

# *Mitsubishi UE Engine Updates New UEC LSH-Eco Series and Service Results*

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 **MITSUBISHI HEAVY INDUSTRIES MARINE MACHINERY & ENGINE CO., LTD.**

- 1. Overview of Mitsubishi UE engine**
- 2. Introduction of UEC50LSH-Eco**
- 3. Technical features of UEC50LSH-Eco**
- 4. Service experiences of UEC50LSH-Eco**
  - Verification on shop test and sea trial**
  - Verification in-service vessel**
- 5. Compliance with IMO-NOx Tier III regulation**
- 6. Conclusion**

## 1. Overview of Mitsubishi UE engine

## 2. Introduction of UEC50LSH-Eco

## 3. Technical features of UEC50LSH-Eco

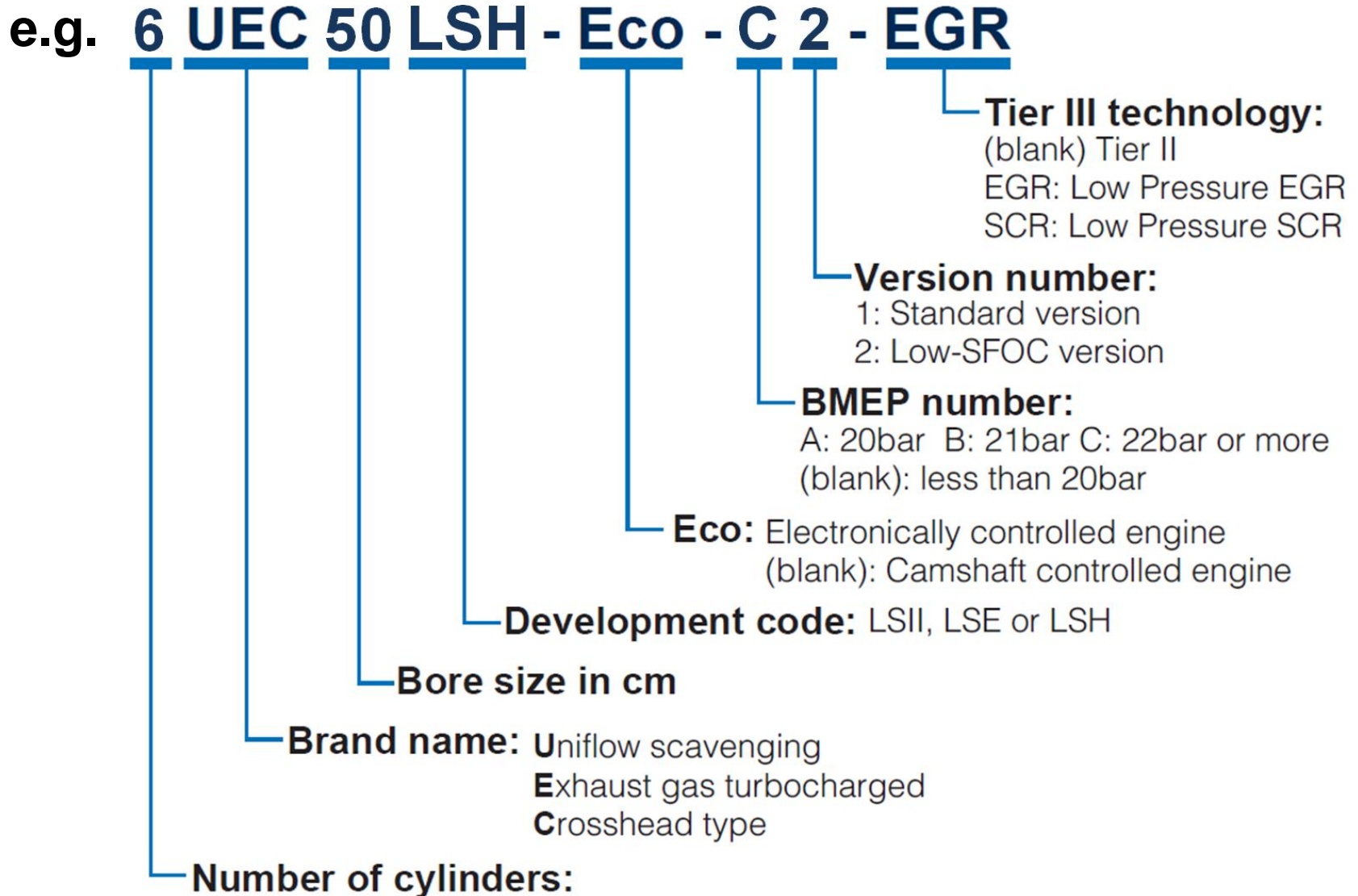
## 4. Service experiences of UEC50LSH-Eco

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## 5. Compliance with IMO-NOx Tier III regulation

## 6. Conclusion

# New UE Engine Line-Up



# Production Records latest LSE & LSH series

As of May.,2016

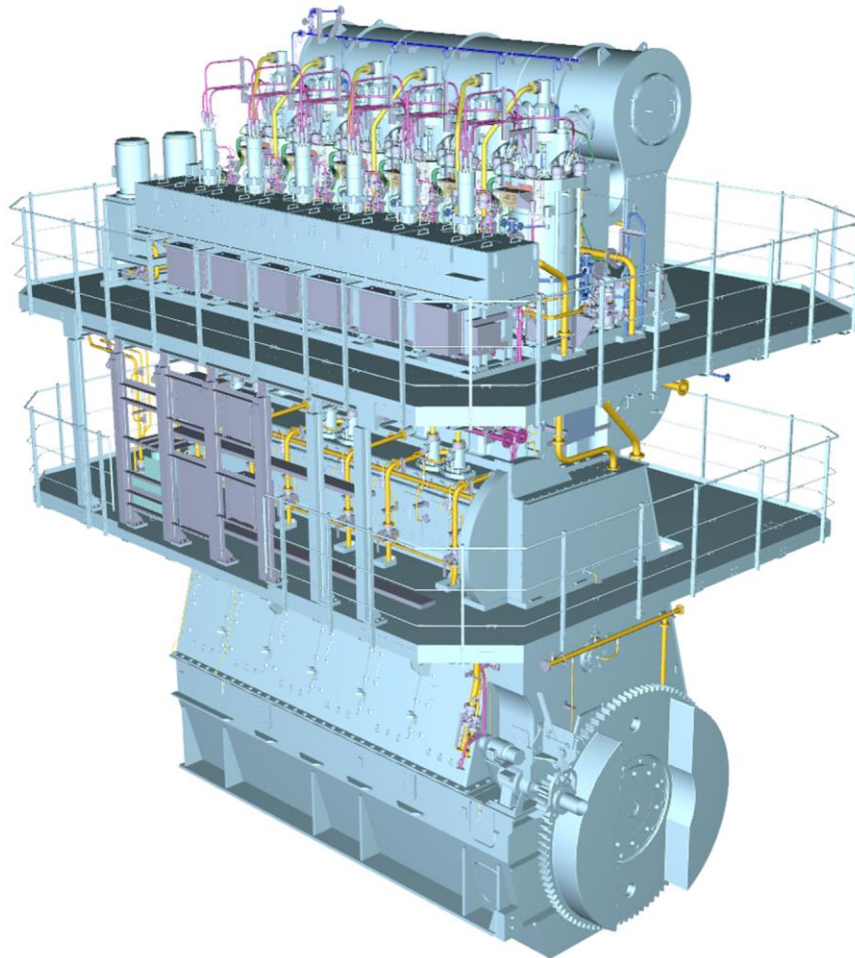
Engine type	Ordered	Delivered	1st set in service
UEC60LSE	28	18	2008. 6 (2014.10 Upgrade)
UEC45LSE	234	195	2008.12 (2014.3 Upgrade)
UEC35LSE	4	1	2014. 6
UEC33LSE	13	3	2014.12
UEC50LSH	21	1	2015. 9

➤ Number of order and manufacturing of latest series are increasing steadily.

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# Development concept of UEC50LSH-Eco-C2

- Researched and analyzed thorough market needs.
- The UEC50LSH-Eco-C2 is one of the best engine satisfying worldwide needs.



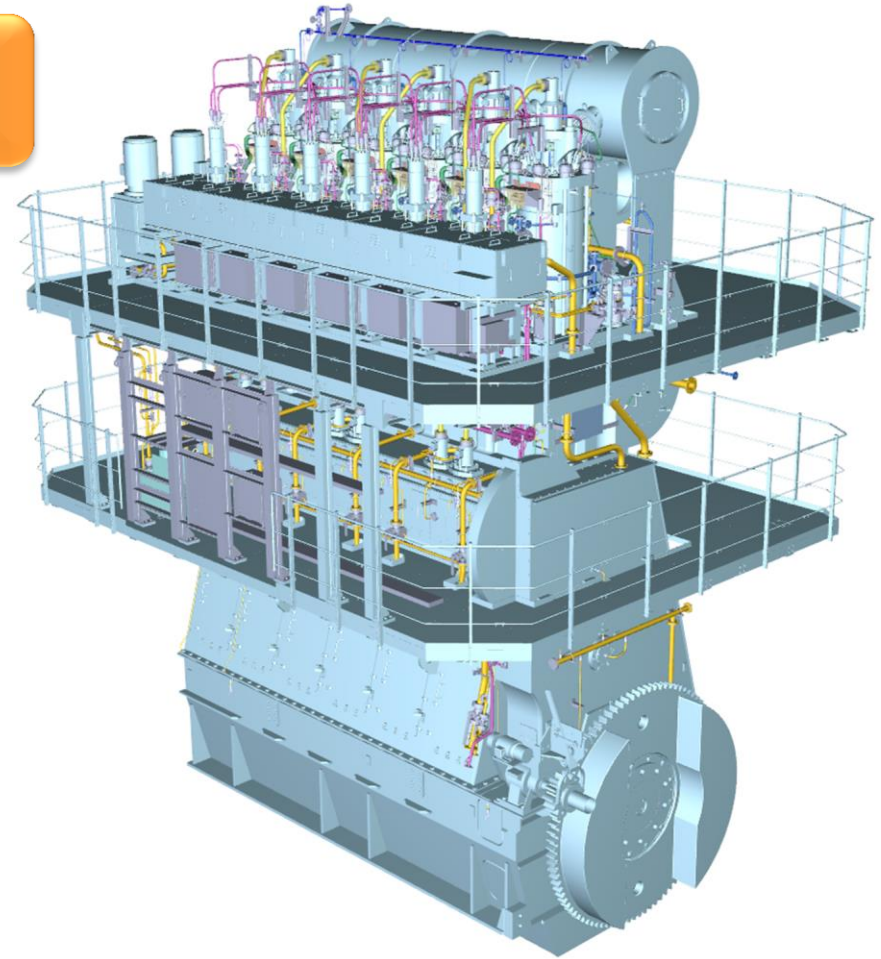
# Development concept of UEC50LSH-Eco-C2

**1. Lower daily fuel oil & cylinder lubricating oil consumption**

**2. Wide rating field**

**3. Compact engine size**

**4. Reliable structure**

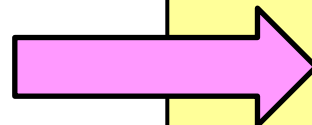


6UEC50LSH-Eco-C2



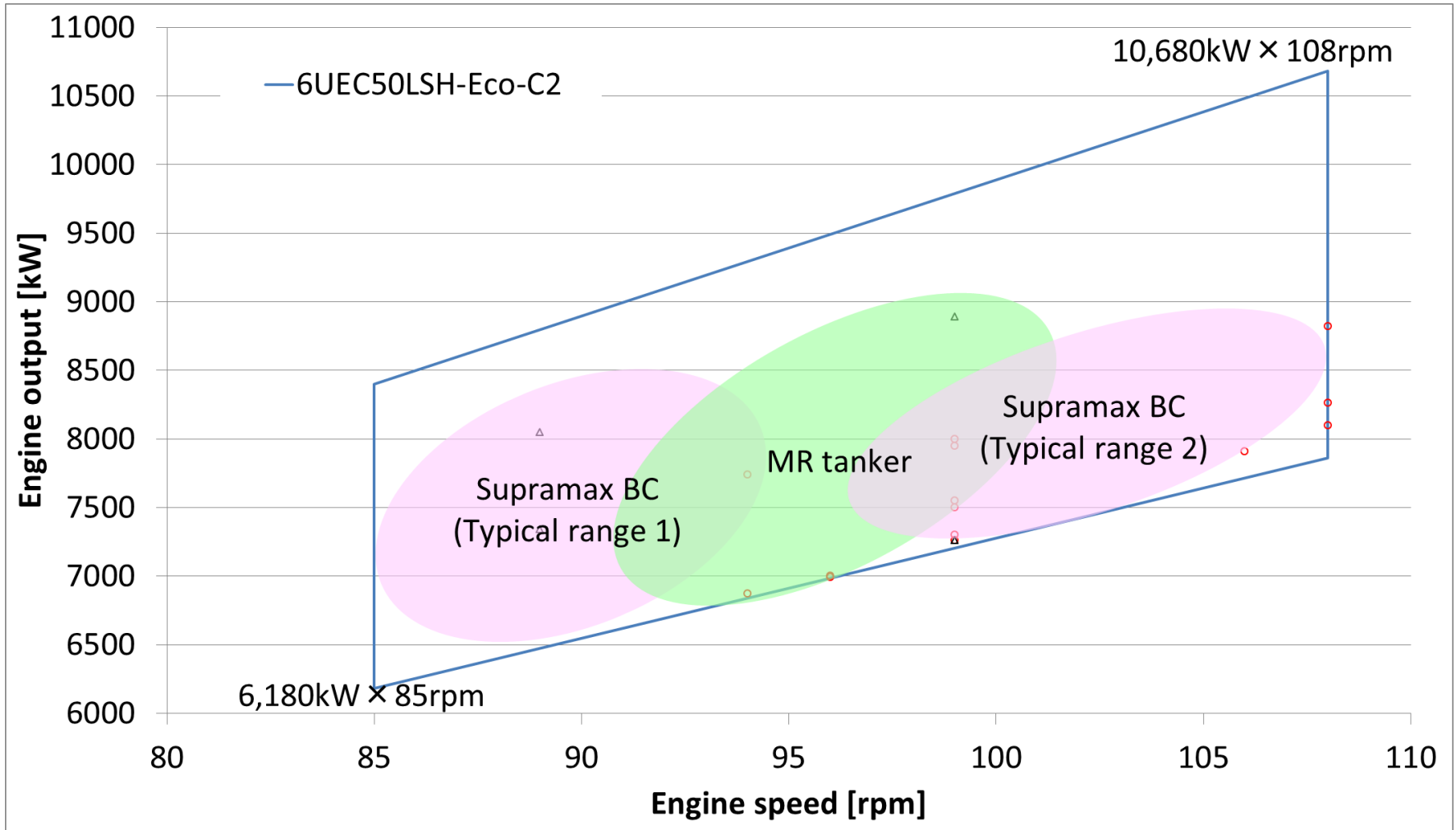
- Improved trade-off relationship between SFOC and NOx by optimized fuel injection rate
- Reduced mechanical loss by optimized configuration of running parts

Engine type		6UEC50 <b>LSE</b> -Eco-B1	6UEC50 <b>LSH</b> -Eco-C2
Bore	mm	500	500
Stroke	mm	2,050	<b>2,300</b>
Stroke / Bore	-	4.1	<b>4.6</b>
Rated output	kW	10,500	10,680
Engine speed	min <sup>-1</sup>	124	108
BMEP	bar	20.0	21.9
Piston speed	m/s	8.50	8.28
SFOC under IMO-NOx regulation Tier2 With 5% tolerance	g/kWh	167	<b><u>164</u></b>

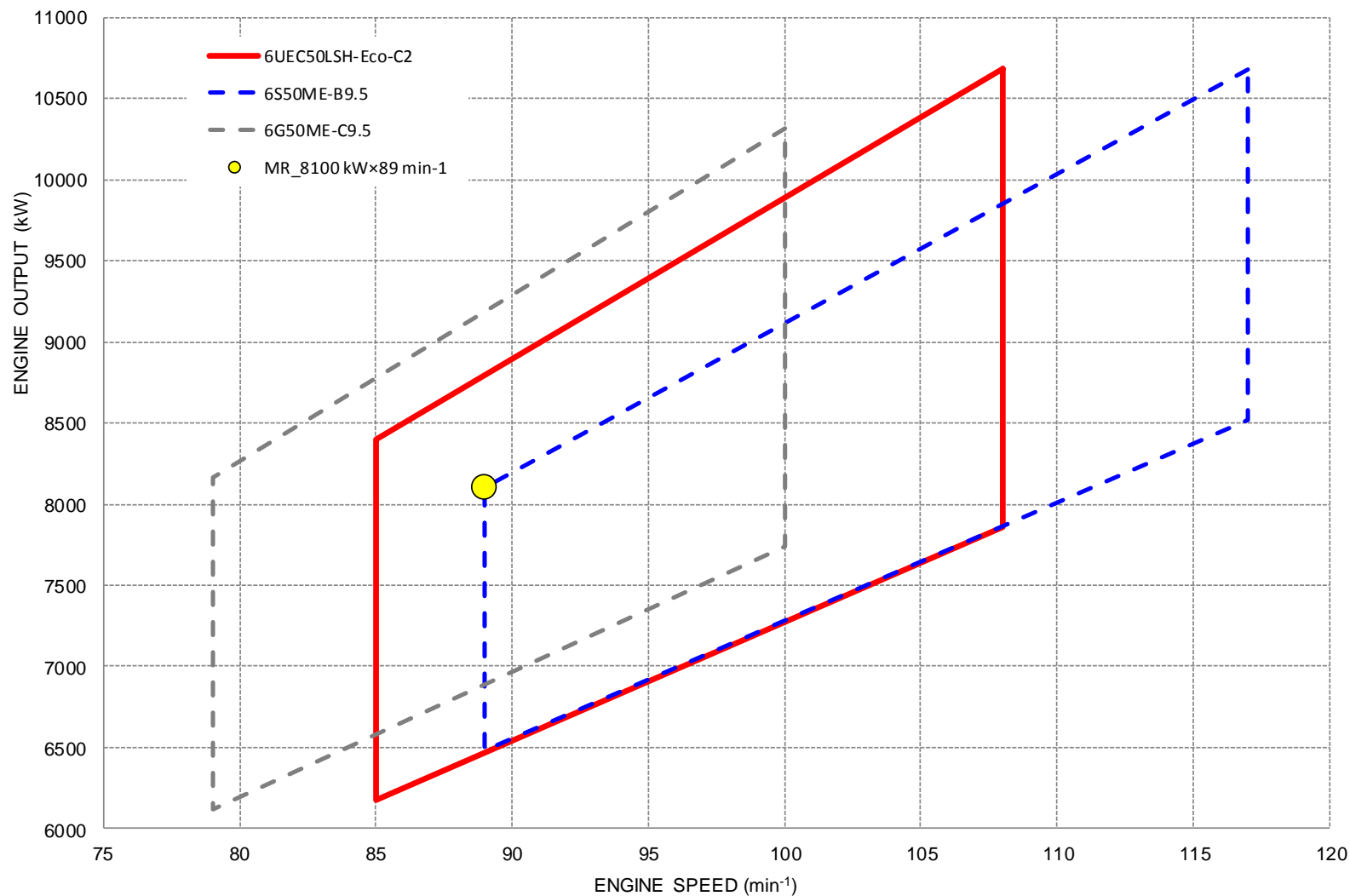


# Wide rating field

- Cover various ships by its wide rating field
- Contribute to flexible planning for shipyards

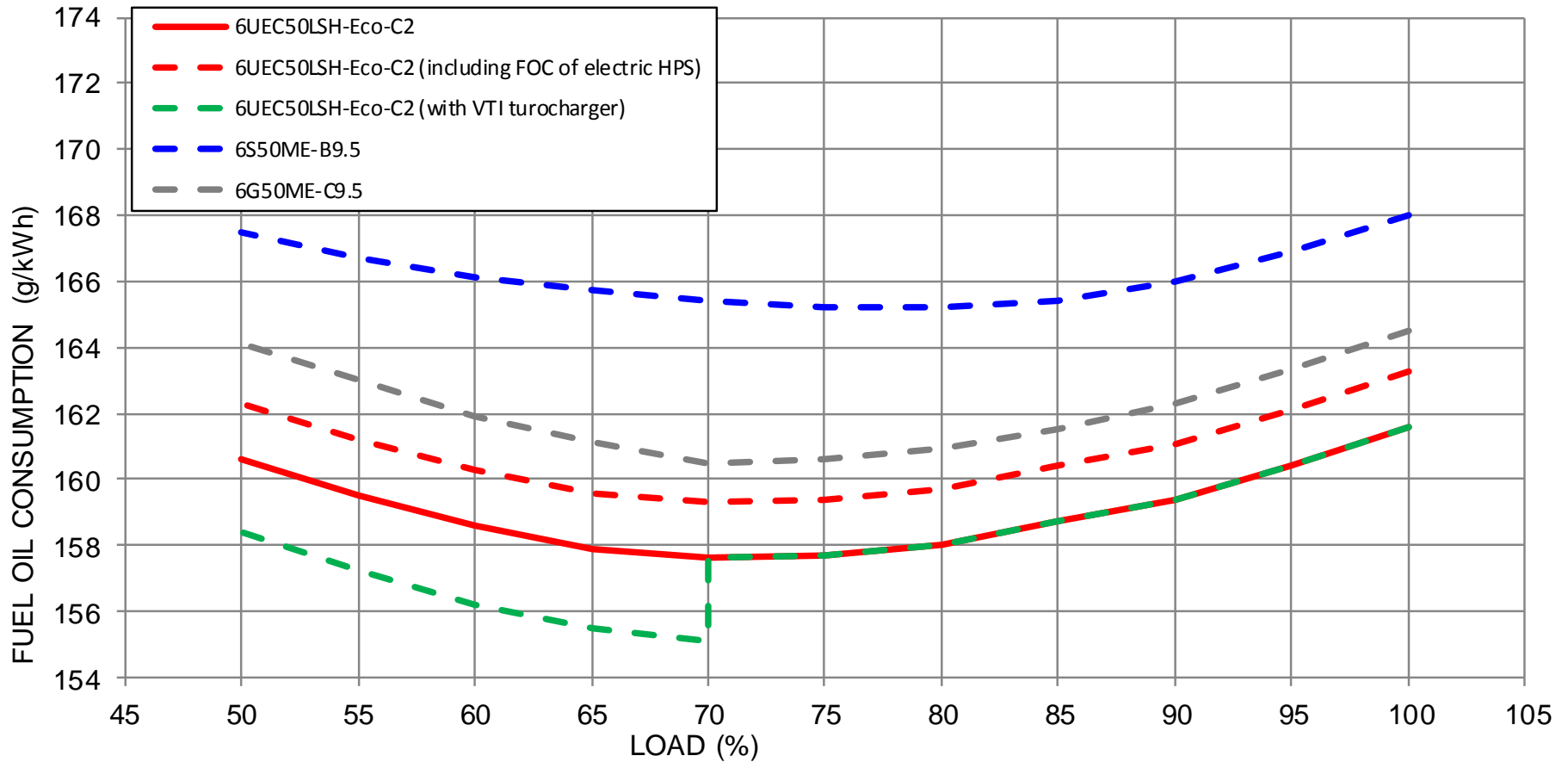


# Rating Field



# Comparison of SFOC Curve

MR: 8,1000kW × 89 min<sup>-1</sup>



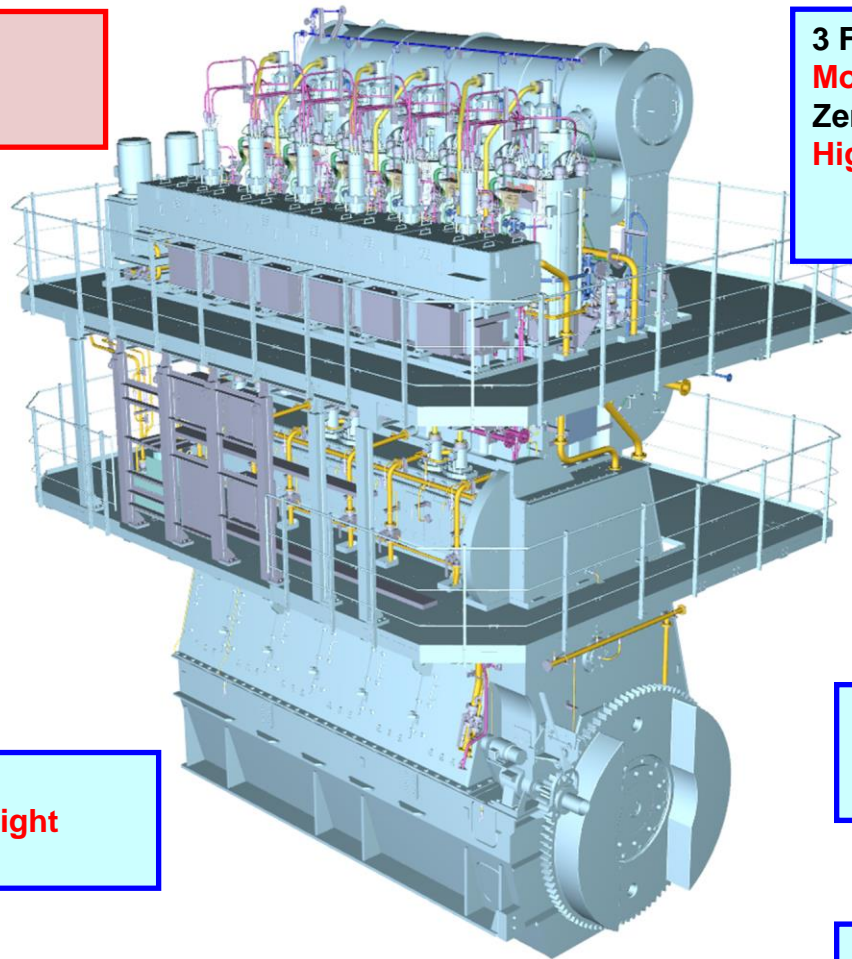
SFOC of UEC50LSH-Eco-C2 is lower than competitor's engines at all load.

- Various analysis and past technical know-how are used to achieve compact and light design **against longer piston stroke.**
- UEC50LSH-Eco engine was designed so as to be replaced easily by same footprint and compact outline.

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# Principle Structure

New concept Eco system  
⇒ **SFOC reduction** by new  
ECO system



3 FOVs per cylinder  
**More uniform combustion**  
Zero-sac FOV  
**Higher reliability** by reduction of HC

**Higher reliability**  
For  
Exhaust valve  
Piston  
Piston ring  
Cylinder liner

Bedplate & Column  
**High stiffness and light weight**

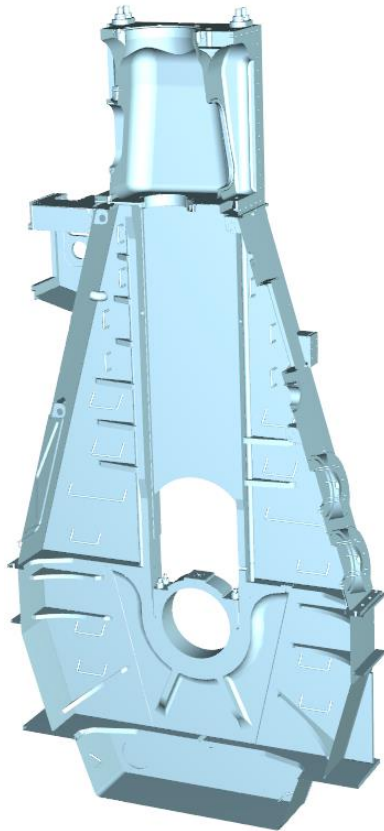
A-ECL system  
⇒ **Reduction of running cost** by  
lower cylinder oil consumption

Main bearing & Crankpin bearing  
⇒ **Improved fatigue strength**  
by aluminum metal

□ Proven design by existing LSE-series

□ New design for 50LSH

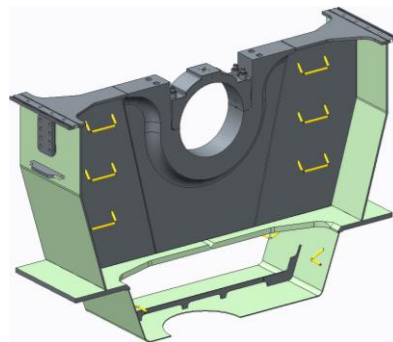
➤ Stiffness and weight of these structures were optimized by FEM and EHD analysis.



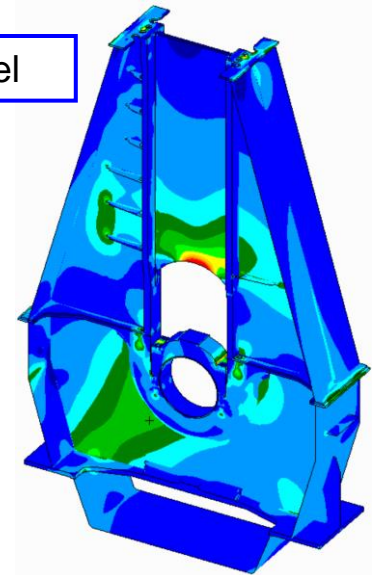
➤ Cylinder jacket is highly stiff and light weight by optimized shape

➤ Highly stiff single wall structures are applied to bedplate and column

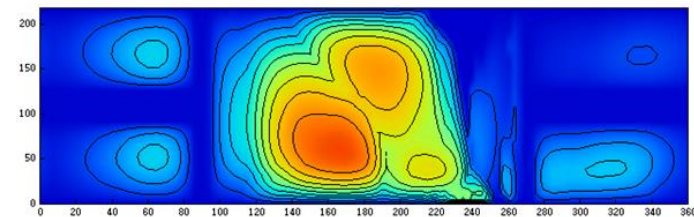
➤ Less deformation of bedplate thanks to twin stay tie bolt on top of bearing girder



FEM model



EHD\* result of main bearing

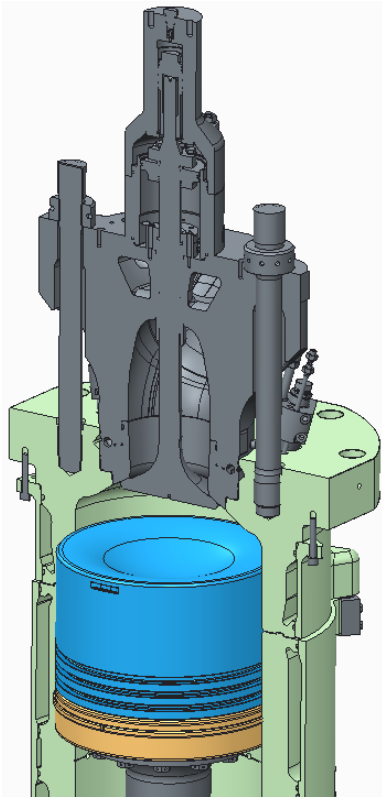


\*EHD : Elastohydrodynamic Lubrication



# Combustion chamber

- The strength and heat condition of combustion chamber were analyzed by FEM and Heat analysis.

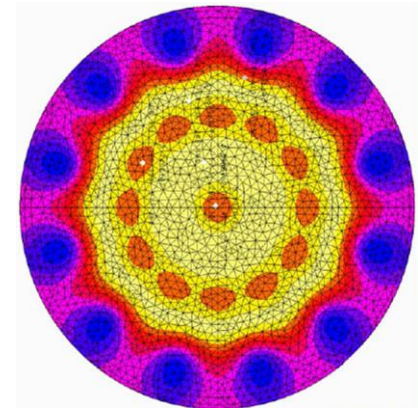
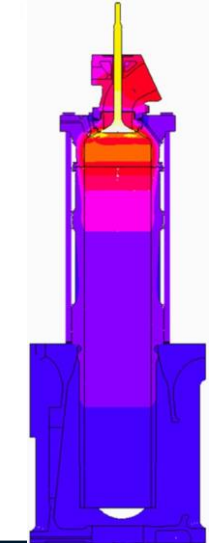
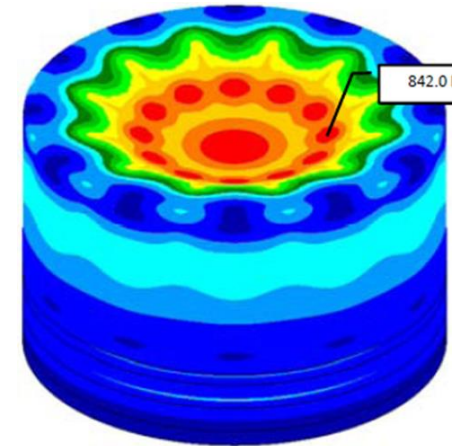
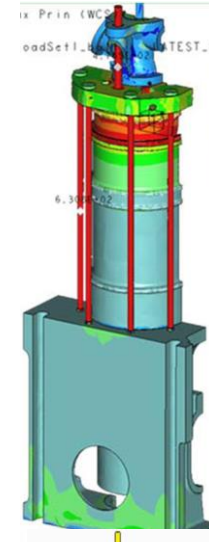


- Nimonic exhaust valve(Standard)
- New heat-resistant material type is available.

- Piston is bore cooling type with high top land

- Temperature is controlled by bypass line of jacket cooling water
- Cylinder liner is non bore cooling type

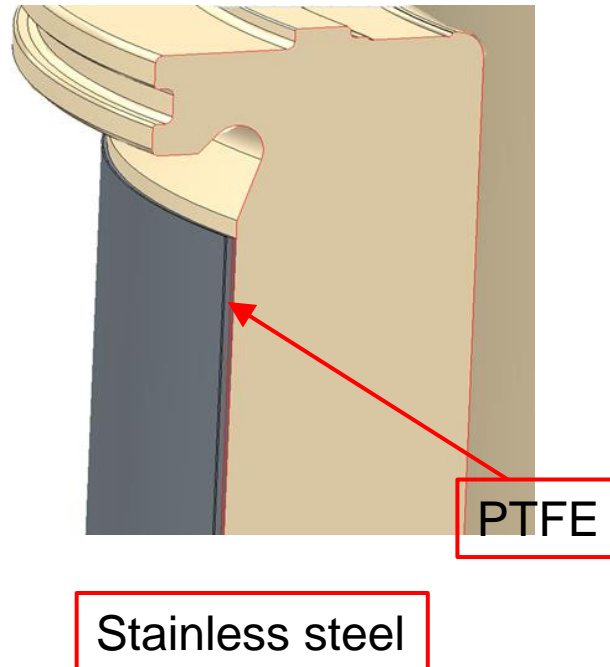
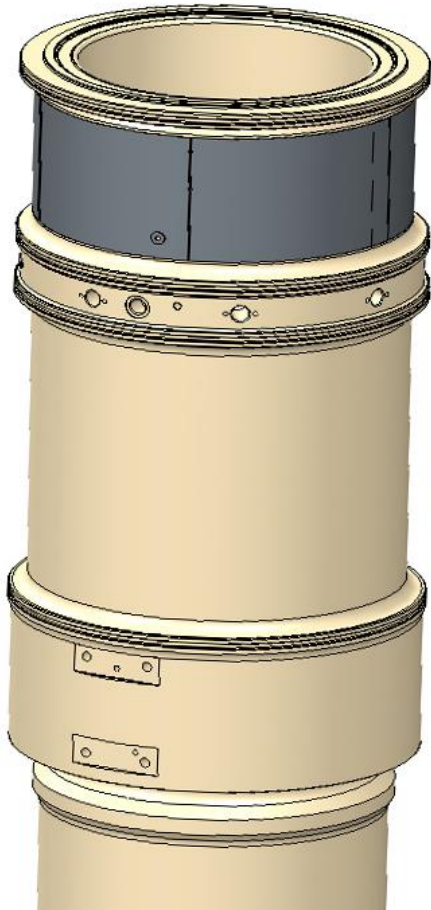
- Well-proven A-ECL\* system  
\*A-ECL : Advanced Electronically Controlled Lubricating system



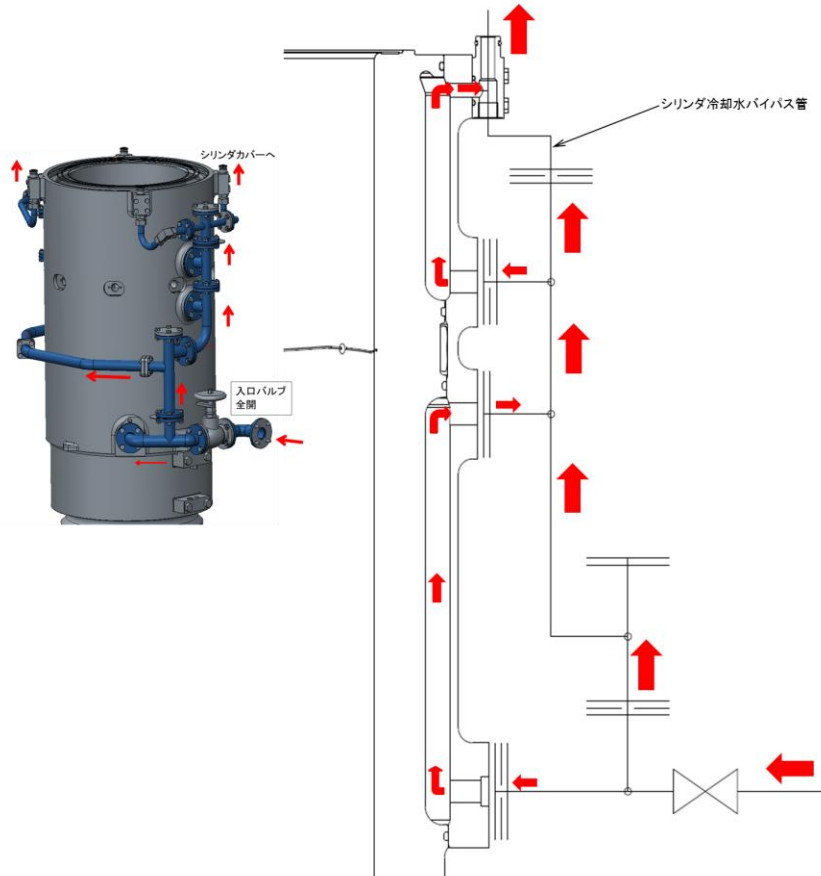
- Optimized cylinder liner temperature by adjustable cooling system and insulation bandage depends on engine rating.
- Optimized position and number of lubricating point on cylinder liner.
- Improved lubricating efficiency by applying Cr-Ce piston ring and plateau honing cylinder liner.
- New recommendation for operation
  - To increase JCW outlet temperature from 85 deg C to 90 deg C.
  - To use BN100 for cyl. lub. oil for  $S > 1.5\%$

# Cylinder liner

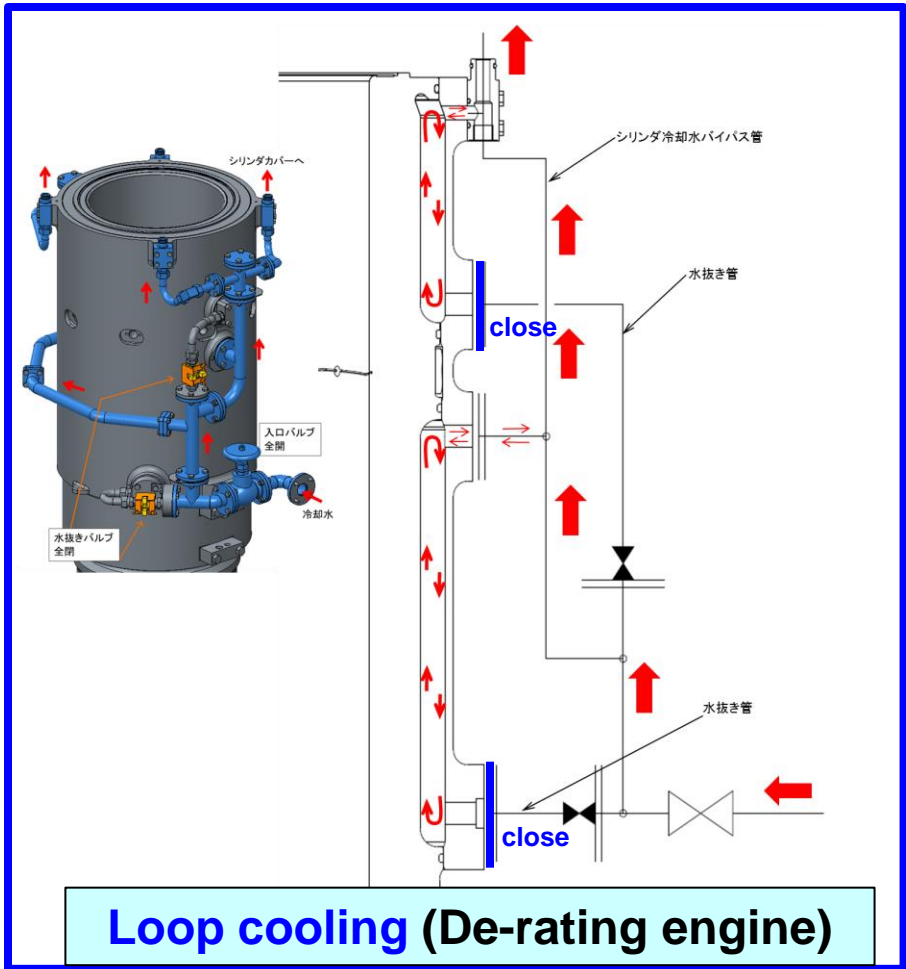
- Insulation bandage is applied at upper part to keep appropriate temperature against slow steaming operation.



# Loop cooling for JCW



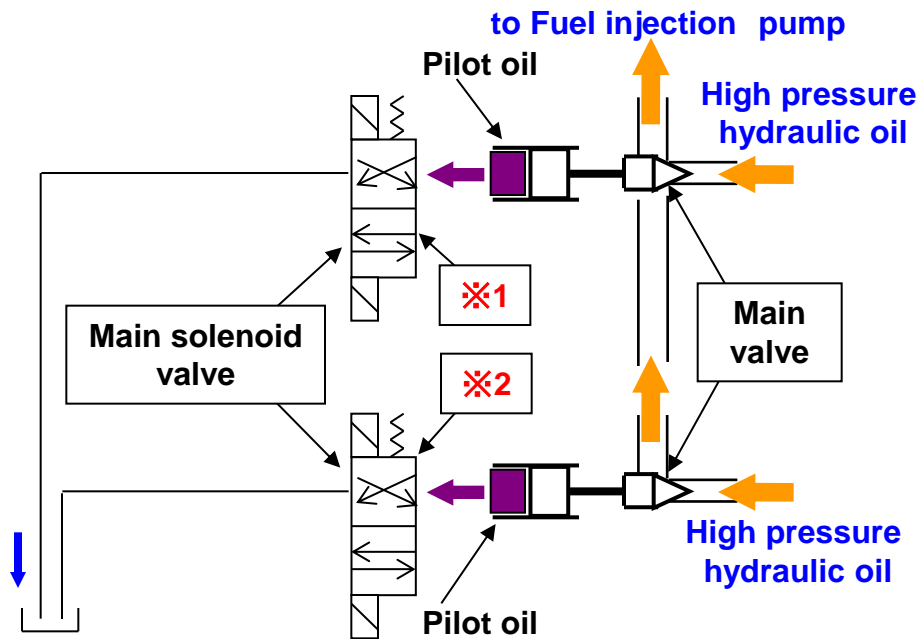
**Uniflow cooling (Higher rating)**



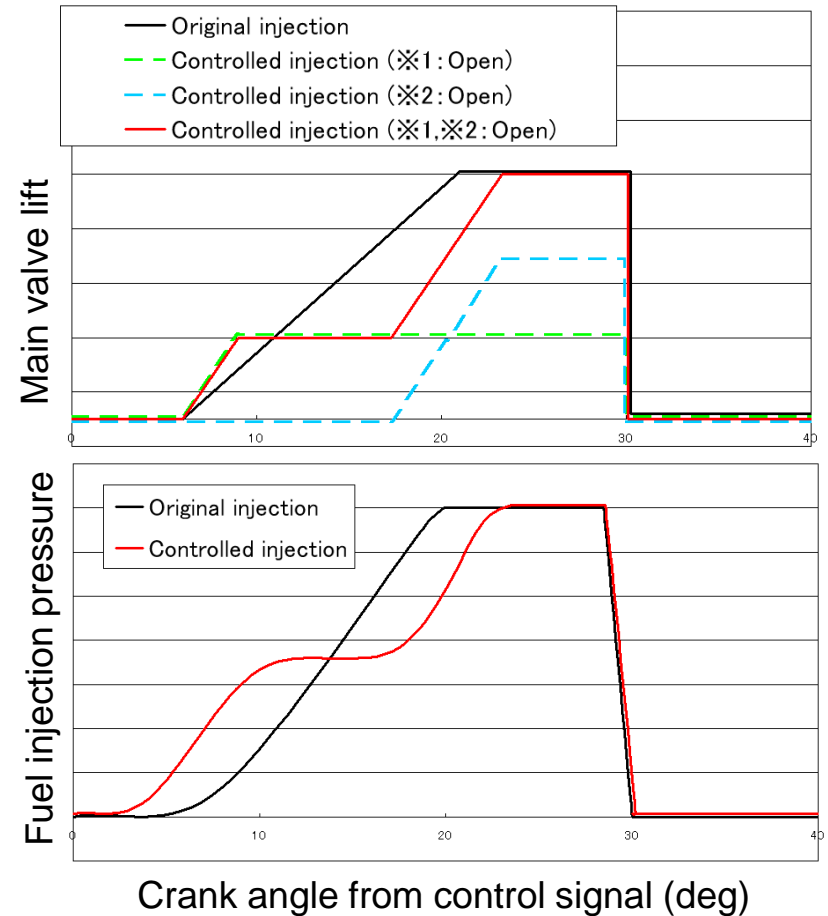
**Loop cooling (De-rating engine)**

- Loop cooling can control liner temperature to avoid low temperature corrosion.
- Optimum specification can be applied for every engine in the rating map.

# Fuel injection rate control



## Concept of fuel injection mode



Fuel injection rate is controlled by differences of main valve's opening timing



Fuel injection rate control improves trade-off relationship of NOx emission and FOC.

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# World-first 6UEC50LSH-Eco-C2 engine

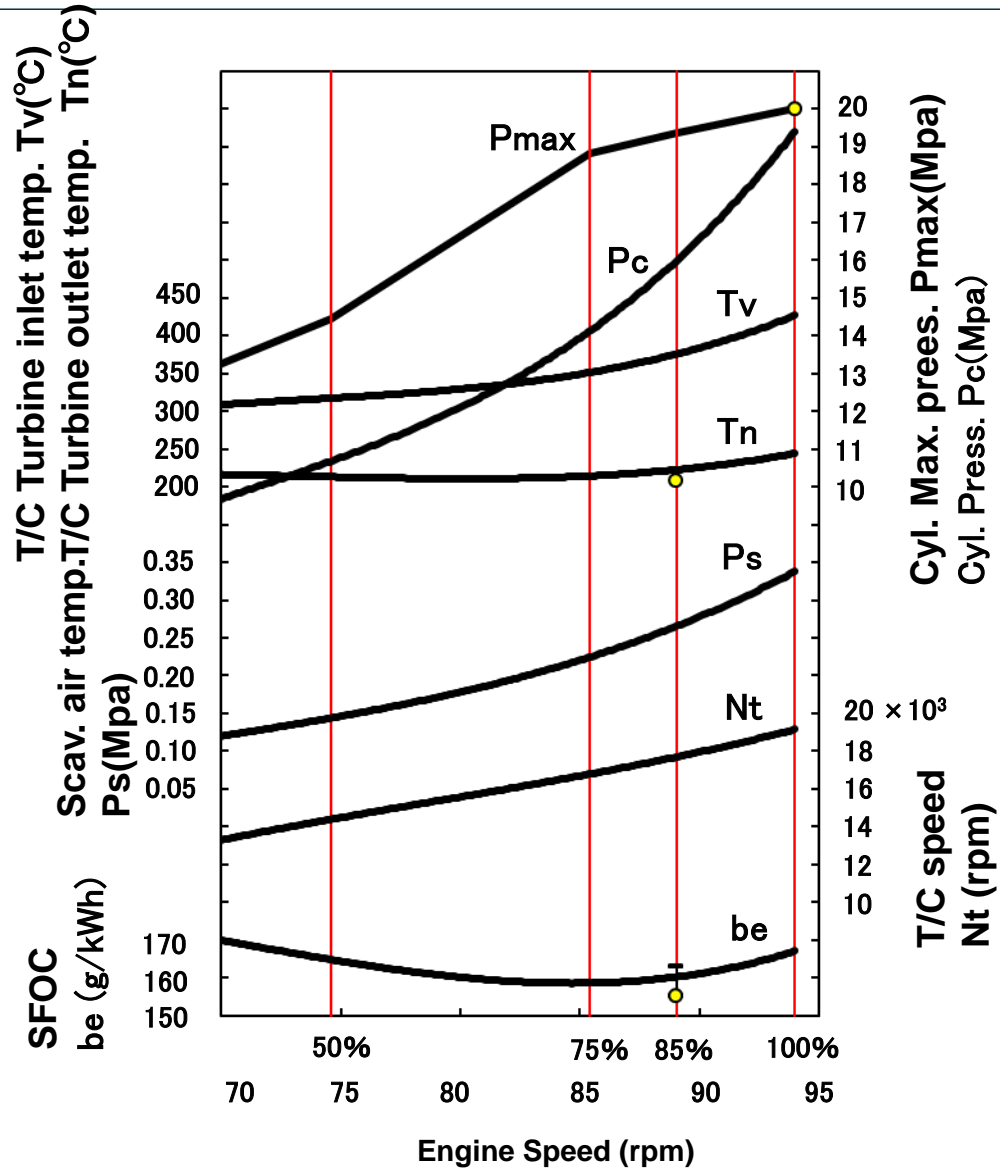


- Engine builder: Kobe Diesel CO.,LTD.
- Engine completion: Feb. 13<sup>th</sup>, 2015
- Shop test: March 3<sup>rd</sup>, 2015
- Sea trial: July 27<sup>th</sup> - 28<sup>th</sup>, 2015
- In-service: Sept. 8<sup>th</sup>, 2015
- Total running hour: Approx.4,000h  
(As of May, 2016)

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# Performance result



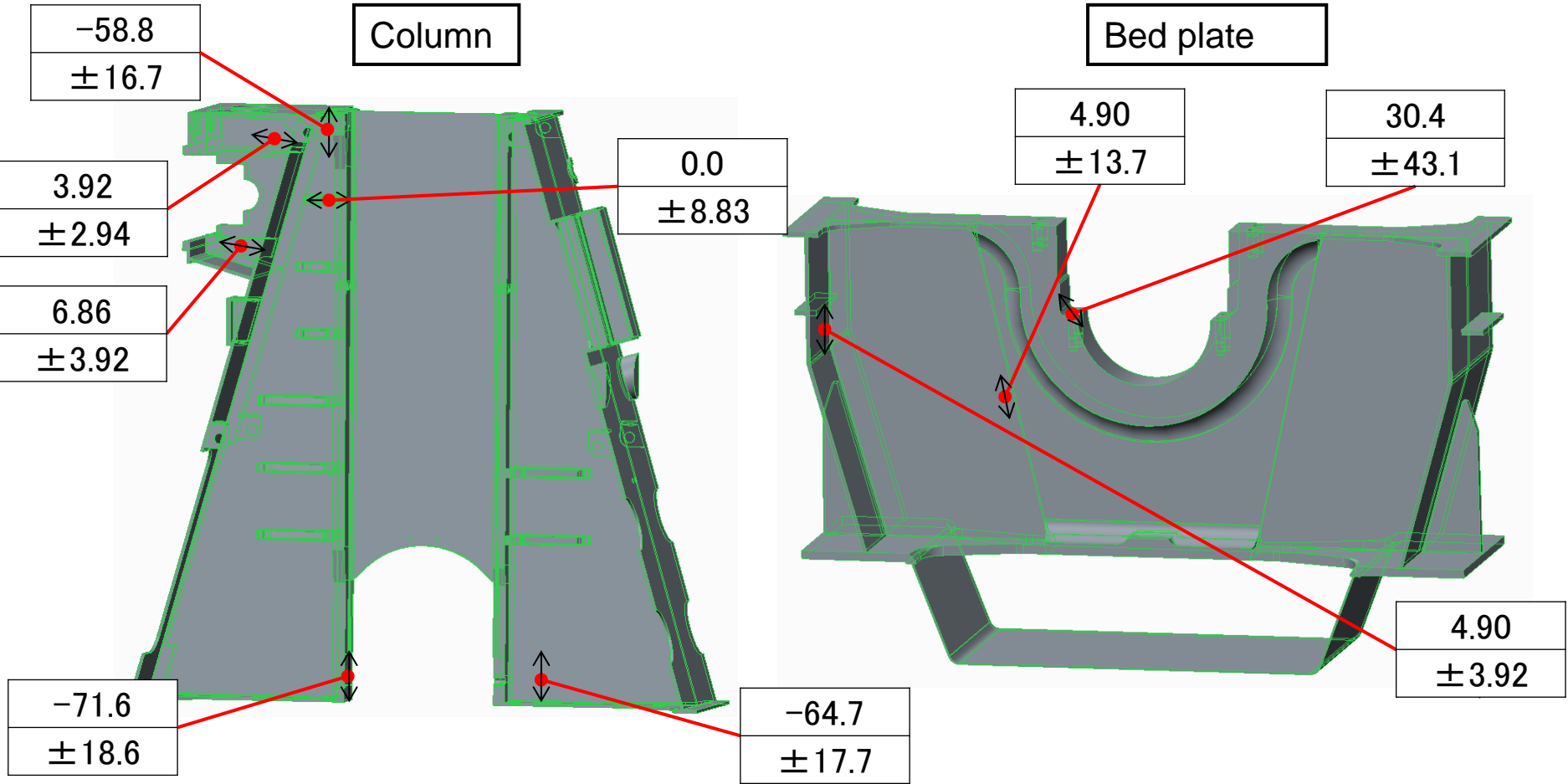
● : Plan

- Confirmed to meet expected performance.
- NOx emission is within Tier2 regulation

Corrected to ISO condition

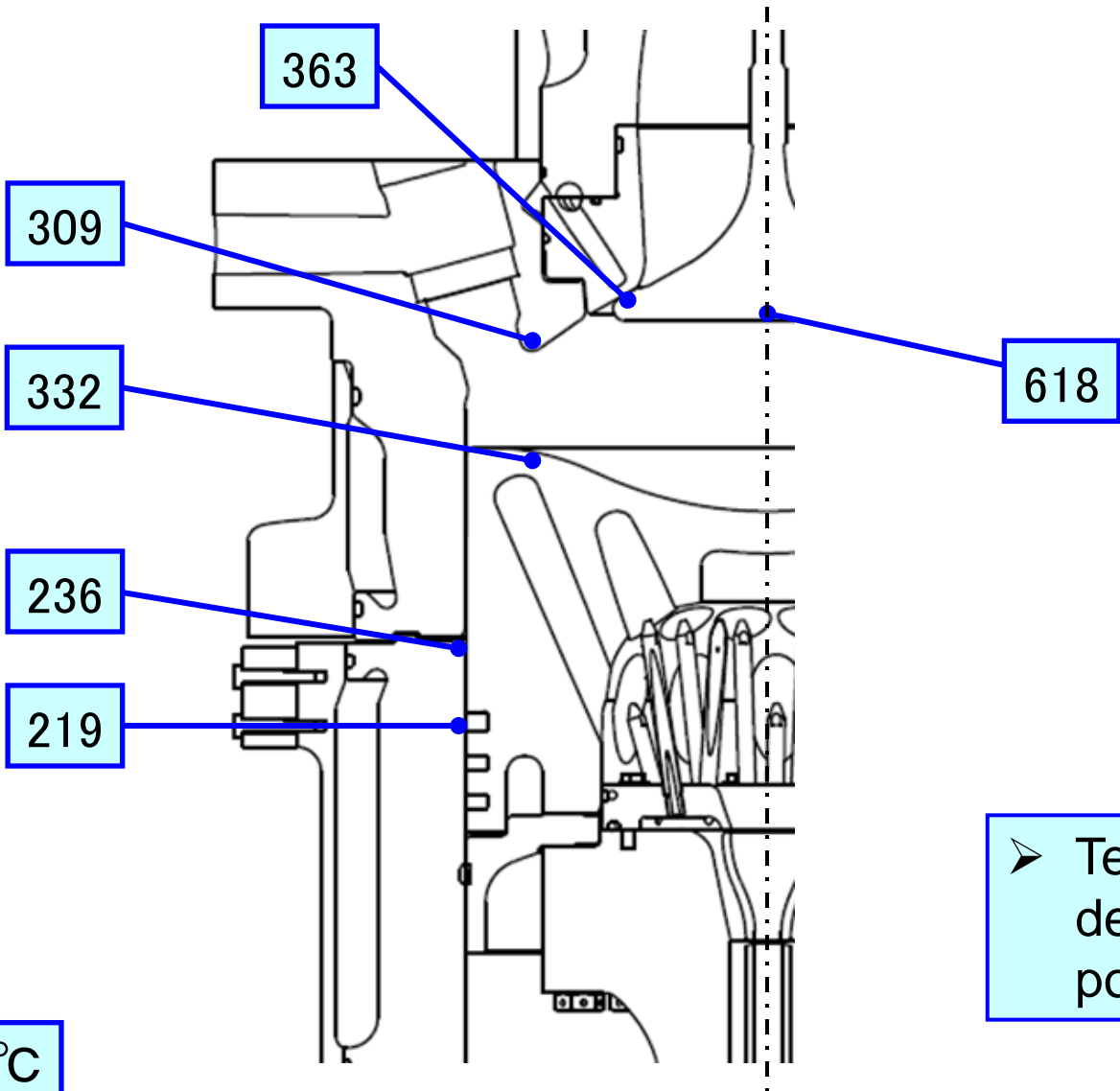
Sufficient reliability was confirmed due to lower mean & fluctuating stress for every points.

Mean stress [MPa]	
Fluctuating stress[MPa]	at 100% load



# Temperature measurement result of combustion chamber

At 100%Load  
(6,870kW x 94 min<sup>-1</sup>)



in °C

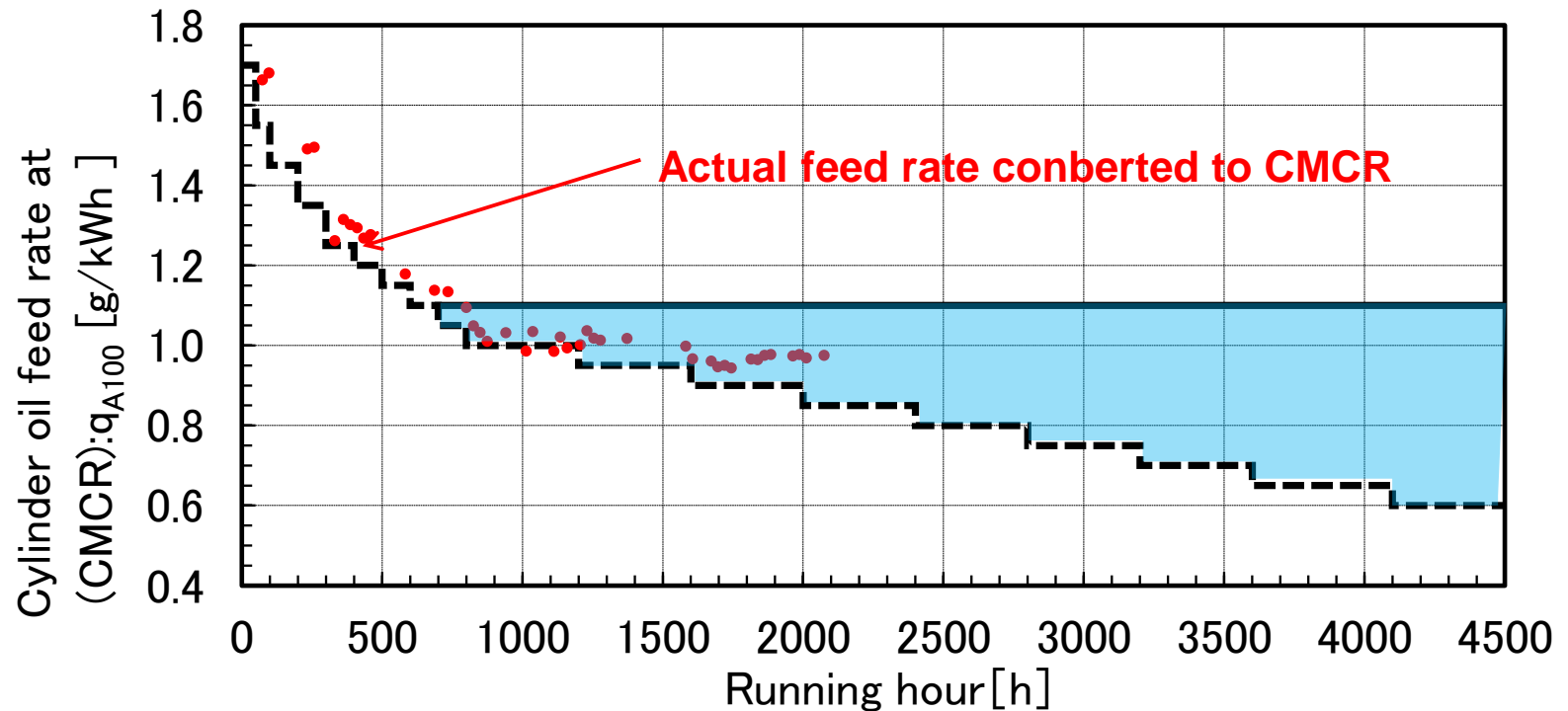
➤ Temperatures are within design limit for every points.

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# Cylinder lubricating oil feed rate

BN100

Sulfur content of using fuel: 2.06 ~ 3.38%

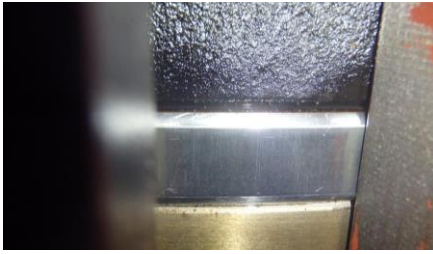


➤ The cylinder lubricating oil feed rate has been reduced successfully according to the guideline of UE engine.

# Inspection Result of Piston, Ring, & Liner (TRH: 3,091hrs)



**TOP** Cr-Ceramic



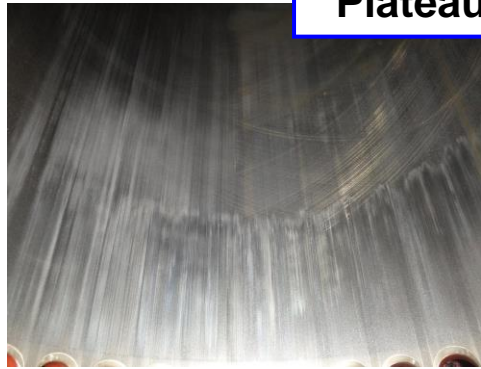
Honing mesh is still left around TDC position

**2nd** Cr-Ceramic



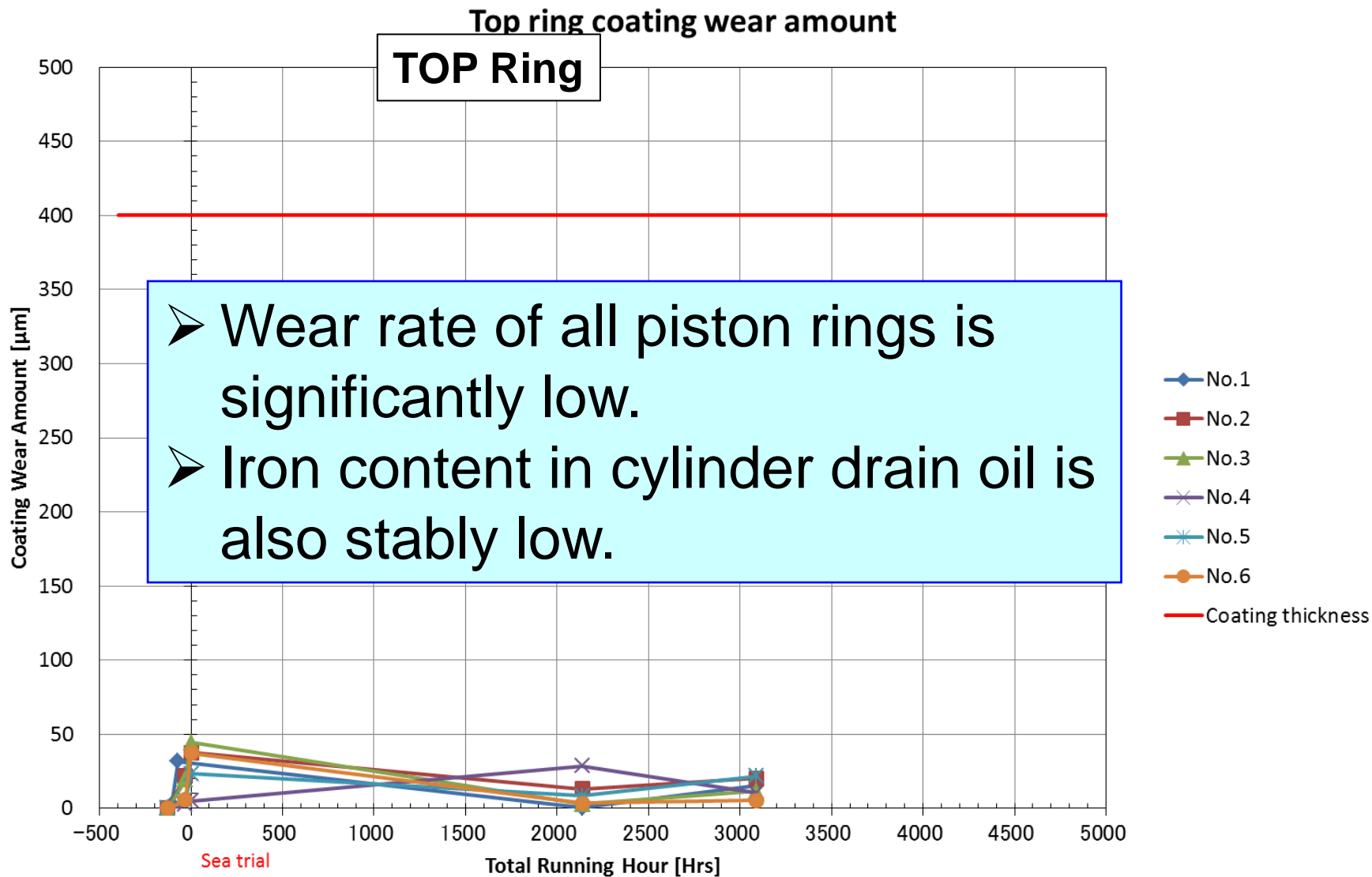
Plateau honing

**3rd** Cr-Ceramic



- Running surface of all cylinder liners are in good condition.
- No low temperature corrosion was observed because honing mesh is still left around TDC position.

# Piston Ring Wear Rate



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- Mitsubishi UE engines can comply with IMO-NOx TierIII regulation with EGR or SCR.
- UEC50LSH-Eco is completed application design of LP-EGR system.

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# Conclusion of New UEC50LSH-Eco

- Developed to meet worldwide needs and will contribute to ship owners, ship operators and shipyards to cut operating costs and installation cost.
- Performance and reliability are already proven.
- Experience of excellent operating condition of in-service engine will be fed back to new buildings.
- Ready for complying with IMO-NOx Tier III regulation.



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