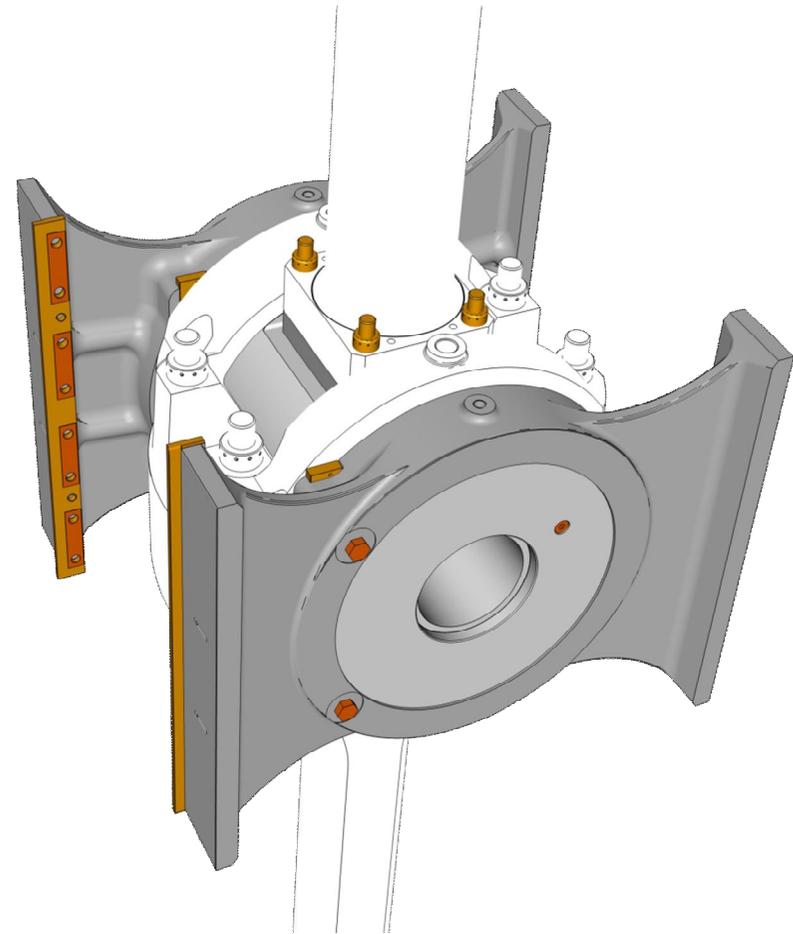
W-X92 – Connecting Rod

- *Connecting rod*
 - Proven low pressure lubrication*
 - *Introduced on W-X62/72/82*
 - Cross head bearing*
 - *One bearing shell with white metal layer*
 - *Cover with white metal running surface*
 - Bottom end bearing*
 - *Two thin bearing shells with white metal layer*

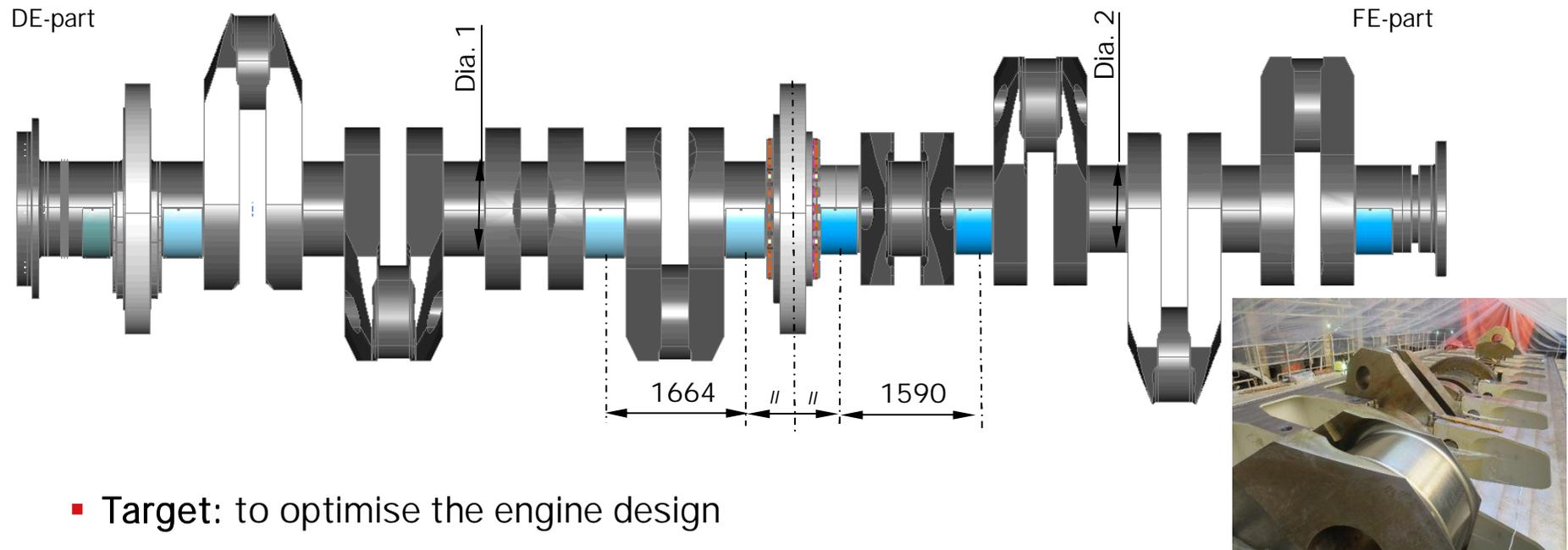


W-X92 – Crosshead

- *Crosshead*
Guide shoe in one piece (steel cast) with white-metal lining
Optimized force transmission for lowest load on engine structure
Large contact surface between guide shoe and guide rail at bottom dead centre
Design similar to W-X62/72/82



W-X92 – Crankshaft, Dual Cylinder Distance



- Target: to optimise the engine design
- Feasibility: the FE part of crankshaft carries less torque and can be optimised
- Design: Different cyl. distance for DE (1664mm) and FE (1590mm)
- Saving: approx. 2.5 % engine cost
- Main parts affected: crankshaft, bedplate, column, crosshead, cylinder jacket
 - Additional spare parts on board: only one main bearing shell

W10X92 – Crankshaft



W8X92 – Crankshaft In One Part

- Crankshaft production capacity increased since introduction of X92 engine
- 8 cylinder crankshaft can be produced in one part
- Both options remain possible: one or two part crankshaft
- **Saving**
 - Engine length: 1.5 m
 - Total weight reduction: ~90 t
 - More cost competitive solution
- Engines ordered and in production

W-X92 – Cylinder Cover, Exhaust Valve

- *Cylinder cover & exhaust valve*

- *Cylinder cover*

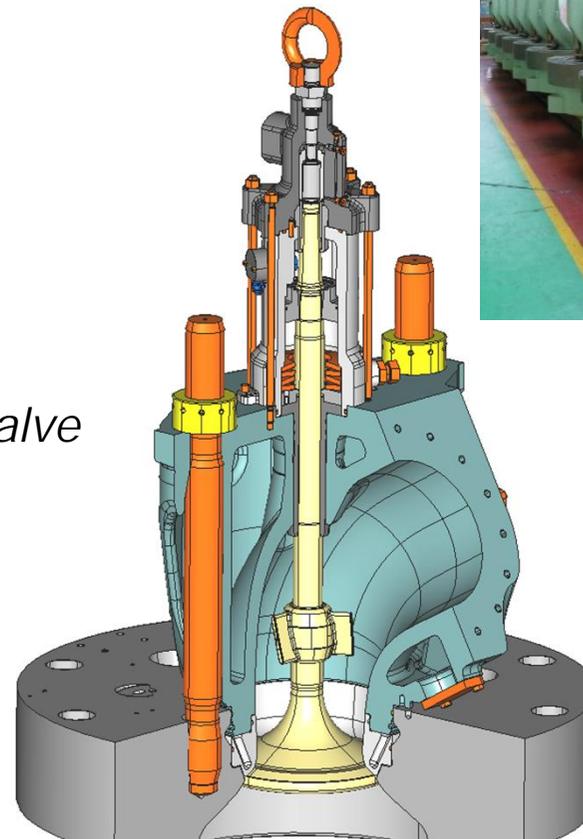
- *W-X82 concept*
- *Bore cooling*
- *Round shape, 10 bolts*

- *Exhaust valve*

- *Water cooled exhaust valve cage*
- *Bore cooled exhaust valve seat*
- *Hydraulic valve drive and air spring*

- *3 fuel injection nozzles*

- *Electronically controlled starting air valve*



W-X92 – Piston

- *Piston*

- 3 piston rings*

- *Introduced on RT-flex82C&T, also on W-X62/72/82*

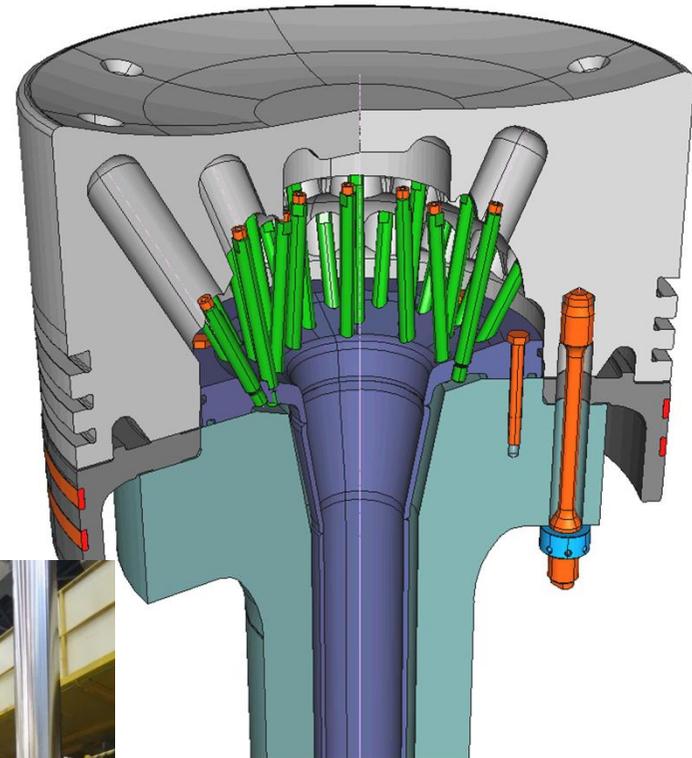
- Well-proven jet-shaker piston cooling concept*

- *Oil cooling*

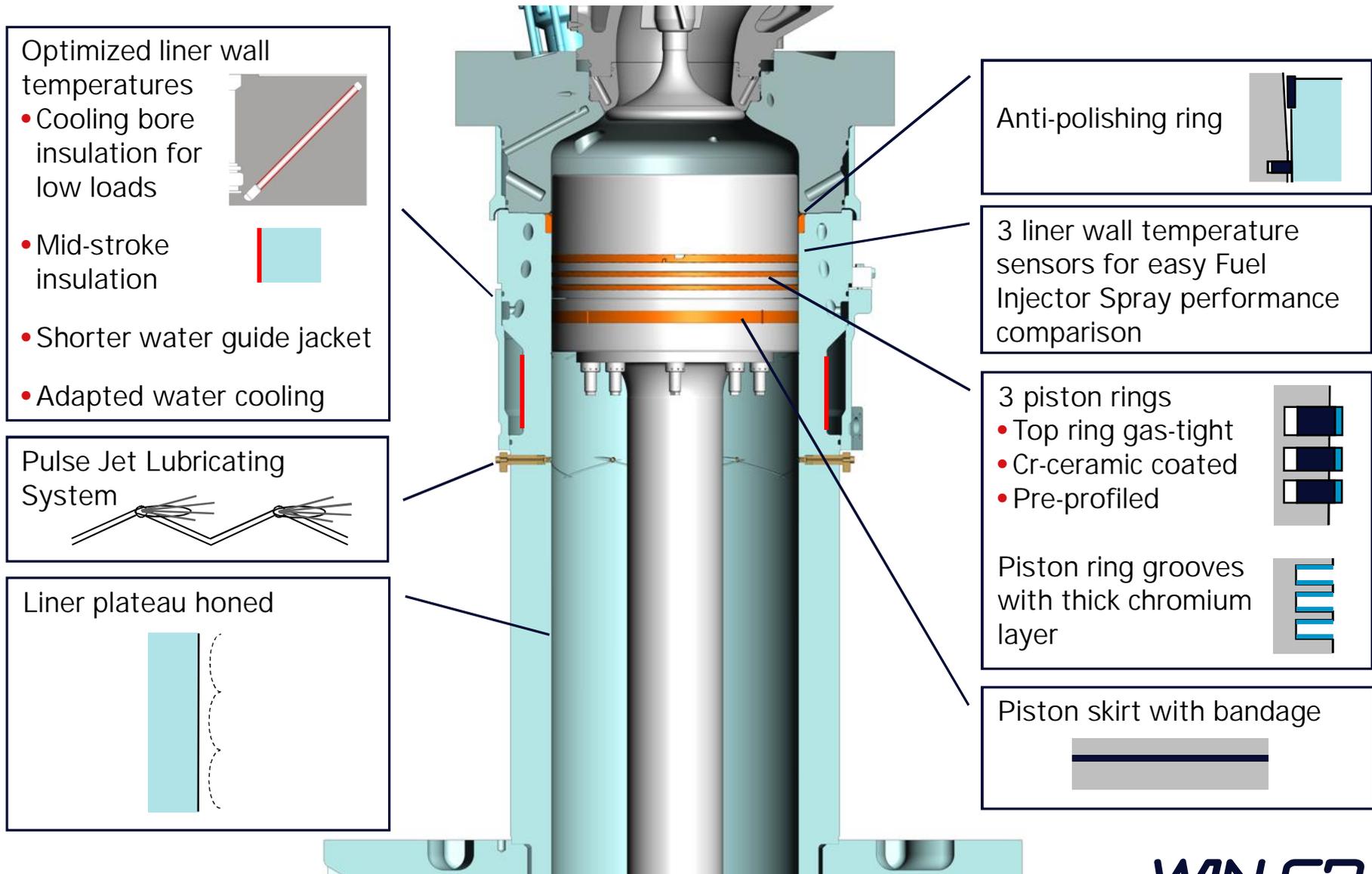
- Stress and temperature optimized by FE calculation*

- *Position and number of cooling bores optimized for even temperature distribution on piston crown*

- High top land*

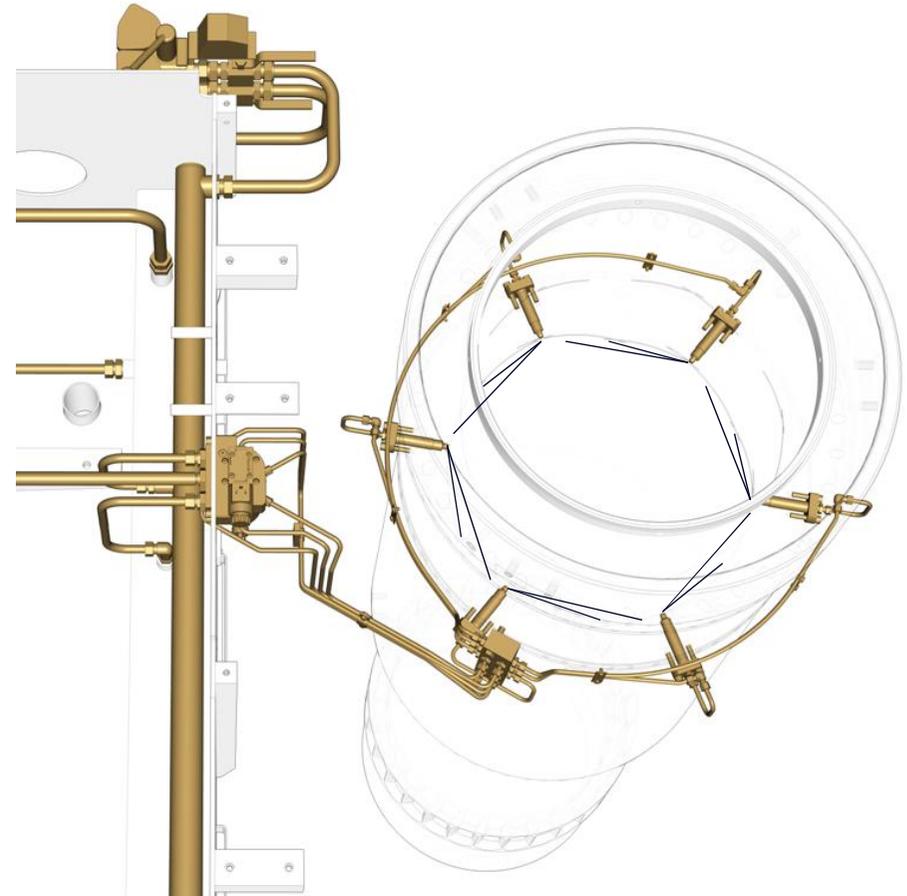
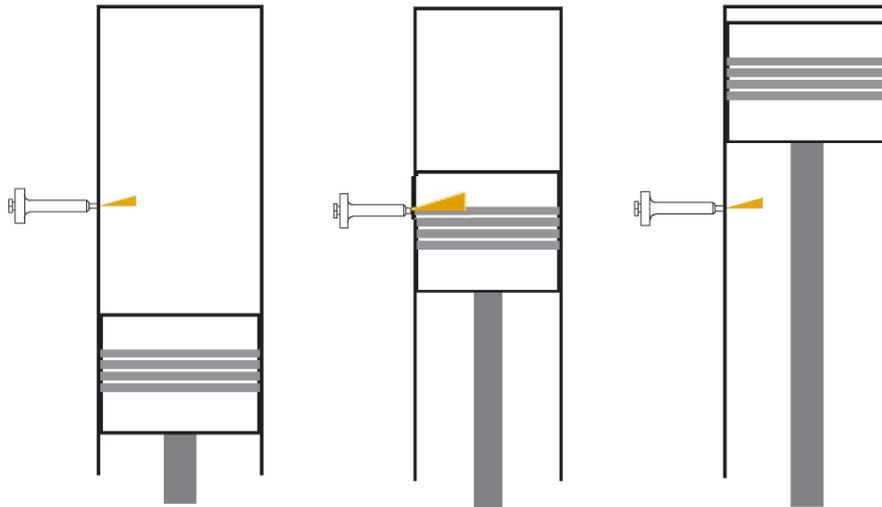


W-X92 – Piston Running Concept



W-X92 – Cylinder Lubrication System

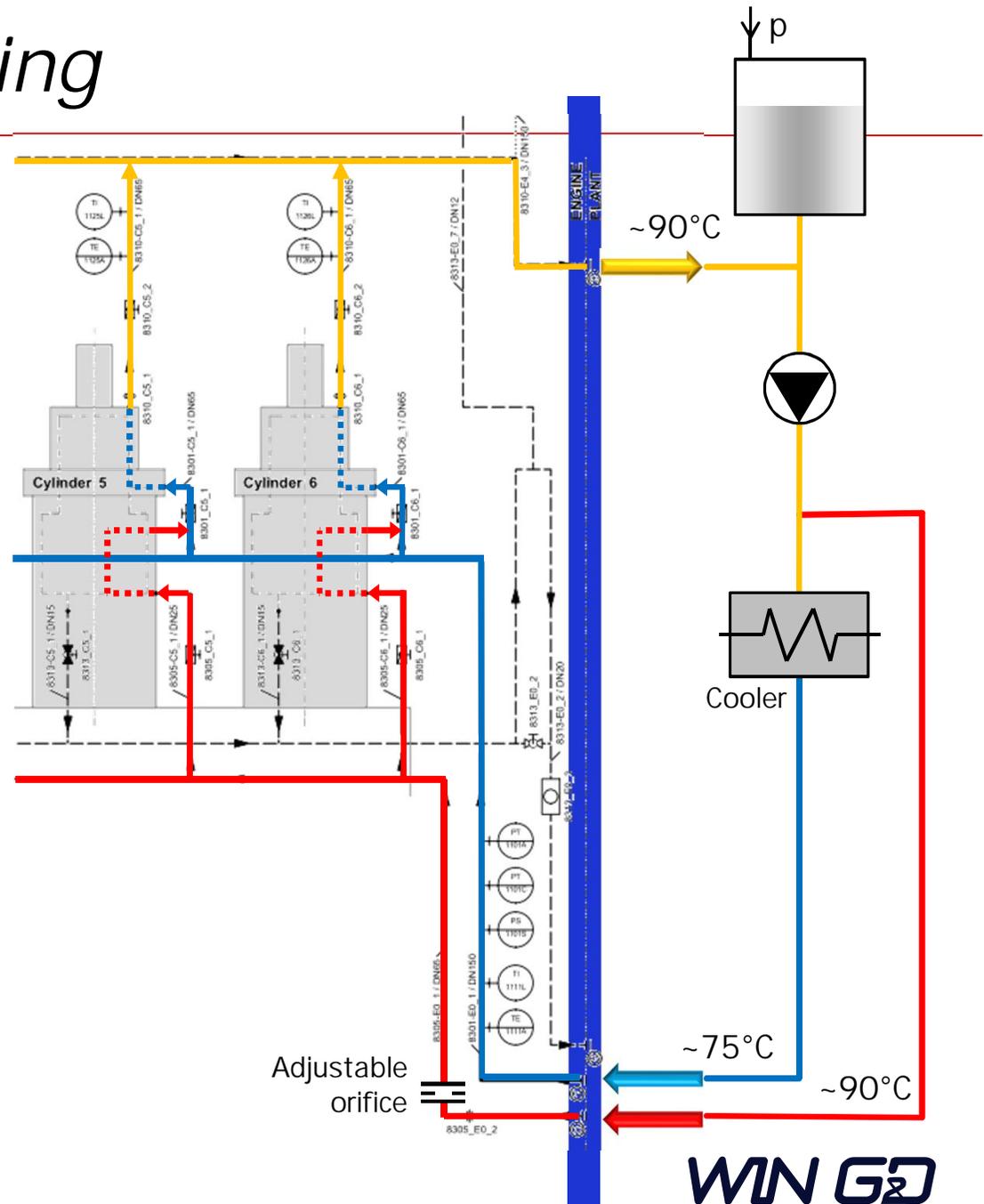
- *Cylinder lubricating system*
Pulse Jet Lubricating System
Flex lube pump
Lube oil distribution into, above and below piston ring pack
10 quills (simple non-return valves) for best radial distribution
Cylinder liner with oil grooves



W-X92 – Liner Cooling

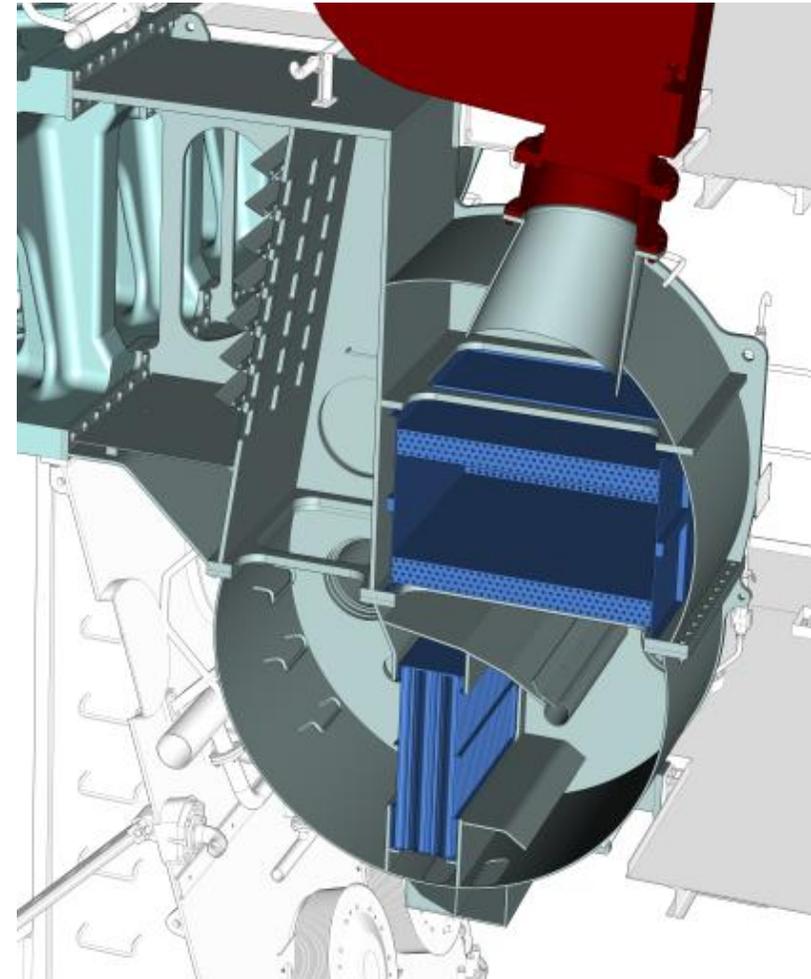
- *Cylinder liner cooling*
- *Bypass solution*
 - *Two yard connection*
 - *„Warm water“ for liner*
 - *„Cold water“ for cylinder cover and exhaust valve*
- *Pressurized cooling system*

Mid-stroke insulation
Insulation of cooling bores
(if necessary)



W-X92 – Water separation

- *Water separation*
Underslung design for efficient natural water separation
 - *Air swirl supported water droplet separation*
 - *Radial acceleration of air flow leads to separation of > 80% of the water droplets*
 - *Additional water separator element for high efficiency*
 - *Effective drain (pressure balanced)*



W-X92 – Flex Fuel Injection

- *Flexsystem – overview*

Rail Unit

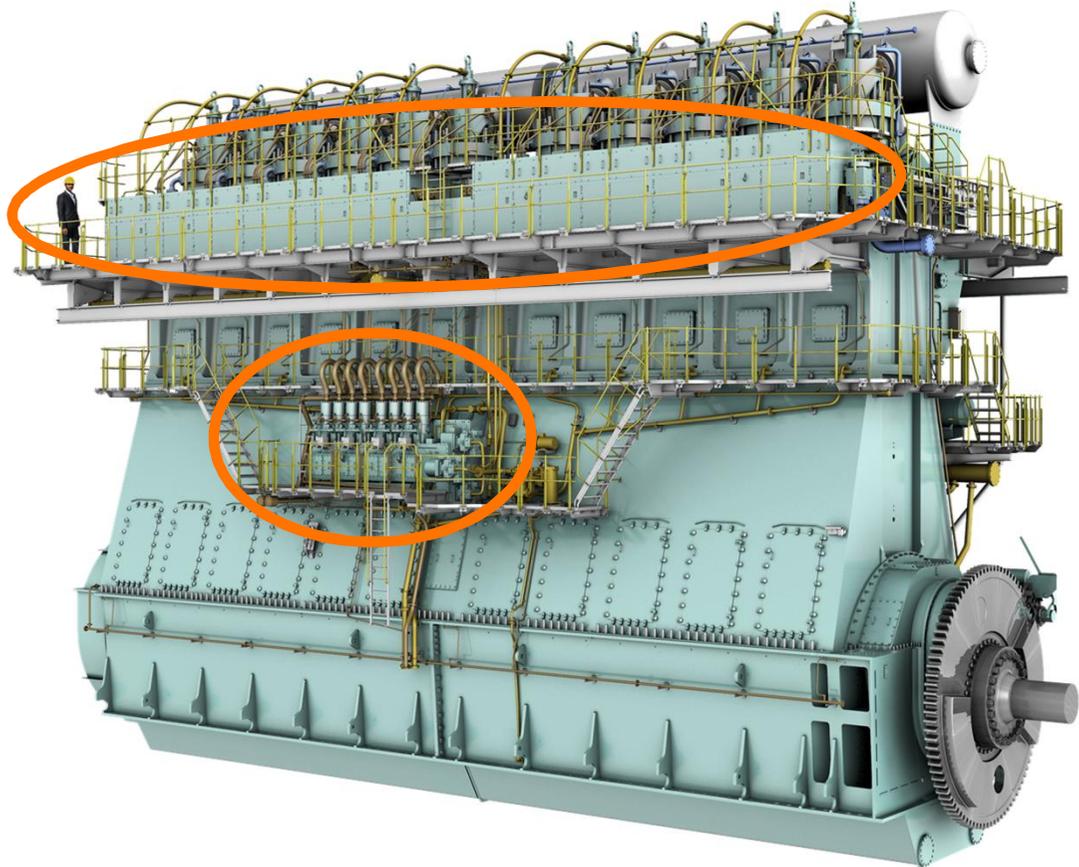
- *High pressure rails for fuel and servo oil*
- *Activation of exhaust valve and fuel injection by electronically controlled rail valves*

Supply Unit

- *Pressurizing of fuel and servo oil*

Redundant piping for fuel and servo oil between Supply Unit and Rail Unit

Redundant SOPs and FOPs



W-X92 – Flex Fuel Injection

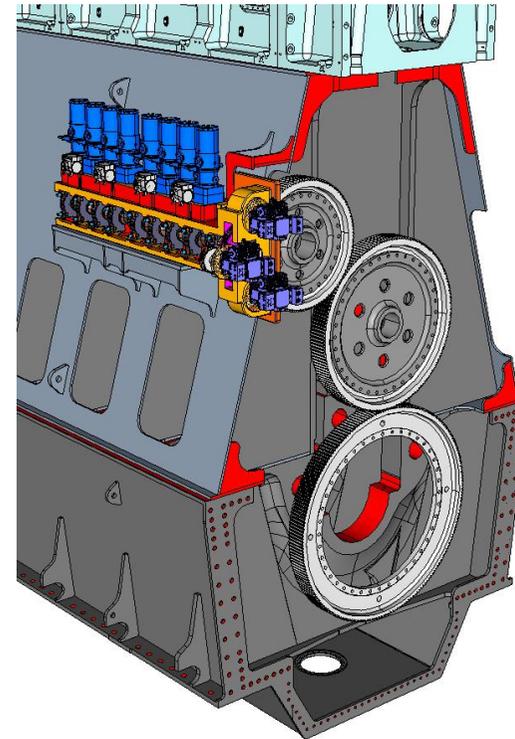
- *Fuel and servo oil pumps*
Combined arrangement of heavy fuel oil and servo oil supply in one housing
Direct drive by the crankshaft wheel

Fuel oil supply

- *Size IV pump, max 800 bar*

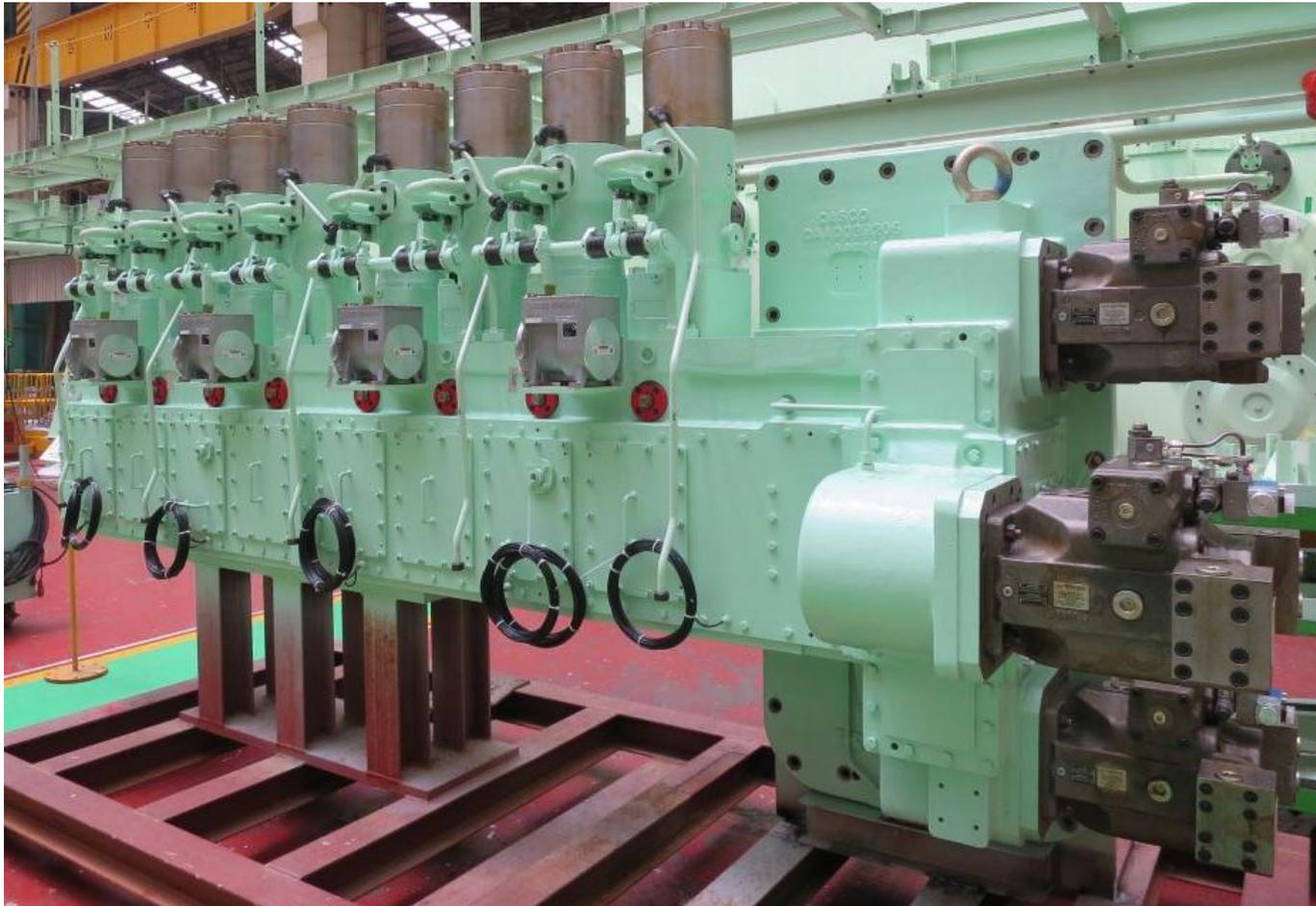
Servo oil supply

- *Bosch pumps, 200 bar*



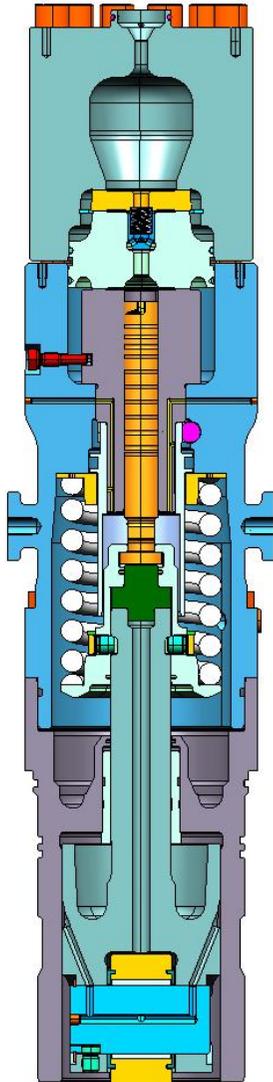
	W6X92	W7X92	W8X92	W9X92	W10X92	W11X92	W12X92
Number of FO pumps	4	6	6	6	8	8	8
	W6X92	W7X92	W8X92	W9X92	W10X92	W11X92	W12X92
Number of SO pumps	2	3	3	3	3	3	3

W-X92 – Flex Fuel Injection



W-X92 – Supply unit with 8 fuel oil pumps and 3 servo oil pumps

W-X92 – Flex Fuel Injection



RT-flex96C ↔ W-X92

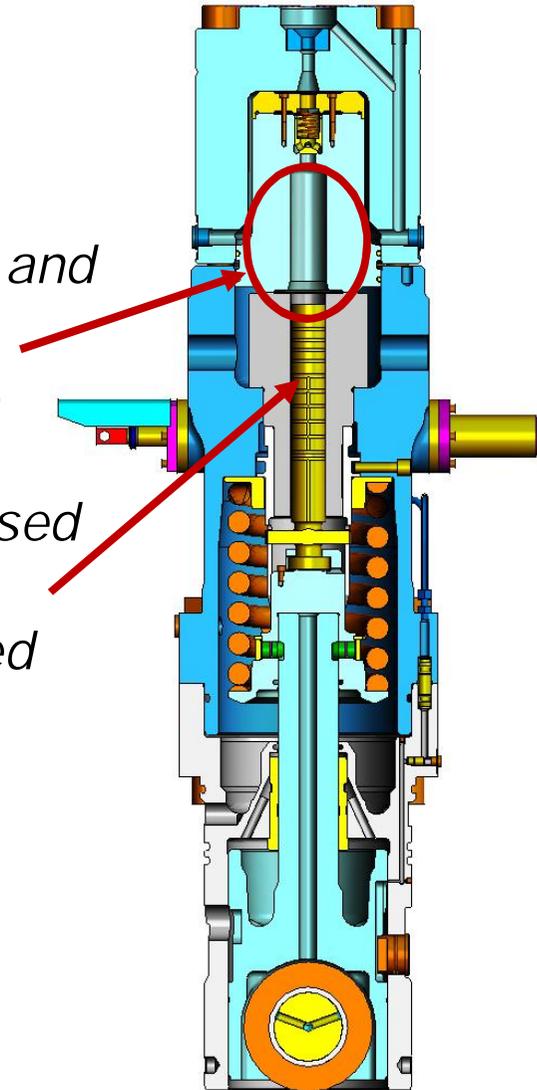
Increased volume between plunger and NRV

➤ *Reduced dynamic force by ~20%*

Plunger diameter and speed optimised

➤ *Reduced static force by ~10%*

➤ *Life time of components improved*



W-X92 – Flex Fuel Injection

- *Fuel injection control*
Volumetrically controlled fuel injection with Injection Control Unit

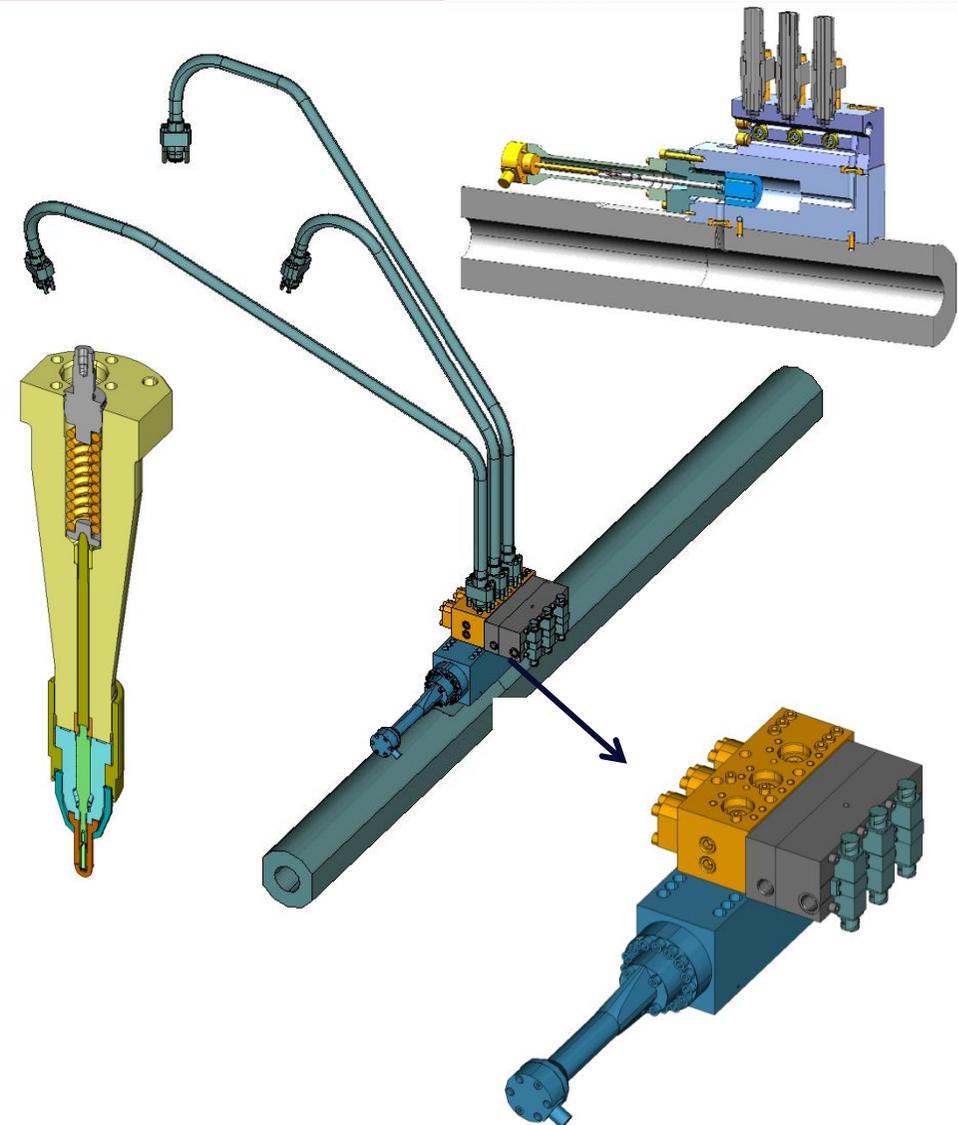
- *Three rail valves per cylinder for optimized injection control at all engine loads*

Single wall rail pipe

FAST nozzle

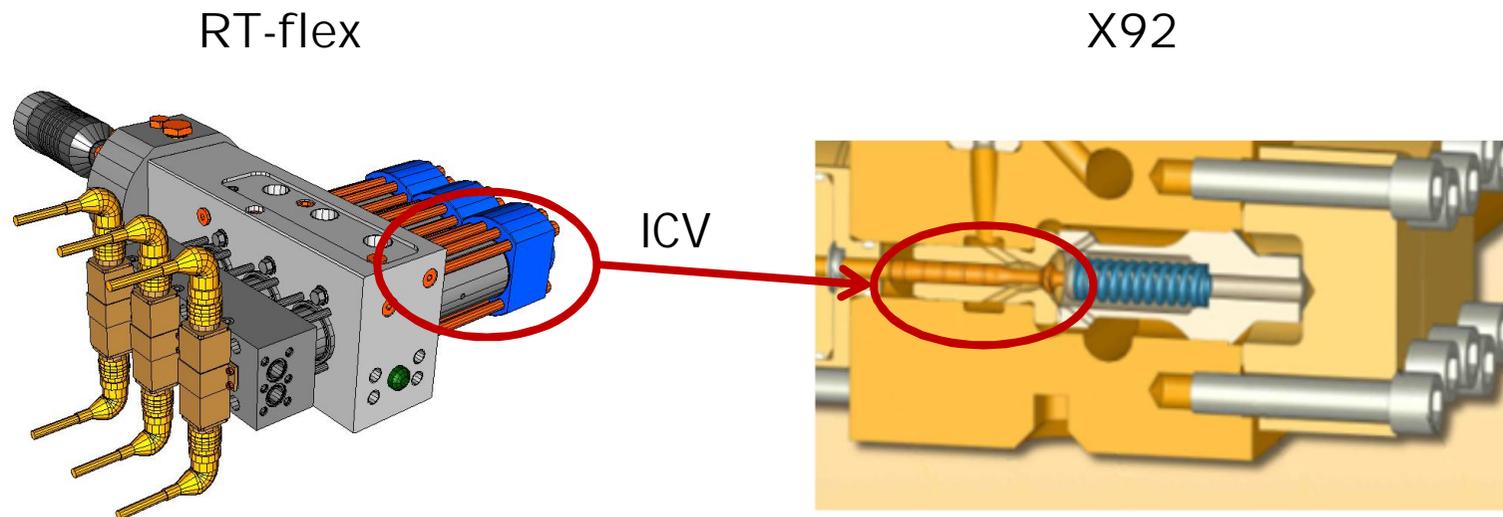
(FAST = Fuel Actuated Sacless Technology)

- *Negligible sack hole volume*
- *Validated since 2010*
- *Clean combustion chamber*
- *Improved BSFC*



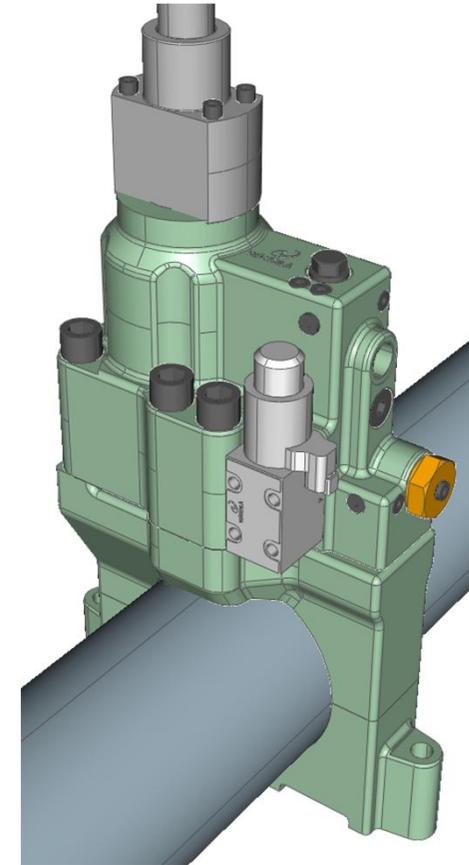
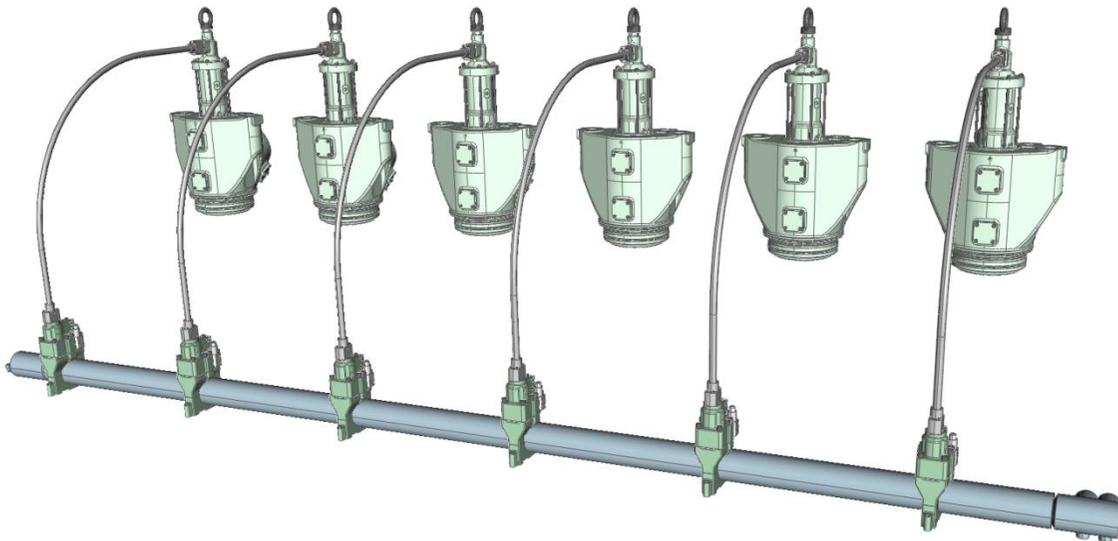
W-X92 – Injection Control Unit

- *Fuel Injection Control Valves (ICV, a wear part) replaced by simpler inserts in the ICU block*
- *Reduced spare part costs*
- *Repair on board possible*
- *Improved maintenance friendliness*



W-X92 – Exhaust Valve Actuation

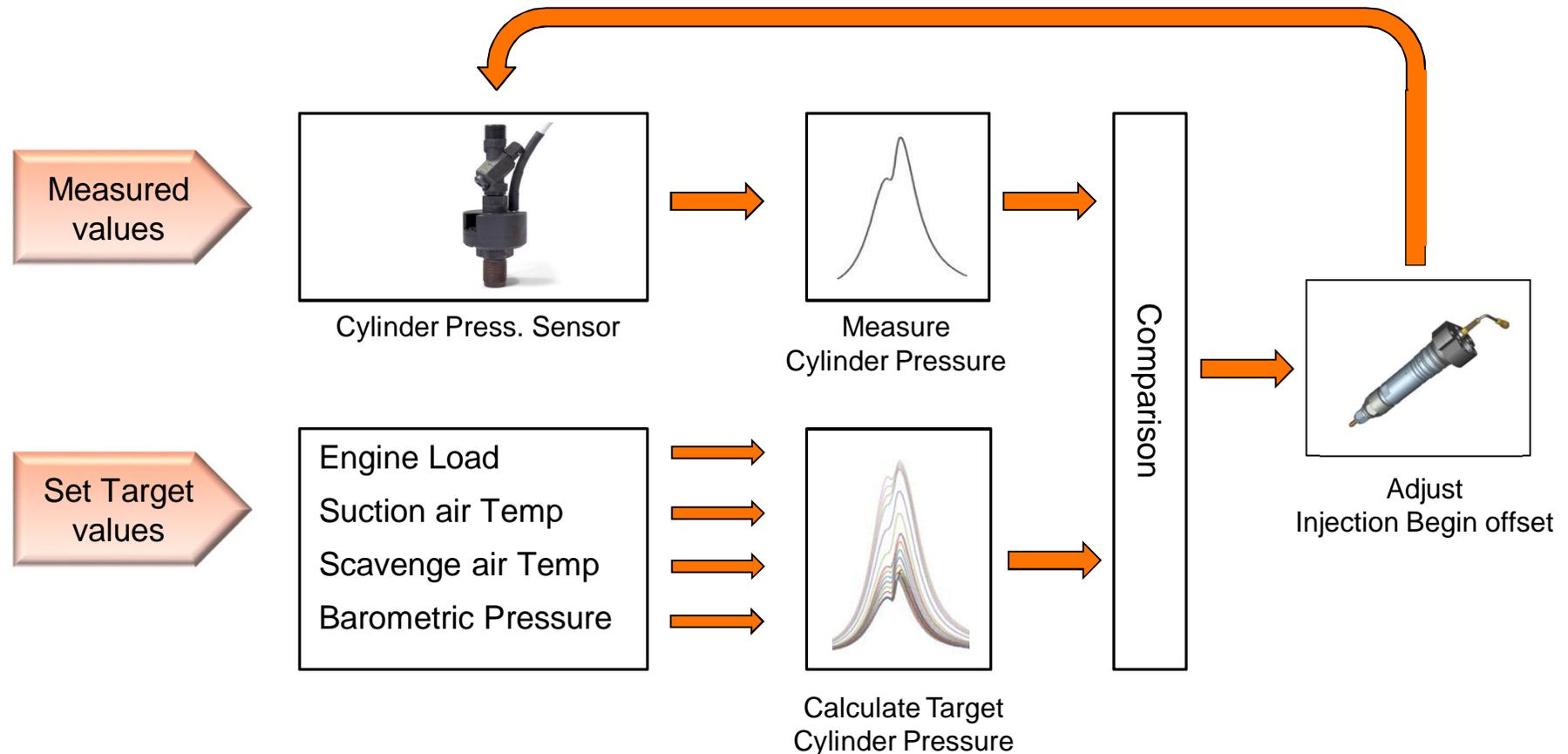
- *Electronically controlled exhaust valve movement*
- *Full flexible opening and closing*
- *Reliable servo oil rail single wall design*



VCU – Exhaust Valve Control Unit

W-X92 – Intelligent Combustion Control

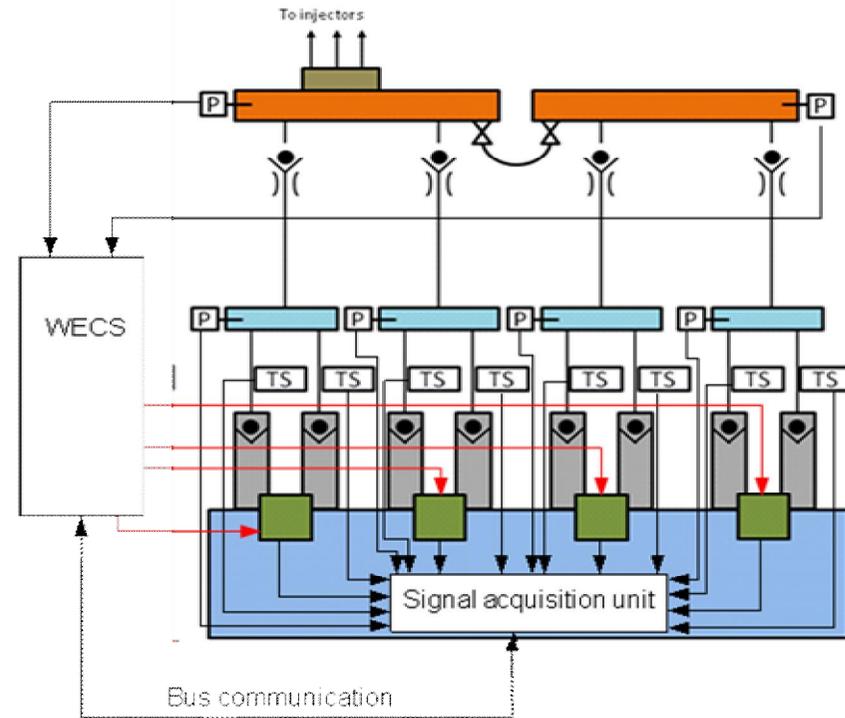
Automated cylinder pressure adjustment and control



- Up to 2.5 g/kWh fuel savings in service
- Continuous monitoring of compression and peak cylinder pressure

W-X92 Engine Control System – WECS 9520

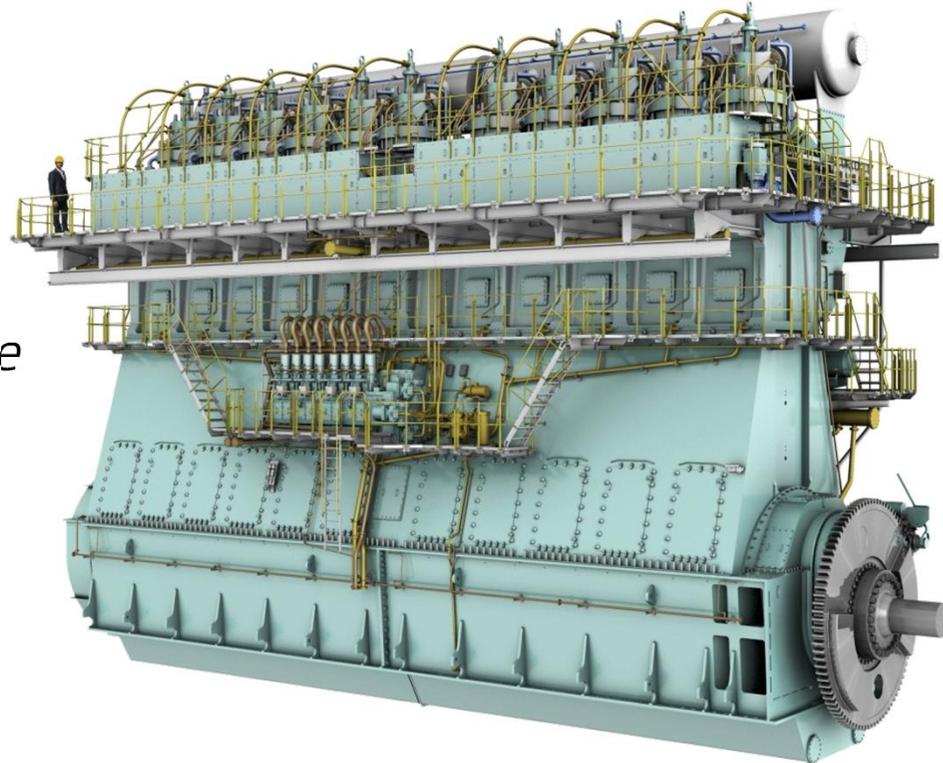
- *WECS 9520 system based on existing RT-flex engines*
- *Added features:*
 - Fuel Pressure Monitoring on fuel accumulators for leakage detection*
 - Cylinder Lubrication control adapted for Flex Lube pump*
 - Cylinder wall temperature monitoring as standard*
 - ICC as standard*



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W-X92 Engines on Order

No of Engines	Engine	C-Vessel	Remarks
4	8X92	9 kTEU	
4	8X92	9 kTEU	1 part C/S
4	8X92	11 kTEU	1 part C/S
3	8X92	11 kTEU	
6	10X92	13 kTEU	
3	11X92	21 kTEU	
4	8X92	11.8 kTEU	1 part C/S
Tot 28			

As of June 2016

W-X92 Engines on Order / in Service

Summary	6 cyl.	7 cyl.	8 cyl.	9 cyl.	10 cyl.	11 cyl.	12 cyl.	Total
On Order			19		6	3		28
In Service			4					4
Total cylinders			32					32

Summary	# engines on order	# engines after shop test	# engines in service	Max. running hours	Accumulated running hours
X92	28	0	4	~4'400	~9'200

As of June 2016

W-X92 Engines in Service



Hanjin Czech W8X92, 9000 TEU Container vessel in service since October 2015

W-X92 Engines in Service

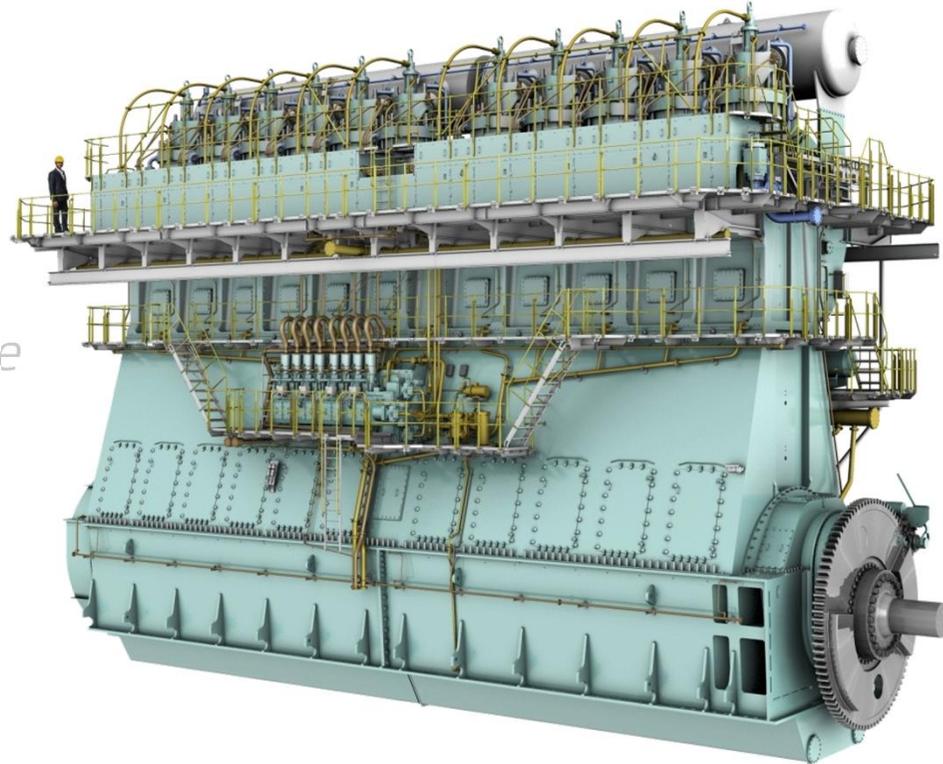


Hanjin Switzerland W8X92, 9000 TEU Container vessel in service since March 2016

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W-X92 Testing

- *W-X92 engine testing*
W8X92 P0130 CINER prototype testing
 - *Power* *38590kW (78.7% R1+)*
 - *Speed* *74 rpm (92.5% R1+)*
 - *Tuning* *Delta Bypass*

- W8X92 P0133 CINER (4th engine)*
 - *Type Approval Test (TAT) on 4th engine on 25-27th August 2015*
 - *Component inspection*

Close field follow-up of the first engine after sea-trial



Successful FAT on 17.02.15 at HHI-EMD

W-X92 Testing

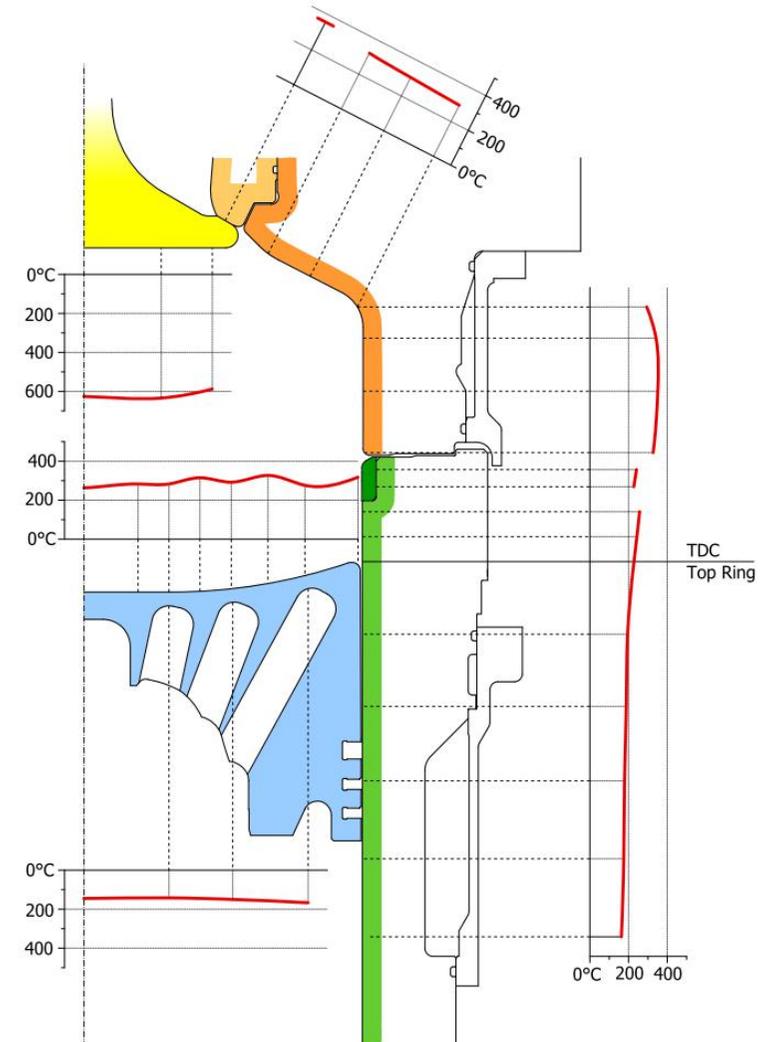
- Extensive prototype testing, measurements:
Temperature measurements

- Piston
- Cylinder liner & cover
- Exhaust valve

Stress measurements

Vibration measurements

- All measured values within permissible limits



W-X92 Testing - Component Inspections

- *Component inspection*
All relevant components checked during testing and after Factory Acceptance Test
- *All components in good condition*



Cylinder liner



Combustion chamber



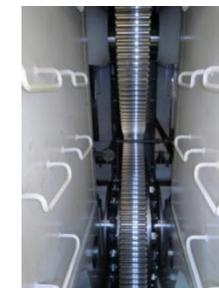
Piston rings



Crosshead



Camshaft in supply unit



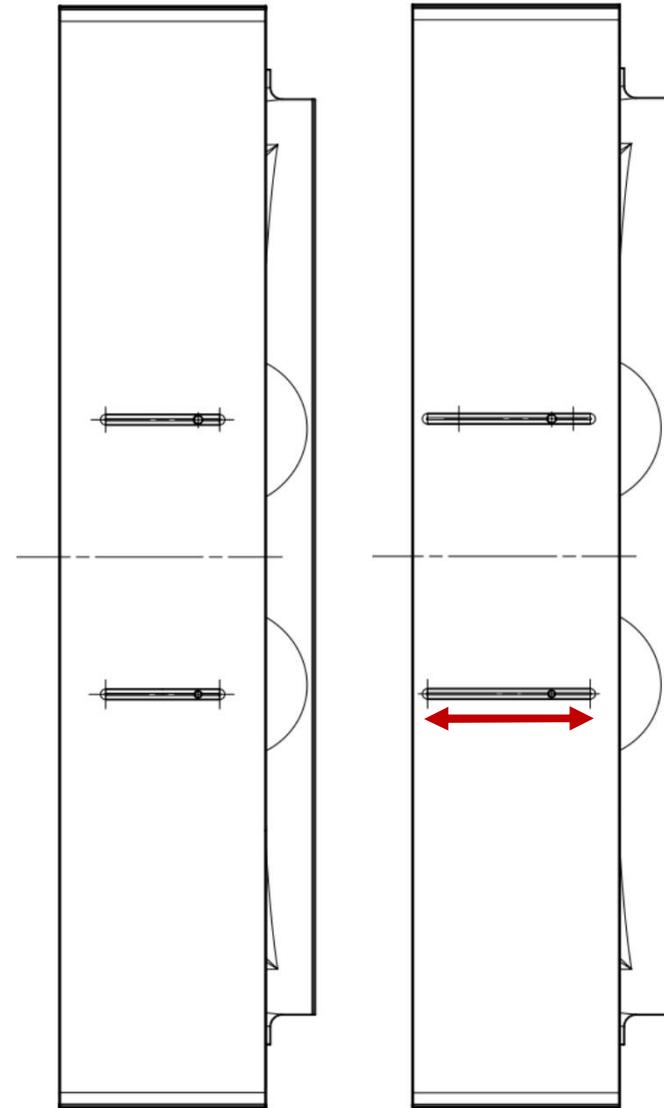
Gear wheels

W-X92 Testing - Component Inspections



*W8X92 – Guide shoe
Inspection after shop test*

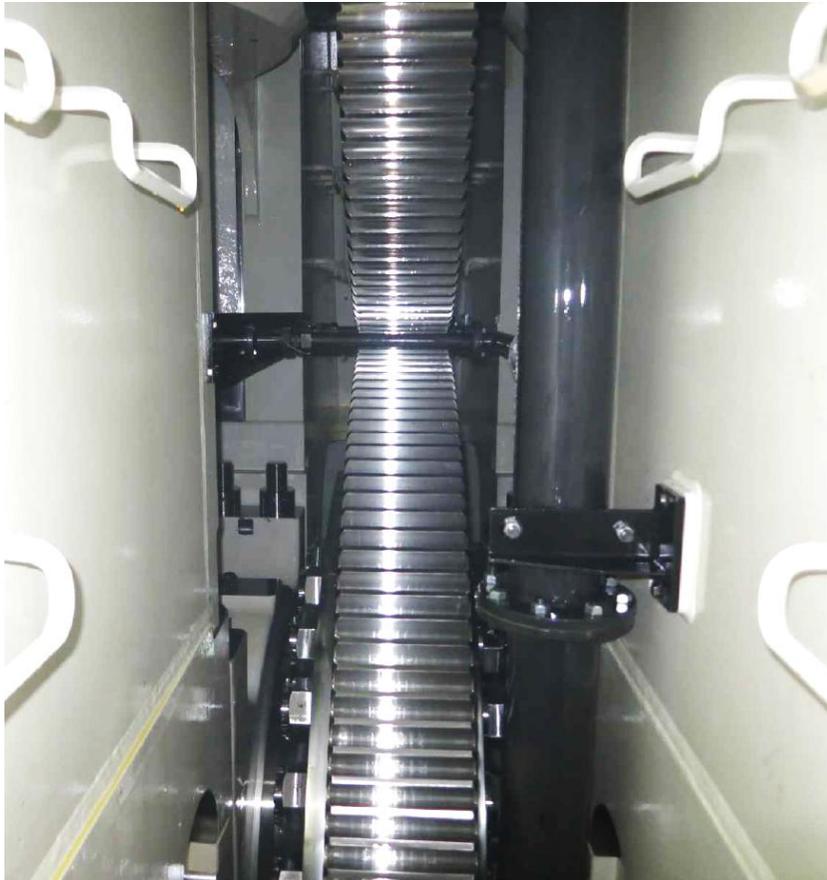
- *Running marks on both edges*
- *Improvement introduced
Oil groove enlarged
Better oil distribution*



W-X92 Service Experience – Gear Wheels

W8X92

Inspection at 153 rhs



- Gear wheels in outstanding condition
- Clean crankcase space



W-X92 Service Experience – Piston Running



W8X92

Inspection at 153 rhs

- *All units in good condition*
- *Oil in use: BN100*
- *2.87 % sulphur*
- *Feed rate: 1.0 g/kWh*
- *Residual BN: 60 – 70*

➔ Feed rate can be further reduced

W-X92 Service Experience – Piston Running



W8X92
Inspection at 153 rhs

- Piston ring in good condition
- Clean piston ring pack
- Moderate deposits on piston head
- Top piston ring with good contact area



W-X92 Service Experience – Piston Running



W8X92

Inspection at 789 rhs

- *All units in good condition*
- *Oil in use: BN100*
- *3.21 % sulphur*
- *Feed rate: 1.0 g/kWh*

➔ Feed rate can be further reduced

W-X92 Service Experience – Piston Running



W8X92
Inspection at 789 rhs

- *Piston ring in good condition*
- *Clean piston ring pack*
- *Moderate deposits on piston head*

- *Top piston ring with good contact area*



W-X92 Service Experience – Piston Running



- *Cylinder liner not cleaned*
- *Honing marks still visible on the whole stroke*
- *Residual BN from piston underside drain is too high*

➔ *Feed rate should be further reduced*

W8X92

Inspection at 4'030 rhs

- *All units in good condition*
- *Oil in use: BN100*
- *Engine load 40-60%*
- *2.75 % sulphur*
- *Feed rate: 0.9 g/kWh*



W-X92 Service Experience – Piston Running



W8X92

Inspection at 4'030 rhs

- Piston ring in good condition
- Clean piston ring pack
- Moderate deposits on piston head
- Top piston ring with good contact area

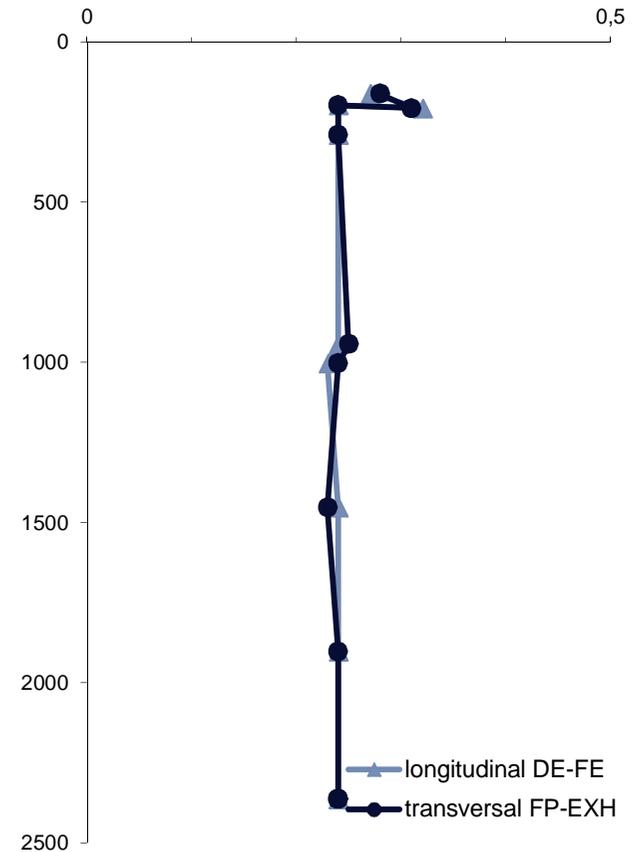
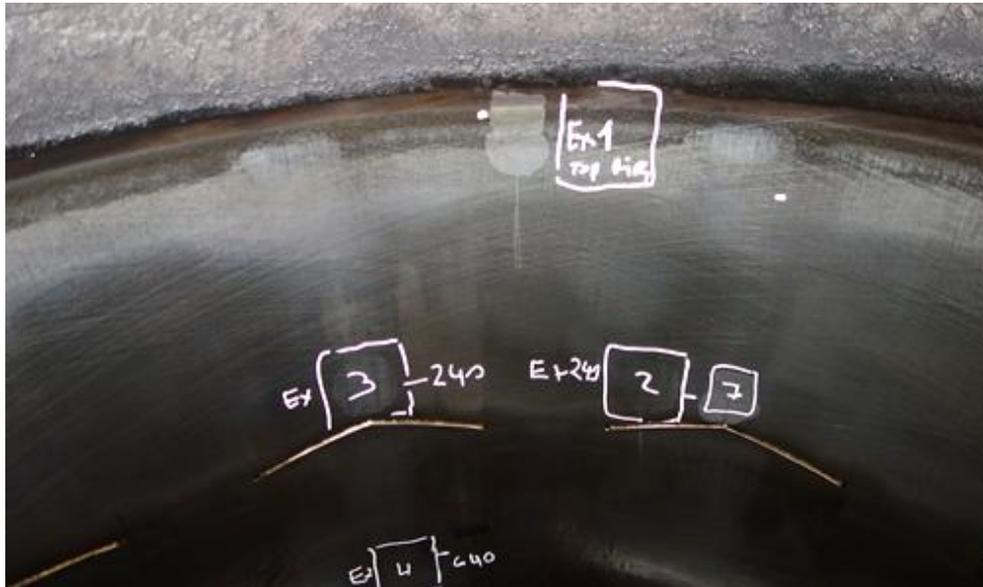


W-X92 Service Experience – Piston Running

W8X92

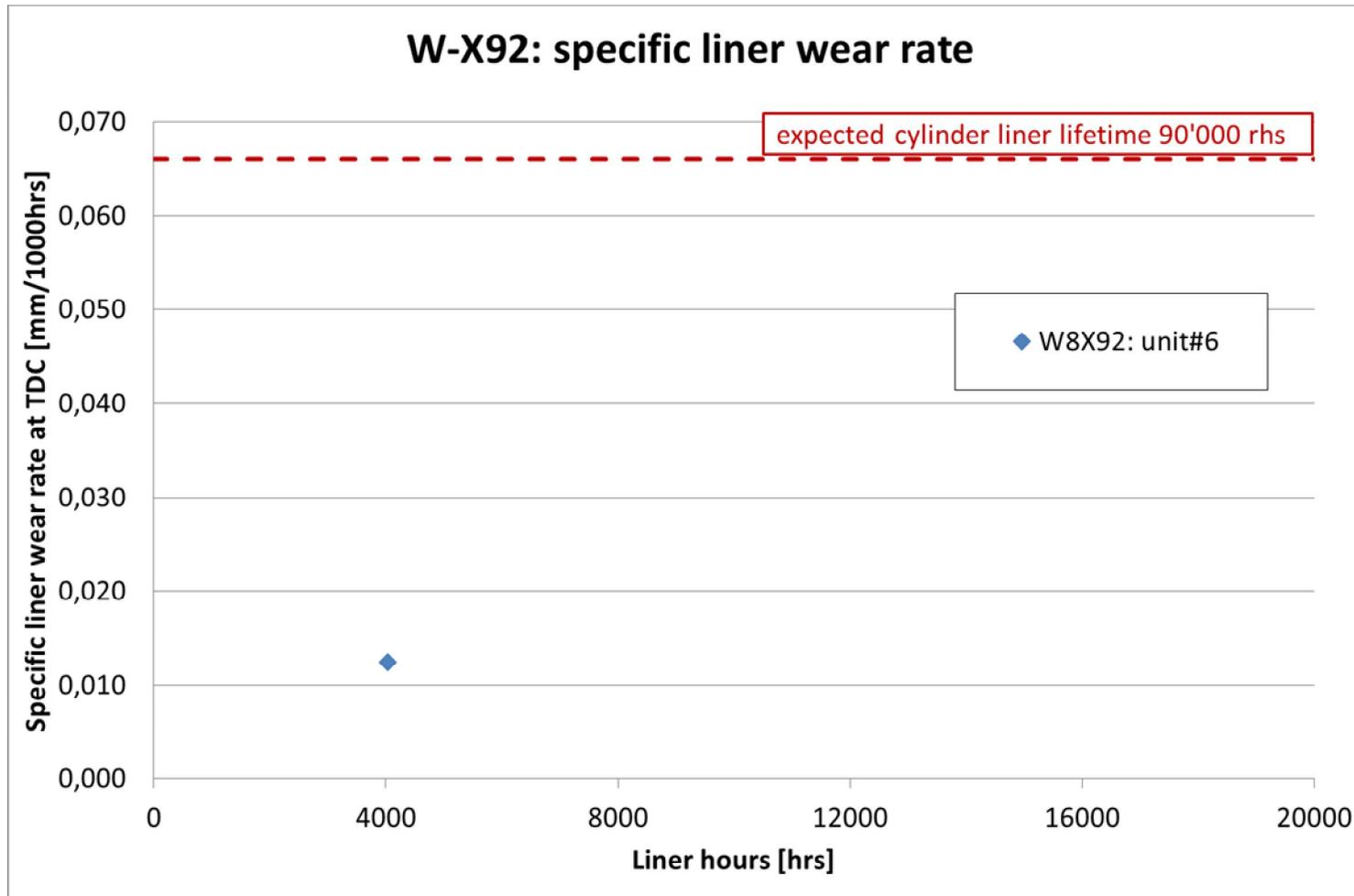
Inspection at 4'030 rhs

- Nearly no wear
- Measured wear rate: 0.01 mm/1000h



Liner wear profile

W-X92 Service Experience – Piston Running



X92 piston running concept with excellent specific liner wear rate

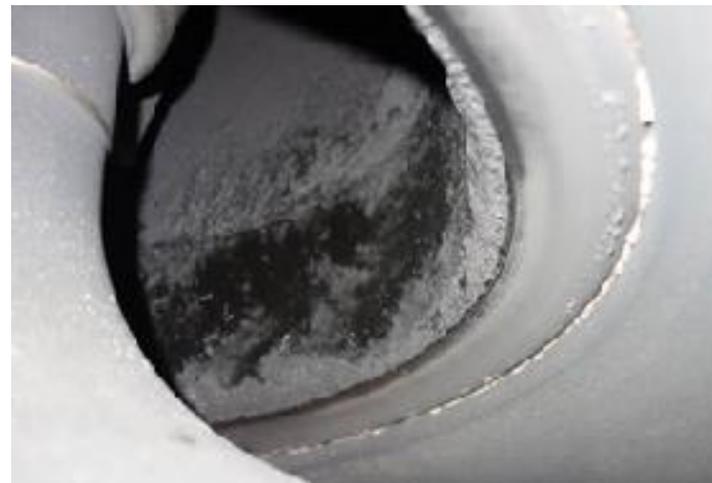
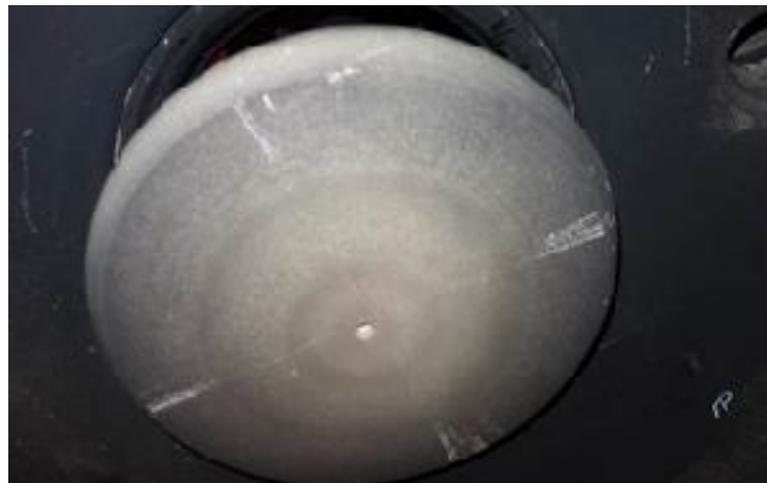
Service Experience – Combustion Chamber



W8X92

Inspection at 4'030 rhs

- *Injector nozzle tips*
 - *Exhaust valve*
 - *Exhaust valve seat*
- ✓ *Good condition*

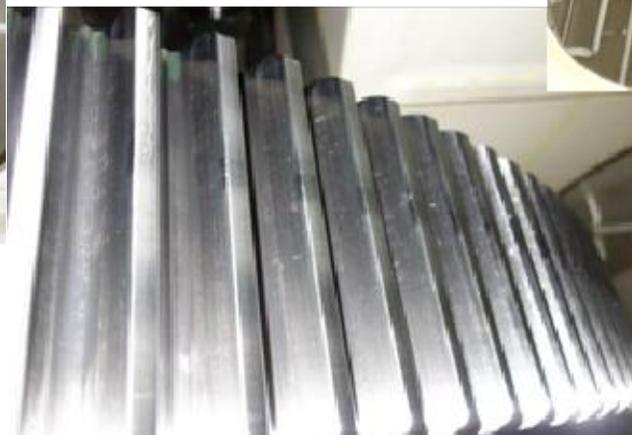


W-X92 Service Experience – Crankcase



W8X92
Inspection at 4'030 rhs

- Clean crankcase
- No abnormality
- ✓ Good condition



W-X92 Service Experience – Supply Unit



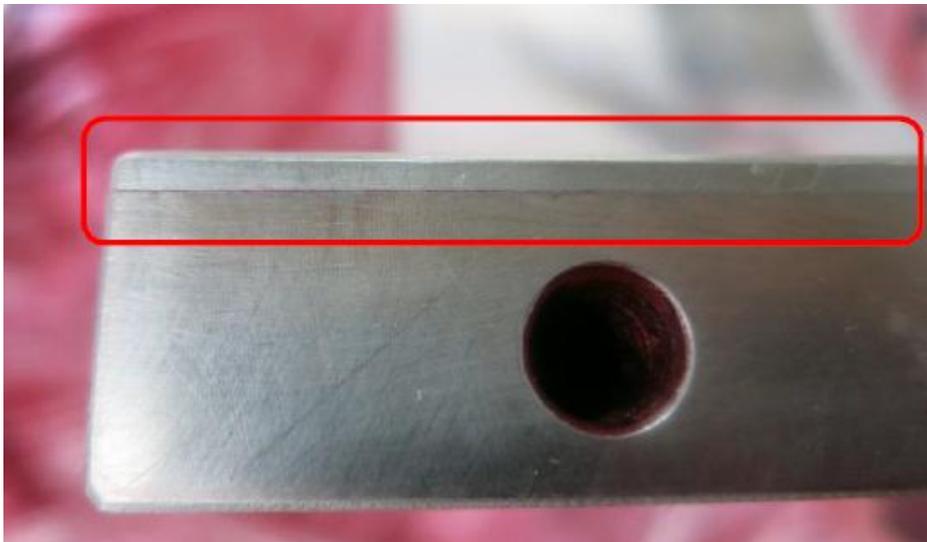
*W8X92 – Supply unit
Inspection at 789 rhs*

- *Camshaft in good condition*
- *All fuel oil pump rollers visually inspected and in excellent condition*



Service Experience – Main Bearing Quality

- *Some main bearing shells of first engine showed no bonding after shop test*
 - *Gap existing between steel back and white metal*
- *Root cause analysis was thoroughly done*
 - *Design*
 - *Manufacturing quality*
 - *Dimensions*
 - *Assembly*



Some oil was coming out from the gap(de-bonding)

Service Experience – Main Bearing Quality

Design, dimensions, assembly

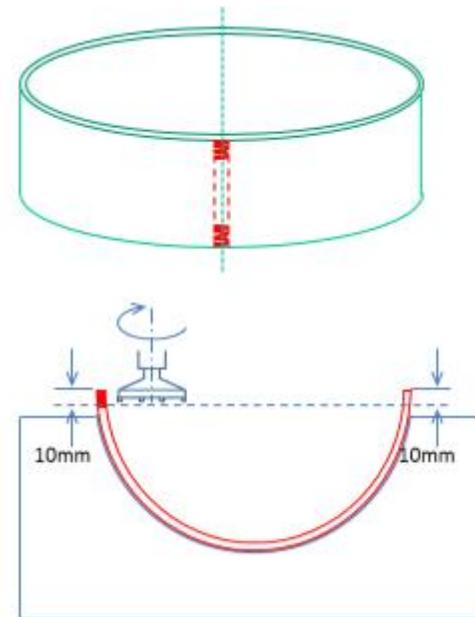
- ✓ *Checked, no abnormality*

Manufacturing quality

- *Manufacturing procedure reviewed*
- *Some deficiencies found*

Manufacturing

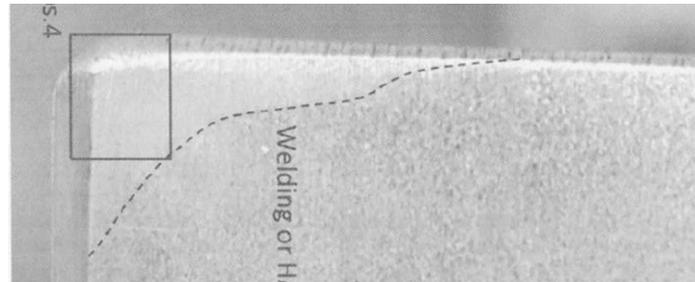
- *Bending plate*
- *Welding*
- *Centrifugal casting*
- *Cutting*
- *Machining*



Service Experience – Main Bearing Quality

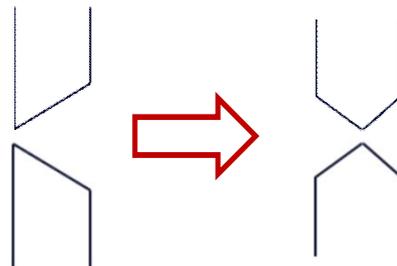
Detected problems

- Surrounding temperature very cold
not possible to keep stable temperature during manufacturing
- Welding influence on bonding/material properties



Improvements applied

- Temperature control
- Welding preparation changed from V-shape to smaller K-joint



Service Experience – Main Bearing Quality

Conclusion

- *Main bearing quality found on first engine after shop test*

- *Root cause analysis done*
 - *Manufacturing quality deficiencies found*
 - *Improvements introduced*
 - *Quality improvement validated by material expert audit*
 - *Test pieces produced and checked*

- *Further engines in production carefully checked*
 - *No reoccurrence*

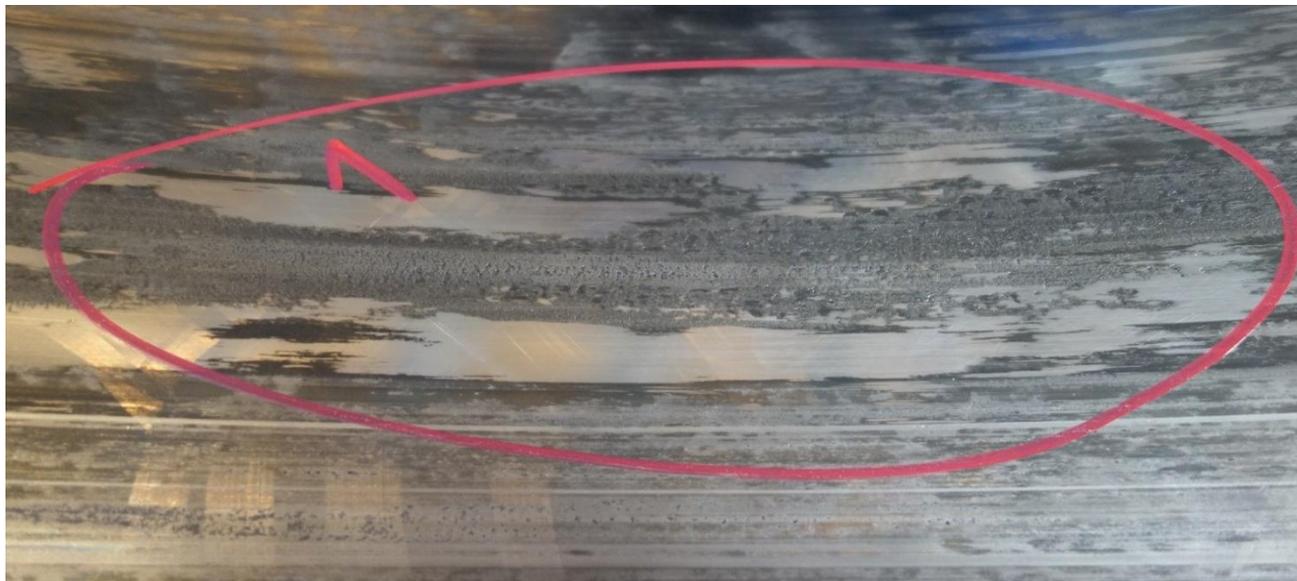
- ✓ *Problem solved before first engine delivery*

Service Experience – Main Bearing #2

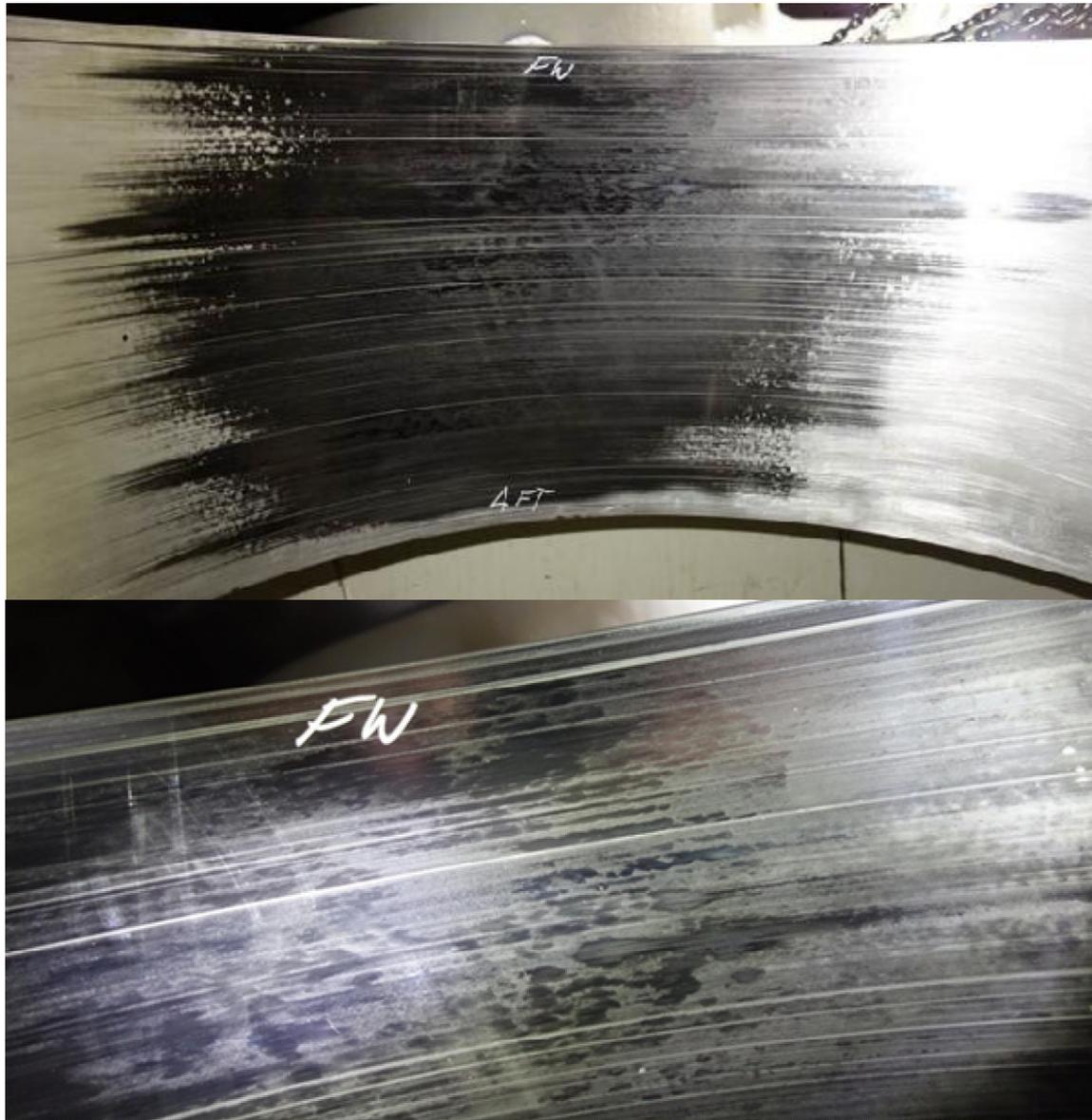


MB#2 at 789h

- Pulled out material
- Probably due to dry turning during assembly
- Shell exchanged
- Main journal in good condition



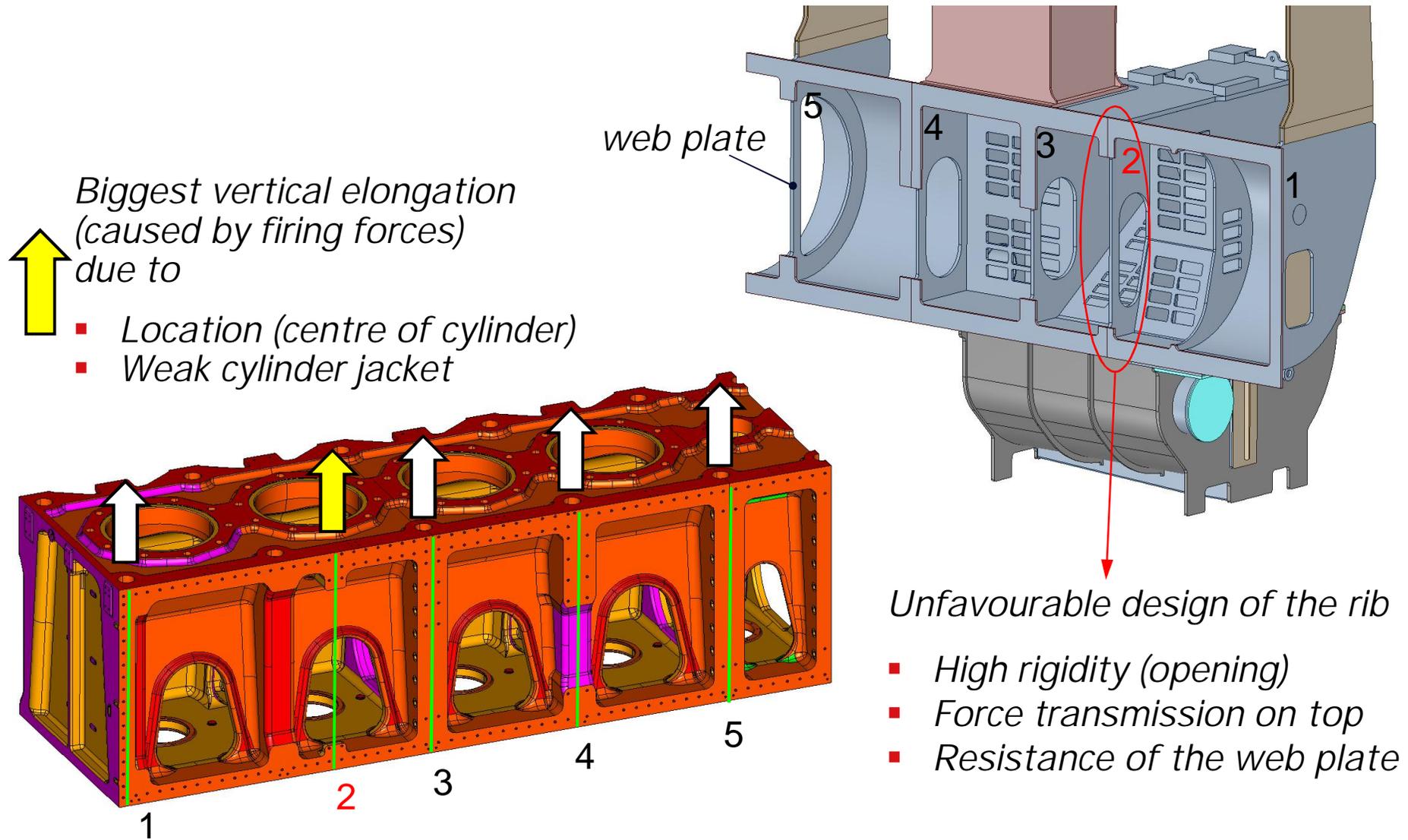
Service Experience – Main Bearing #2



*MB#2 at 4000 h
Shell at 3'200 h*

- *Running marks evenly distributed*
- *No pulled out material*
- *Confirmation of good running behaviour*
- *Main journal in good condition*

Service Experience – Scavenge Air Receiver



Biggest vertical elongation
(caused by firing forces)
due to

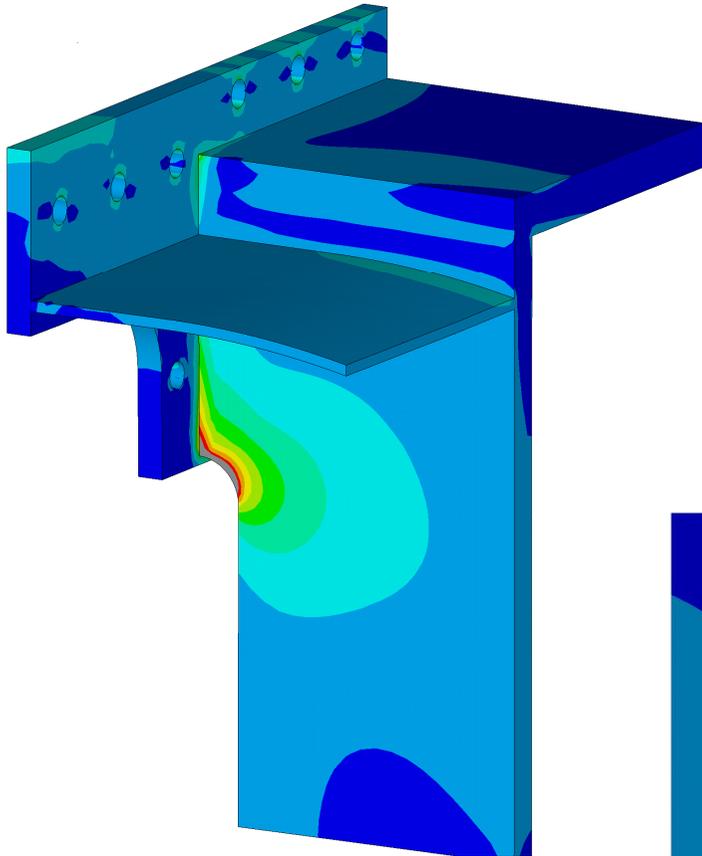
- Location (centre of cylinder)
- Weak cylinder jacket

Unfavourable design of the rib

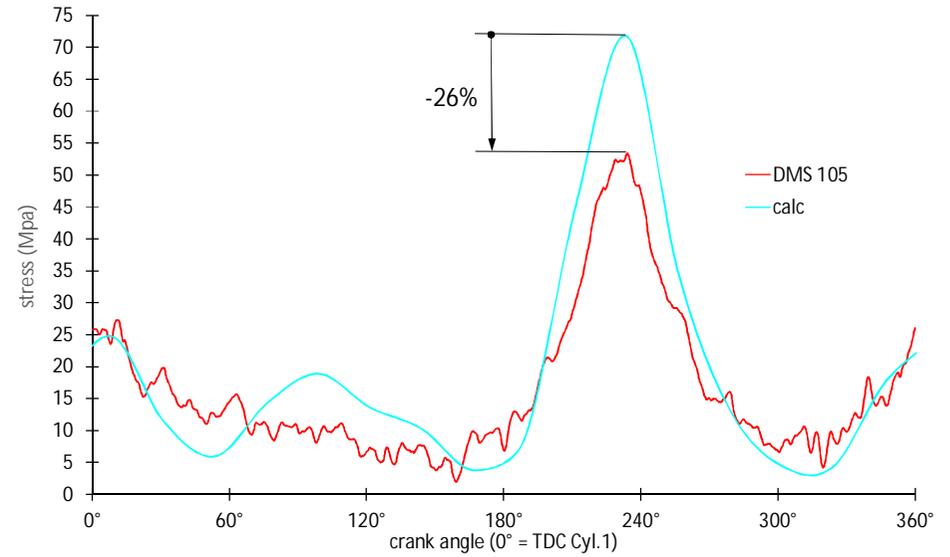
- High rigidity (opening)
- Force transmission on top
- Resistance of the web plate

Service Experience – Scavenge Air Receiver

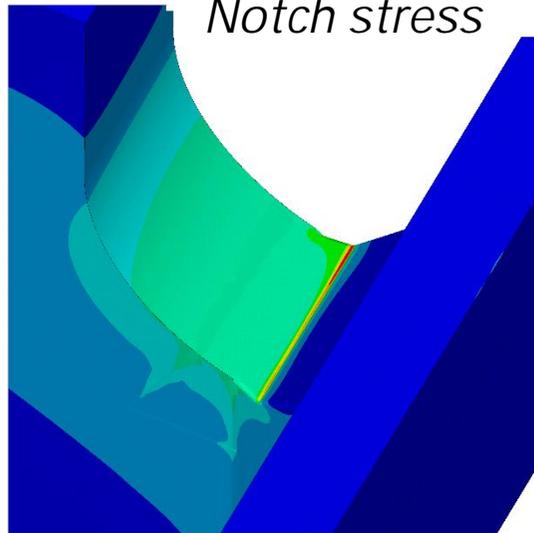
Structural stress



Comparison measured & calculated stresses



Notch stress



Safety not given

→ Design change needed

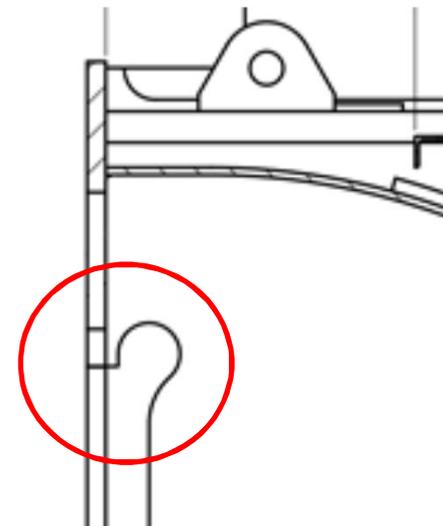
Service Experience – Scavenge Air Receiver

Conclusion and countermeasures

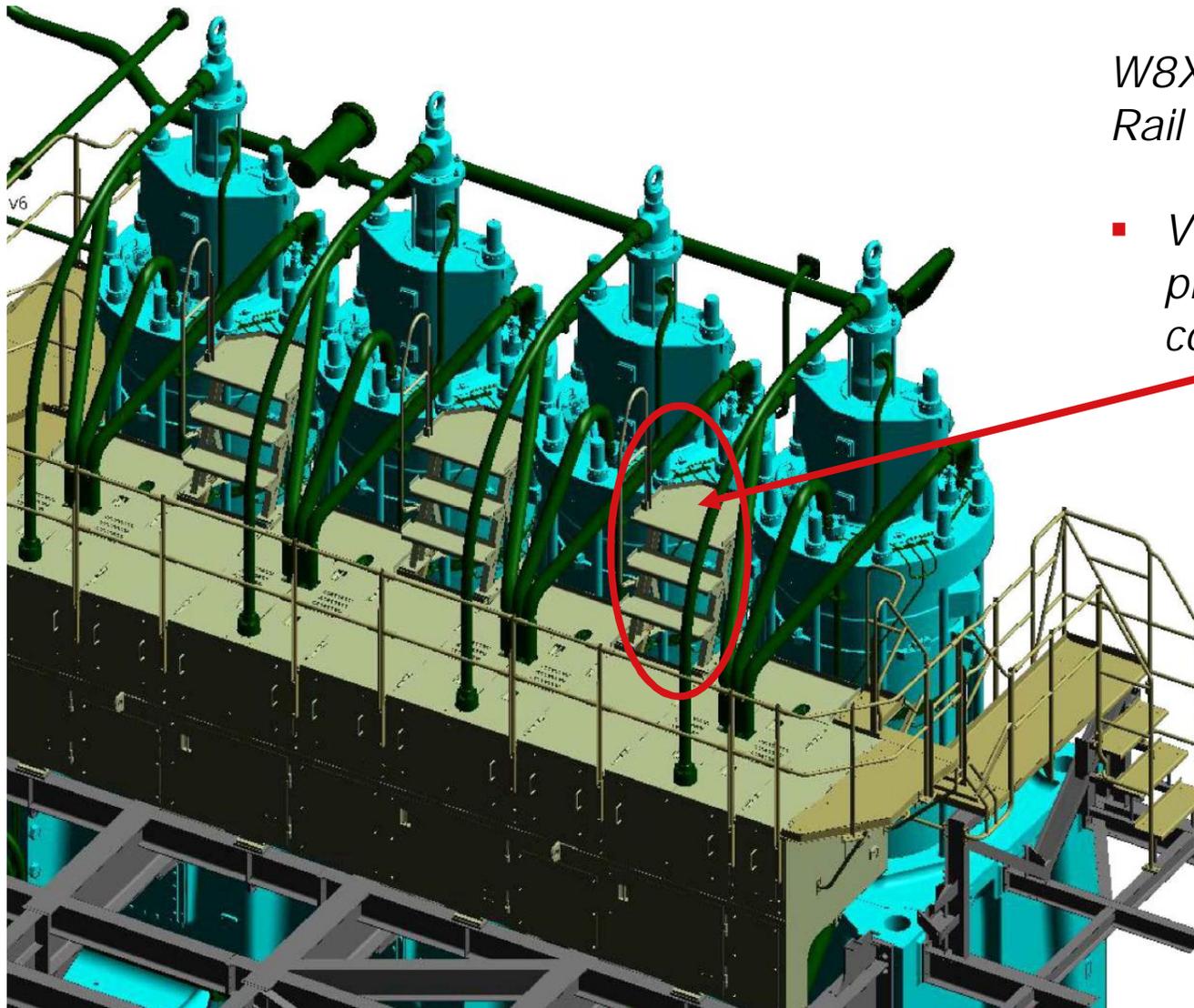
- *First 4 engines produced*
 - *2 ribs per engine to be modified*
 - *Smooth grinding of weld transitions*

- *New engines*
 - *Design change implemented before production*
 - *Stress release shape applied*

- ✓ *Problem solved*



Service Experience – Rail Unit Box



W8X92
Rail unit box

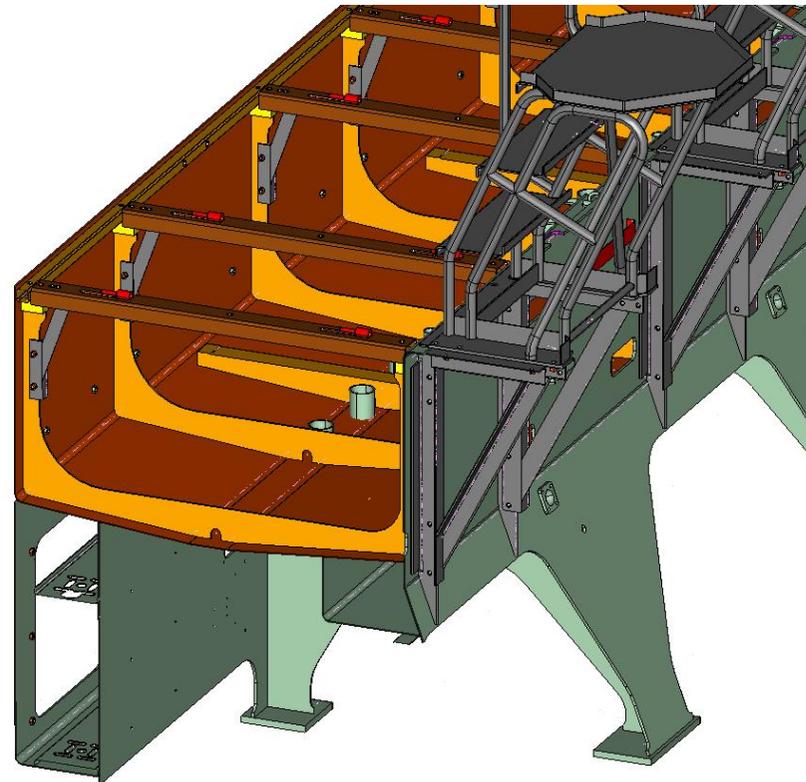
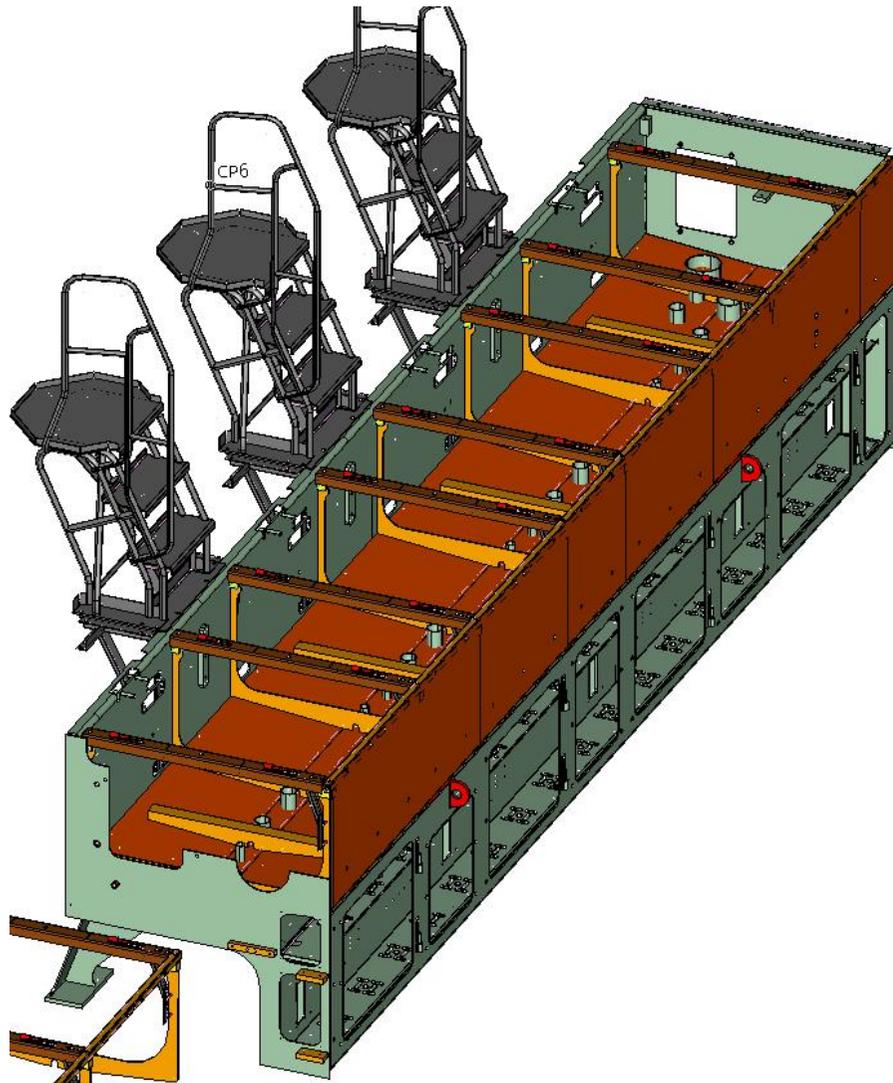
- *Vibration on inspection platform for cylinder cover*

Service Experience – Rail Unit Box

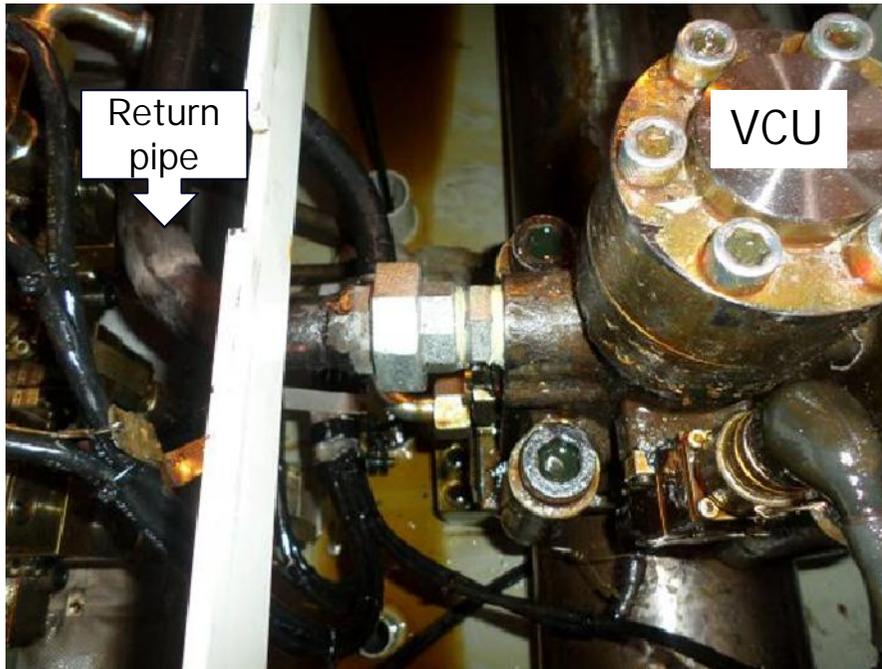
W8X92

Rail unit box

✓ Reinforcement of the complete rail unit box



Service Experience – VCU Return Pipe



W8X92 – VCU return pipe

- Oil leakage at the connection
- Possible due to not correct pre-assembly
- Retrofit solution designed



W-X92 – Conclusions

- *Basic W-X92 engine development finished*
- *First engines shop tested within 2015*
 - *All measurements, temperatures, stresses & vibrations within limits*
 - *TAT successfully carried out in August 2015*
 - *Field follow-up defined and planned*
- *28x W-X92 engines on order*
- *Three W8X92 engines in service since end Oct. 2015*
 - *General service experience very successful*
 - *Excellent piston running service experience*
 - *Crank train bearings without complaint*

The W-X92 engine is a very competitive prime mover for Post Panamax Container Vessels

W-X92 – Conclusions

- Reliability
 - Proven designs from W-X35/40/62/72/82
 - Extensive validation

- Performance
 - Ultra-low engine speed
 - Flex system
 - Advanced cylinder lubrication system

- Cost optimised
 - Design for manufacturing
 - Total Cost of Ownership

- TIER III READY