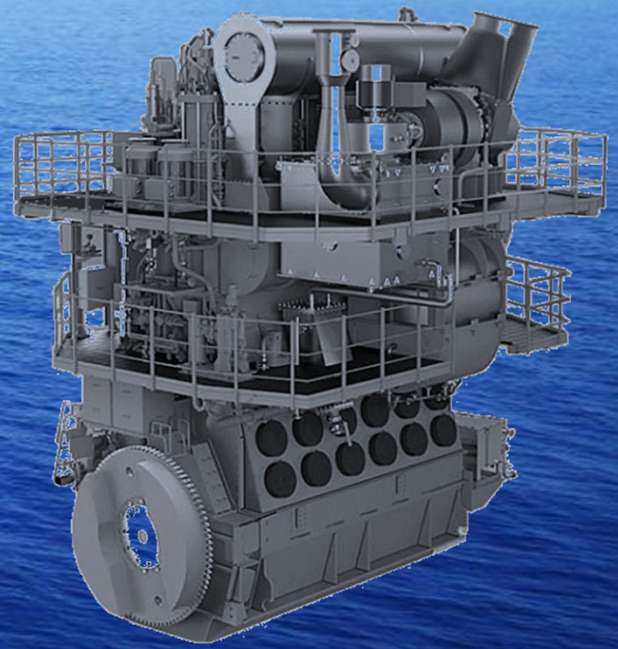
Japan Engine Corporation

11th CIMAC CASCADES in Wuxi, China

The latest technologies of J-ENG's UE Engine, toward higher efficiency



October 11 2019

Japan Engine Corporation
Hideo Okamura

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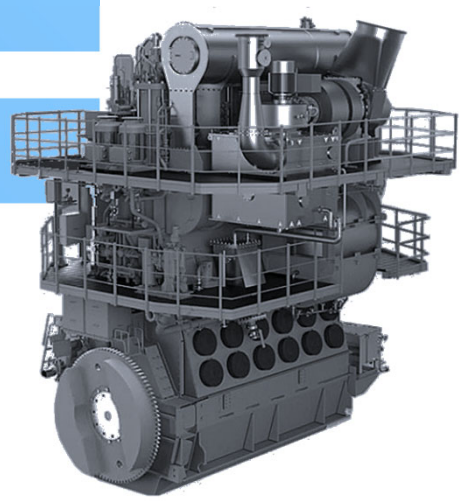

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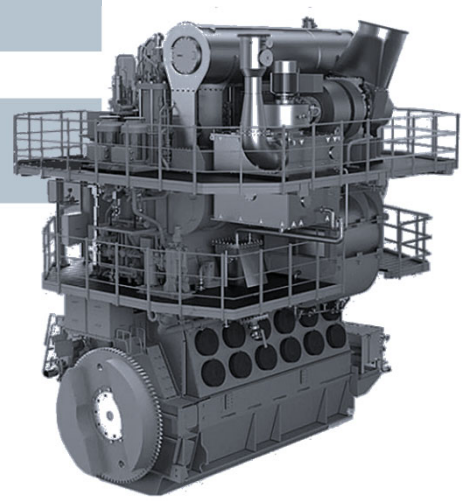
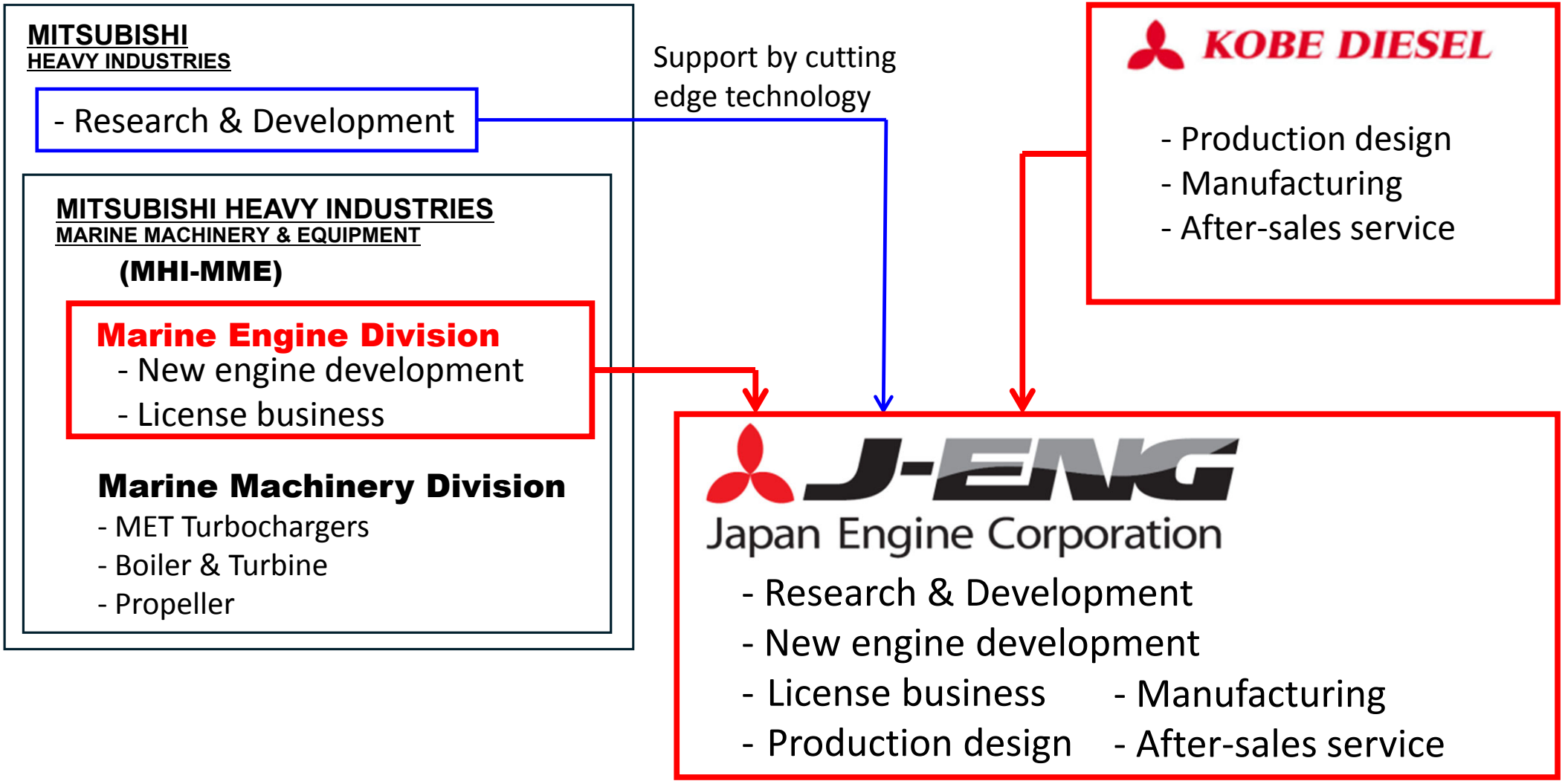


Company profile



Naming rule

e.g. **6 UEC 42 LSH - Eco - D 3 - EGR**

Tier III technology:
(blank) Tier II
EGR: Low Pressure EGR
SCR: Low Pressure SCR

Version number:
1: Standard version
2: Low-SFOC version
3: Extra Low-SFOC version(UEC50LSH-Eco)

BMEP number:
A: 20bar B: 21bar C: 22bar or 22.5bar
D: 24bar
(blank): less than 20bar

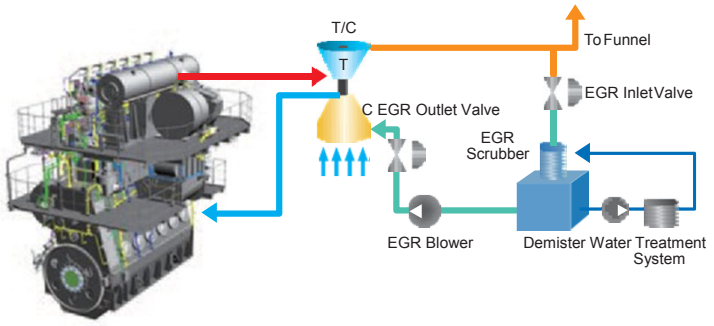
Eco: Electronically controlled engine
(blank): Camshaft controlled engine

Development code: LSII, LSE, LSH,LSJ (MGO mono-fuel engine)

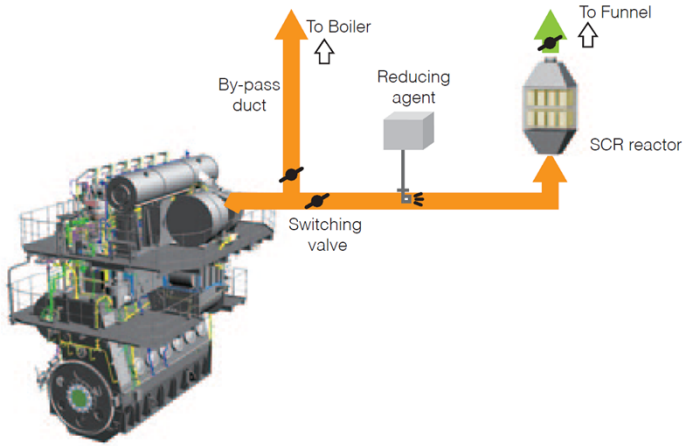
Bore size in cm

Brand name: **U**niflow scavenging
Exhaust gas turbocharged
Crosshead type

Number of cylinders:



Low pressure EGR system



Low pressure SCR system

Developing history of UE engine

8UEC60LSII-Eco

6UEC50LSE

6UEC35LSE-Eco

6UEC50LSH-Eco

5UEC50LSJ

Supported by 日本財団 THE NIPPON FOUNDATION

J-ENG Japan Engine Corporation

42LSJ
42LSH-Eco
35LSJ
50LSJ
50LSH-Eco
33LSE
80LSE-Eco
35LSE Eco
45LSE Eco
50LSE Eco
60LSE Eco
68LSE
52LSE Eco
LSII Type Eco
L/LA/LS Type
H/HA Type
A/B/C/D/E Type

Eco: Electronically controlled engine

Development technologies accumulated over 60 years

1955

1950 1960 1970 1980 1985 1990 1995 2000 2005 2010 2015 2020

UE Engine　Production Records of LSII / LSE / LSH

As of Aug, 2019

Engine type	Ordered	Delivered	1st set in service
85 LSC	7	7	1993.12
85 LSII	50	50	1992. 7
75 LSII	20	20	1988. 4
60 LSII	201	201	1995. 8
50 LSII	243	243	1994. 2
43 LSII	26	26	2004. 6
37 LSII	19	19	2000. 9
33 LSII	139	124	1994. 6
80 LSE	2	2	2013. 6
68 LSE	15	15	2003. 5
60 LSE	35	32	2008. 6
52 LSE	30	30	2001. 9
50 LSE	18	18	2007. 2
45 LSE	262	251	2008.12
35 LSE	14	7	2014. 6
33 LSE	34	29	2014.12
50 LSH	41	21	2015. 8
Total	1156	1095	-

UEC42LSH is the successor of UEC45LSE,
and developed by using proven UEC50LSH technologies.

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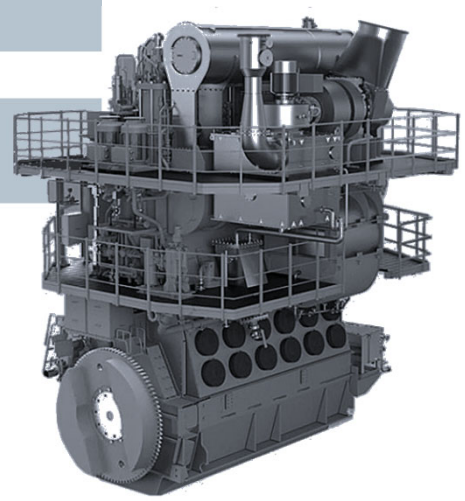
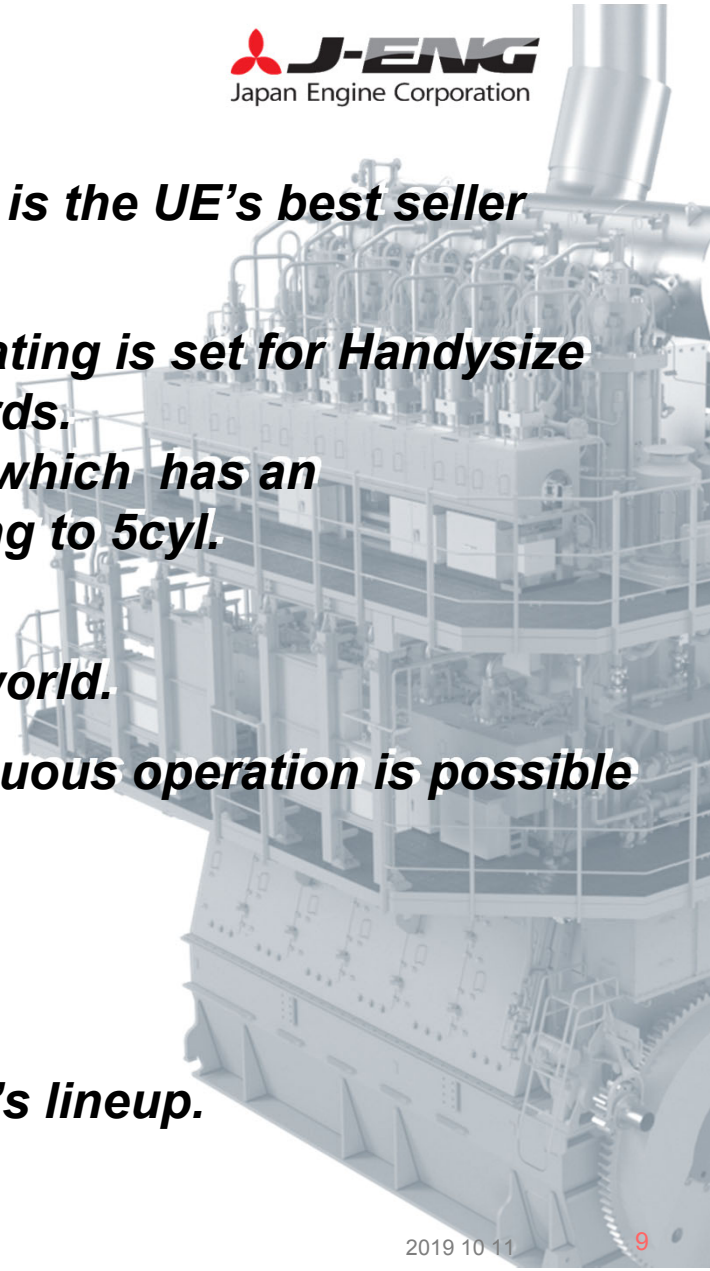


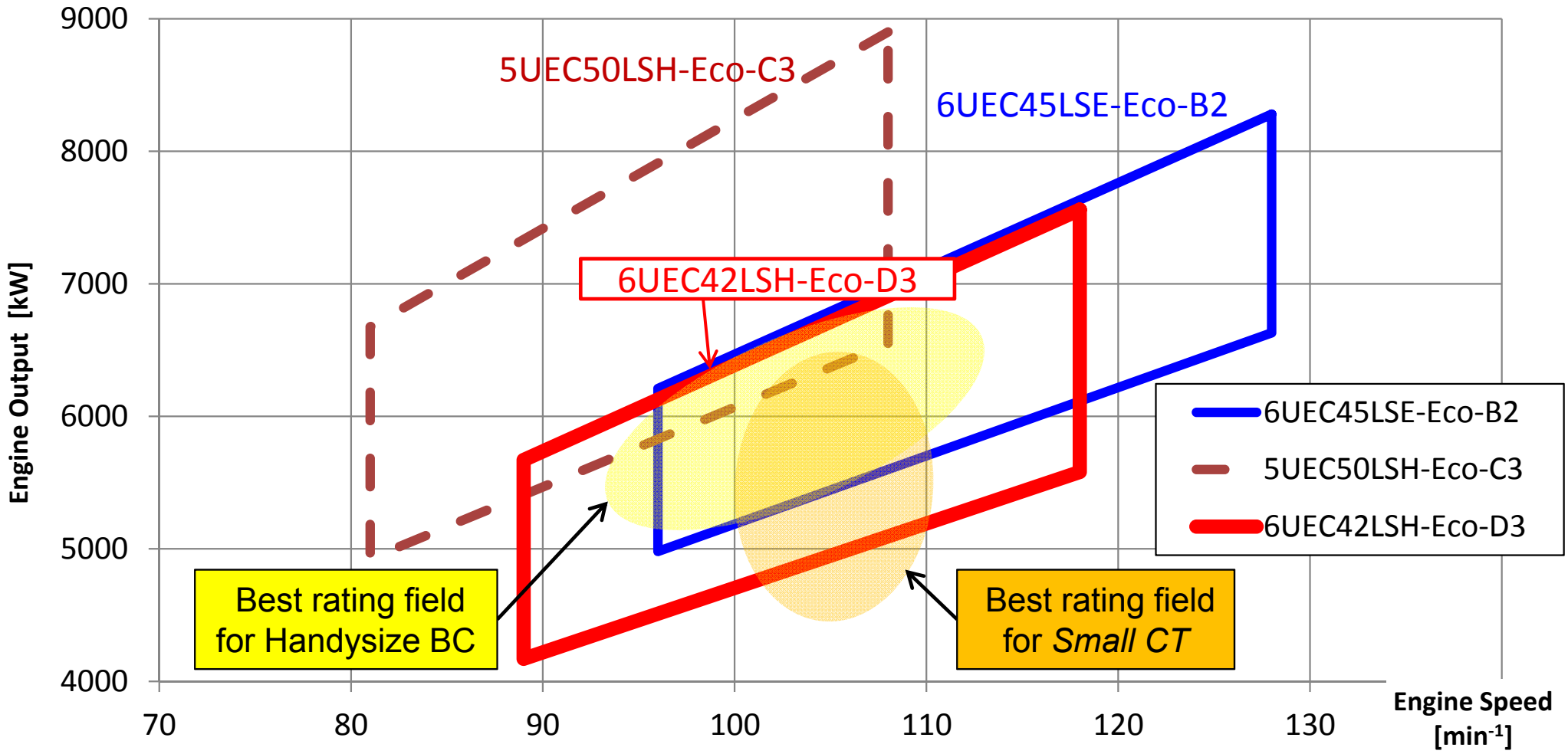
UEC42LSH-Eco Development concept

Japan Engine Corporation



- ***"UEC42LSH" is a successor to UEC45LSE engine, which is the UE's best seller engine ordered over 260 sets so far.***
- ***Based on comprehensive market research, the optimal rating is set for Handysize BC, Small CT, etc. for the domestic and overseas shipyards. Especially for Handysize BC's rating field, 6UEC42LSH , which has an advantage in terms of vibration, can be applied comparing to 5cyl. (50cm bore) engine.***
- ***UEC42LSH-Eco-D3 can achieve the lowest SFOC in the world.***
- ***Long time slow steaming can be easily operated. (Continuous operation is possible down to 20% load without any load up)***
- ***Compact engine size and weight.***
- ***Promote the digitalization in future.***
- ***MGO mono-fuel engine "UEC42LSJ" also joins in the UE's lineup.***

UEC42LSH-Eco Rating Field



UEC42LSH-Eco Main Particulars

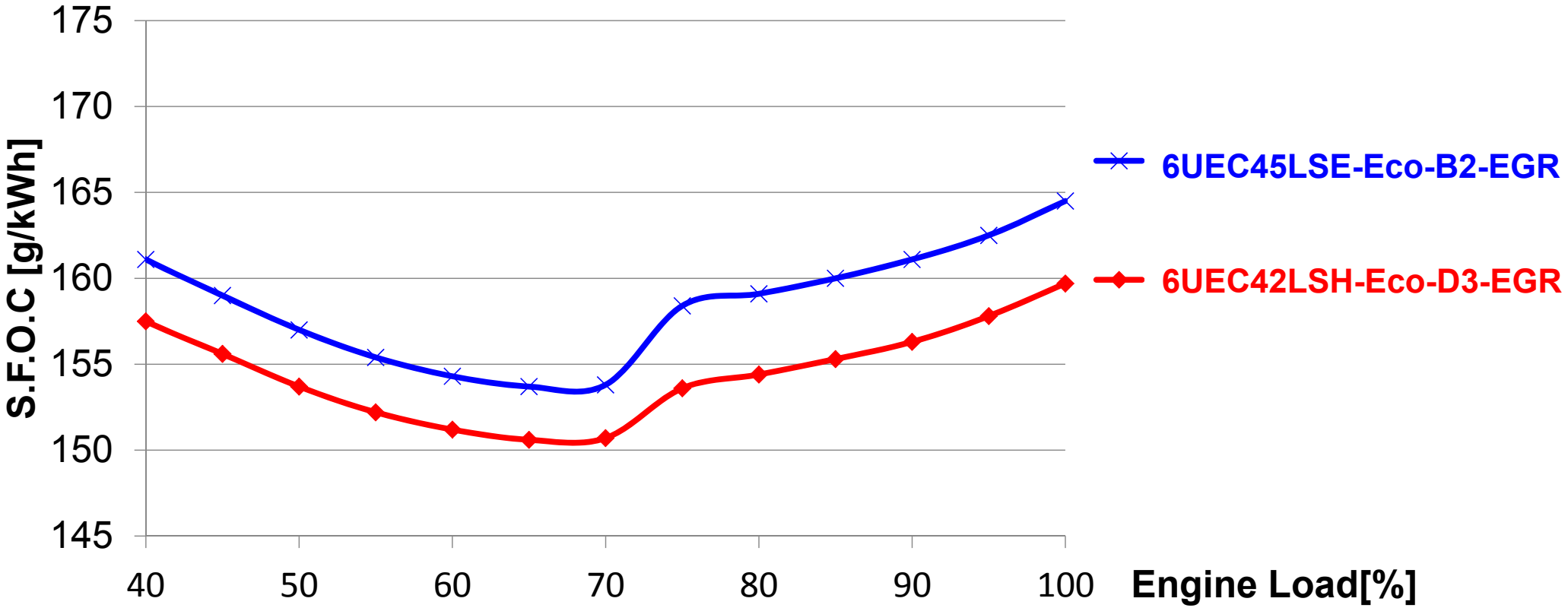
Model		6UEC42LSH-Eco-D3	6UEC45LSE-Eco-B2	5UEC50LSH-Eco-C3
Bore	[mm]	420	450	500
Stroke	[mm]	1,930	1,930	2,300
Stroke/Bore	—	4.6	4.3	4.6
Output	[kW]	7,560	8,280	8,900
Engine speed	[rpm]	118	128	108
Pme	[bar]	24.0	21.1	21.9
Piston speed	[m/s]	7.6	8.2	8.3
SFOC @100%Load				
Tier2 Mode	[g/kWh]	164	169	164
Tier3 Mode	[g/kWh]	165.6 (LP-EGR)	170.7 (LP-EGR)	165.6 (LP-EGR)

-3.0%

The lowest SFOC engine in the world

UEC42LSH-Eco Comparison of Fuel oil consumption

Comparison rating point：5,430kW x 105rpm（TierII Mode）



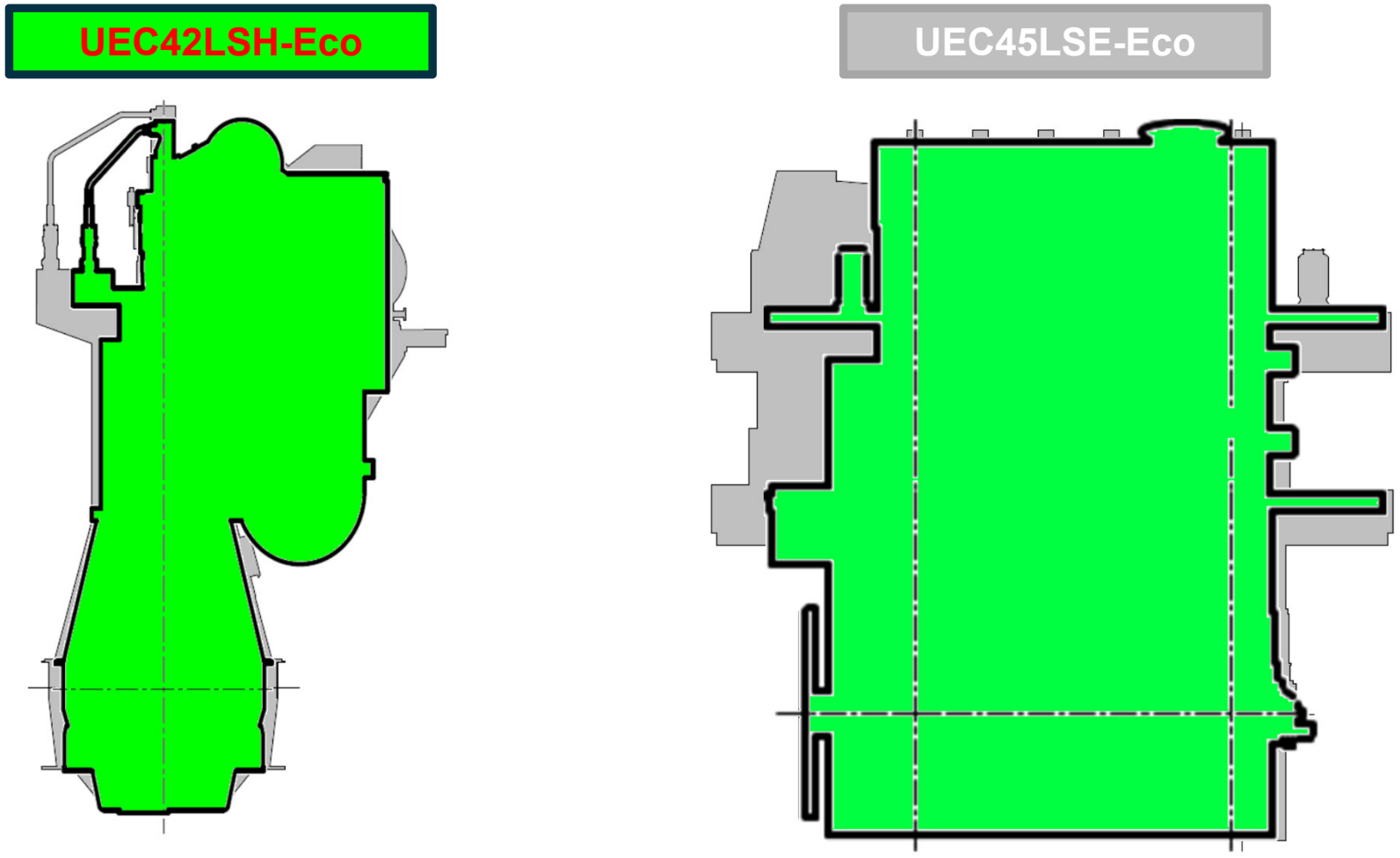
6UEC42LSH-Eco-D3 can achieve much lower fuel oil consumption.

UEC42LSH-Eco Comparison of Dimensions

Model		6UEC42LSH-Eco-D3	6UEC45LSE-Eco-B2	5UEC50LSH-Eco-C3
Engine length (Catalogue figure)	[mm]	5,646 (Lcc760)	-4.2% 5,894 (Lcc792)	5,560 (Lcc870)
Piston overhaul	[mm]	8,850 (St1930)	8,860 (St1930)	10,050 (St2300)
Crank shaft center	[mm]	1,000	1,000	1,190
Bedplate width	[mm]	2,800	-6.7% 3,000	3,350
Weight (without EGR)	[ton]	170	-9.1% 187	194

Compact engine size and weight

UEC42LSH-Eco Comparison of Dimensions



UEC42LSH can achieve downsizing from UEC45LSE

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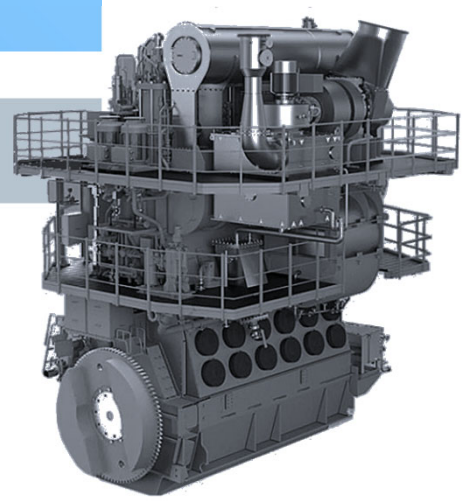

UEC42LSH-Eco　Principle structure and advantages

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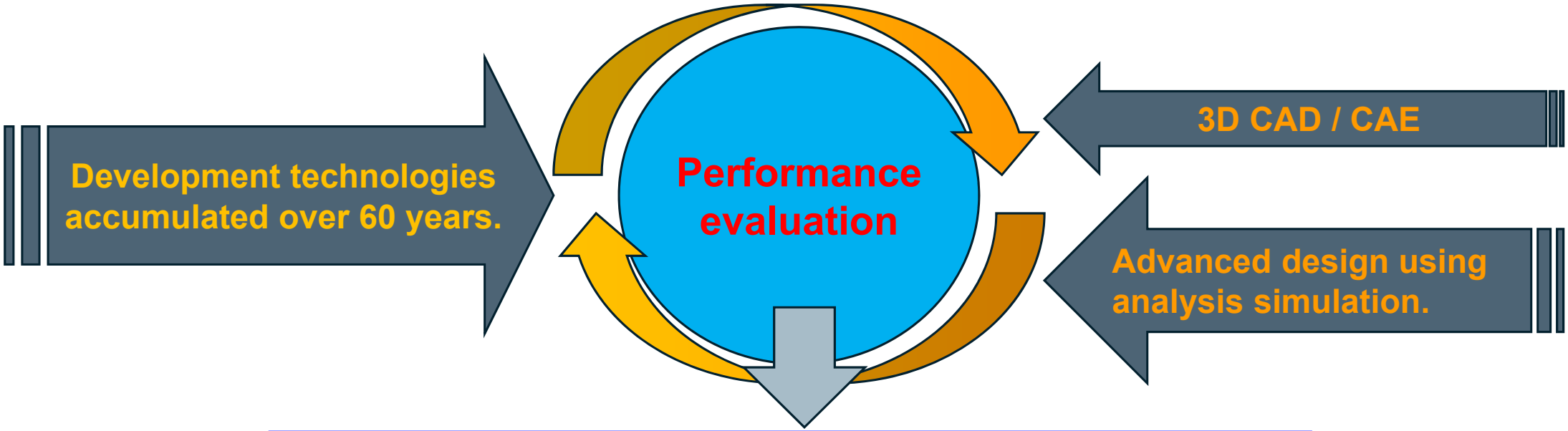
Design process
-Utilization of MBD (Model Based Development)

Conceptual Design → Functional Design → Layout Design → Structural Design → Manufacturing Design



Utilizing advanced CAE based on the latest technologies

UEC42LSH-Eco　Principle structure and advantages

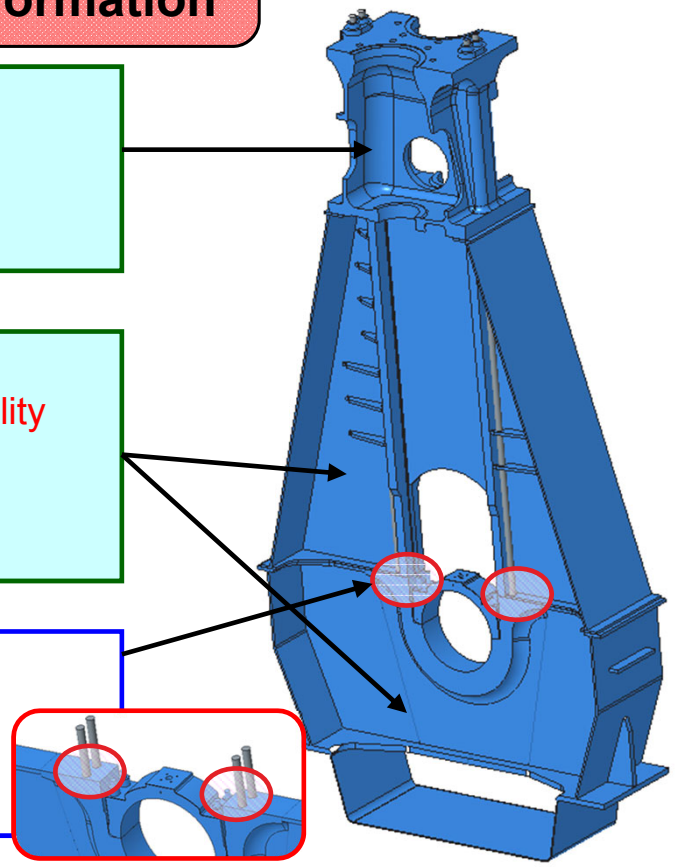
J-ENG Japan Engine Corporation

Main structure
-Compact size, light weight, less deformation

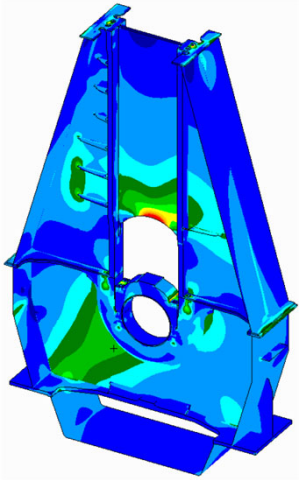
Cylinder jacket
・High stiffness by appropriate configuration and material change(applying **FCD**)
⇒Higher reliability(Piston running behavior)

Bedplate & column
・High stiffness by single separate wall ⇒Higher reliability
・Reduce deformation of column sliding plate by appropriate configuration
⇒Higher reliability(Piston running behavior)

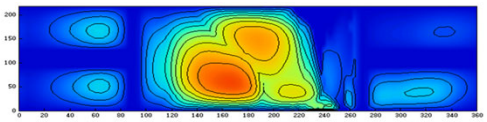
Tie rod
・High stiffness by twin stay tie bolt with low alloy steel
・Reduce deformation of main bearing girder
⇒Higher reliability



FEM model



EHL* analysis



*EHL : Elastohydrodynamic Lubrication

➢ Stiffness and weight of these structures are optimized by **FEM** and **EHL** analysis.

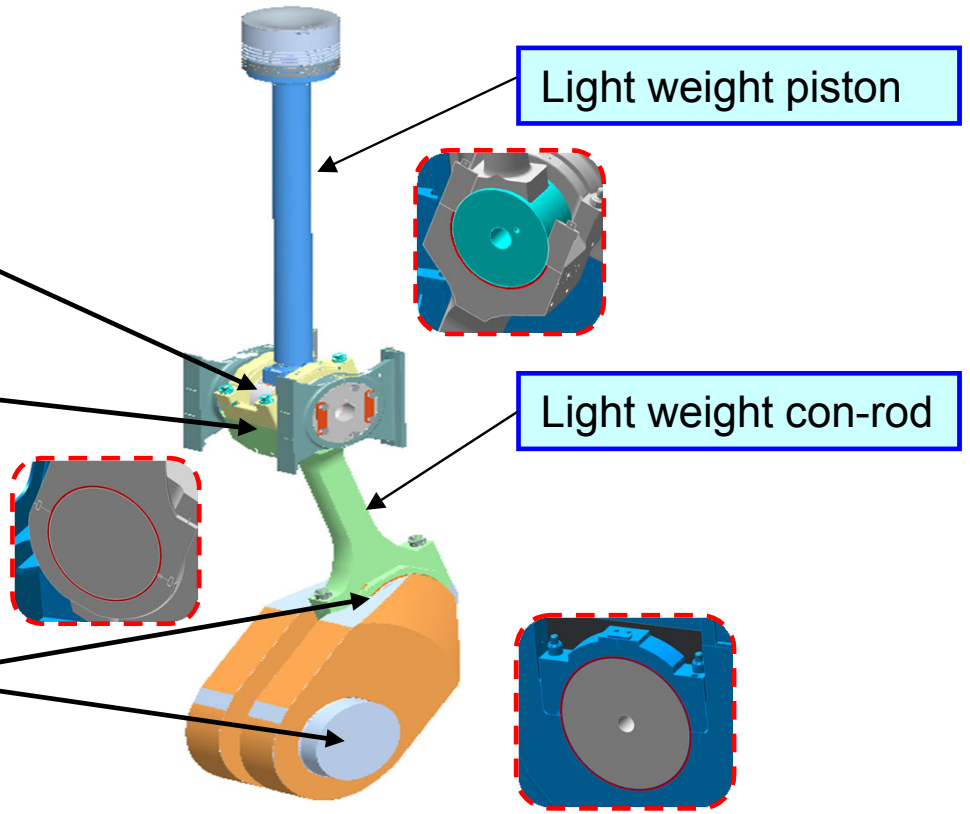
UEC42LSH-Eco Principle structure and advantages

Moving parts
-Compact size, light weight

Crosshead
・Lower mechanical loss due to high rigidity and appropriate surface press. of guide shoe
⇒Higher reliability, **Lower FOC**

Crosshead bearing
・Lower oil film press. by applying pocket type without center oil groove, Higher fatigue strength by aluminum metal ⇒Higher reliability, **Compact size**

Main bearing & crankpin bearing
・Higher fatigue strength by aluminum metal
⇒High reliability, **Compact size**

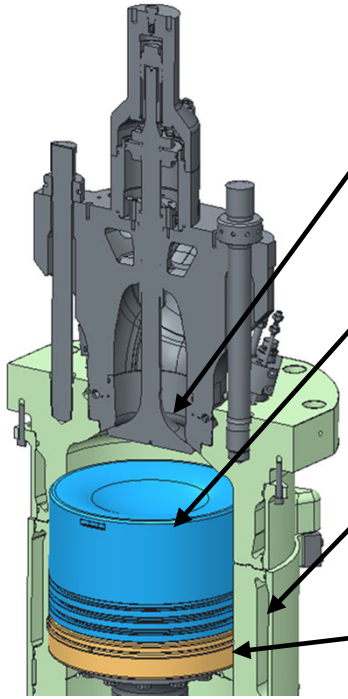


➢ Achieve **lower fuel oil consumption** by optimization of moving parts weight and reduction of **mechanical loss**.

UEC42LSH-Eco Principle structure and advantages

J-ENG Japan Engine Corporation

Combustion chamber
-Reduction of thermal load, thermal stress



Nimonic Exh. valve
High heat resistant alloy, **Nimonic** or DSA760 as standard

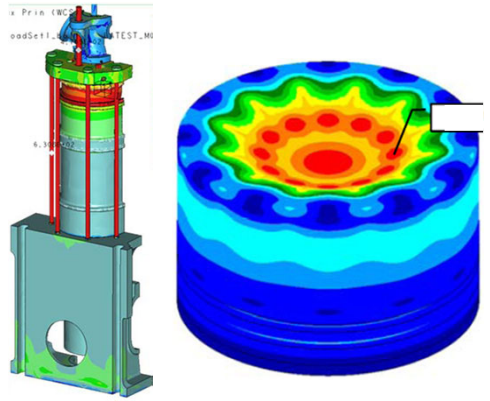
Piston
・Bore cooling type and high top land.
Lower temperature by increase cooling capacity
Reduce influence by combustion gas

Cylinder liner
・Liner temp. control by insulation band and loop cooling
・Lower **mechanical loss** by plateau honing
⇒Better slow steaming operation, **Lower FOC**

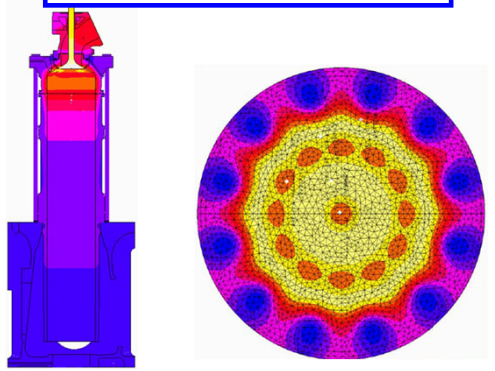
Cylinder lubricating system
・Appropriate lubricating by A-ECL*

➢ The strength and heat condition of combustion chamber are analyzed by **FEM** and **Thermal analysis**.

FEM model



Thermal analysis



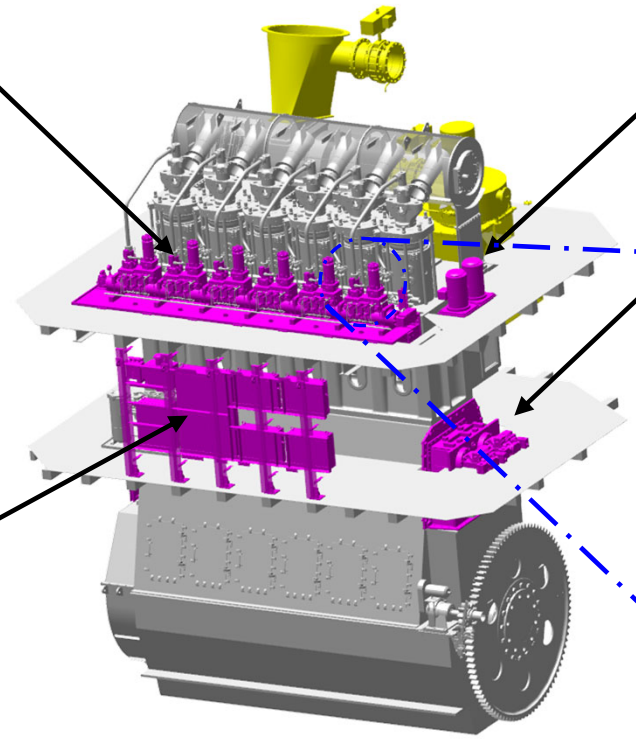
*A-ECL :
Advanced Electronically Controlled Lubricating system

UEC42LSH-Eco Principle structure and advantages

Eco system
-Development by J-ENG own technologies = "No Black Box"

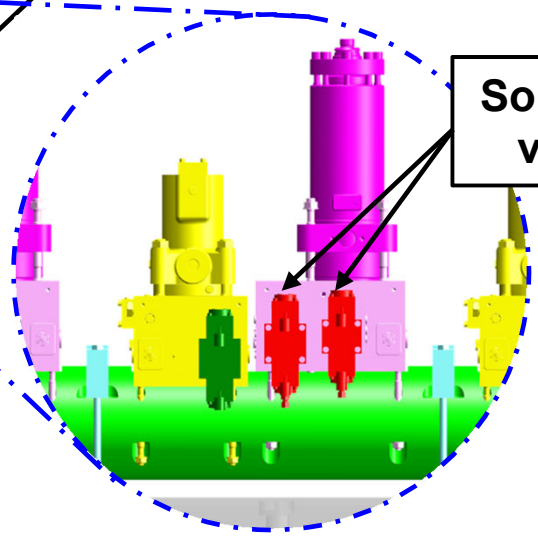
Cylinder control unit
- Accumulating block
- Fuel injection pump
- Exhaust valve lower part
- Solenoid valve unit
  - Solenoid valve
  - Valve plate
  - Main valve

Control unit
- Engine control unit (ECU)
- Power distribution unit (PWD)
- Local control unit (LCB)
- Multi IO unit (MIO)
- Driver unit (DRV)



Electric driven pump
(for hyd. oil)

Engine driven pump
(for hyd. oil)

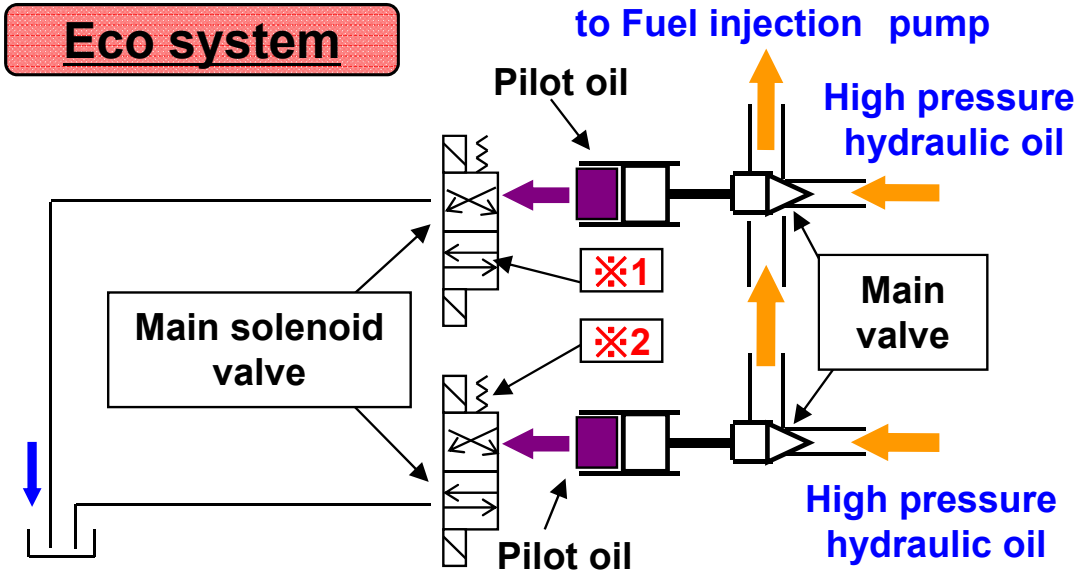


Solenoid valve

FO. side: 2 Solenoid valves

UEC42LSH-Eco Fuel injection rate control

Eco system

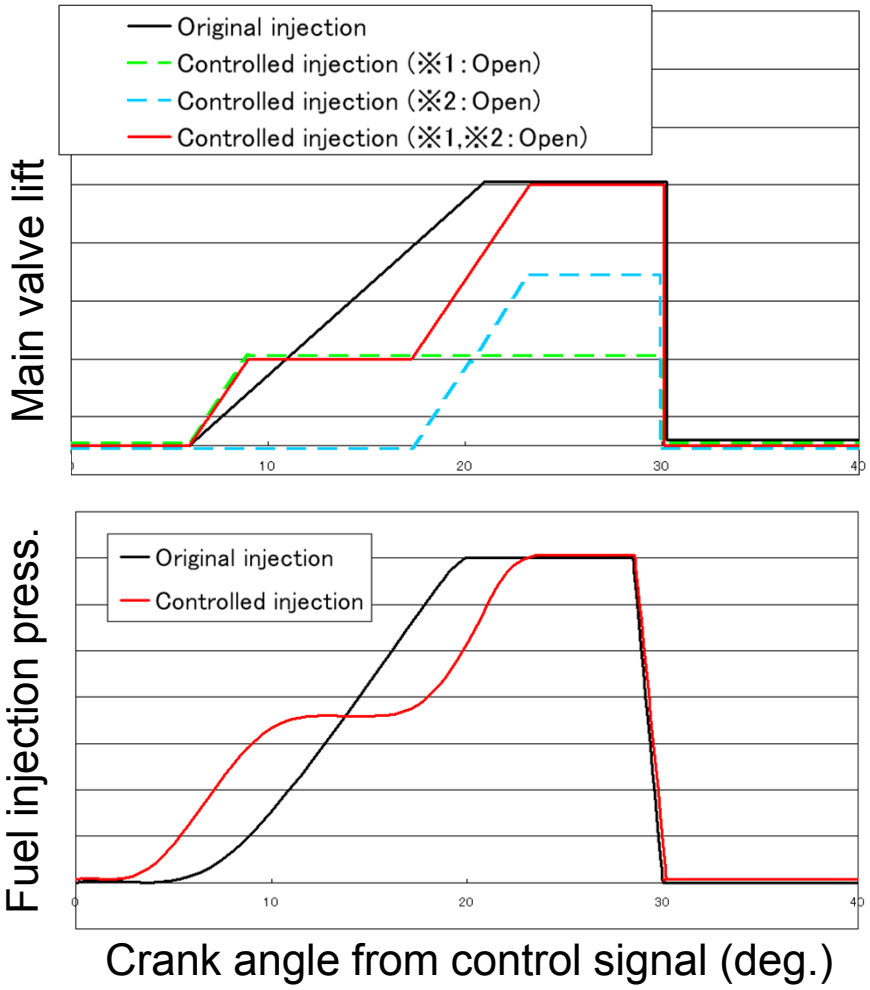


[Control mechanism]

- Fuel injection rate is controlled by differences of main valve's lift and opening timing
- Main valve's opening timing is controlled by each S/V

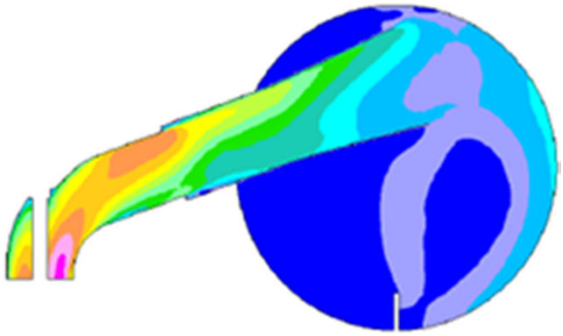
Controlled fuel injection rate contributes to improve the trade-off relationship of NOx emission and FOC.

Concept of fuel injection mode



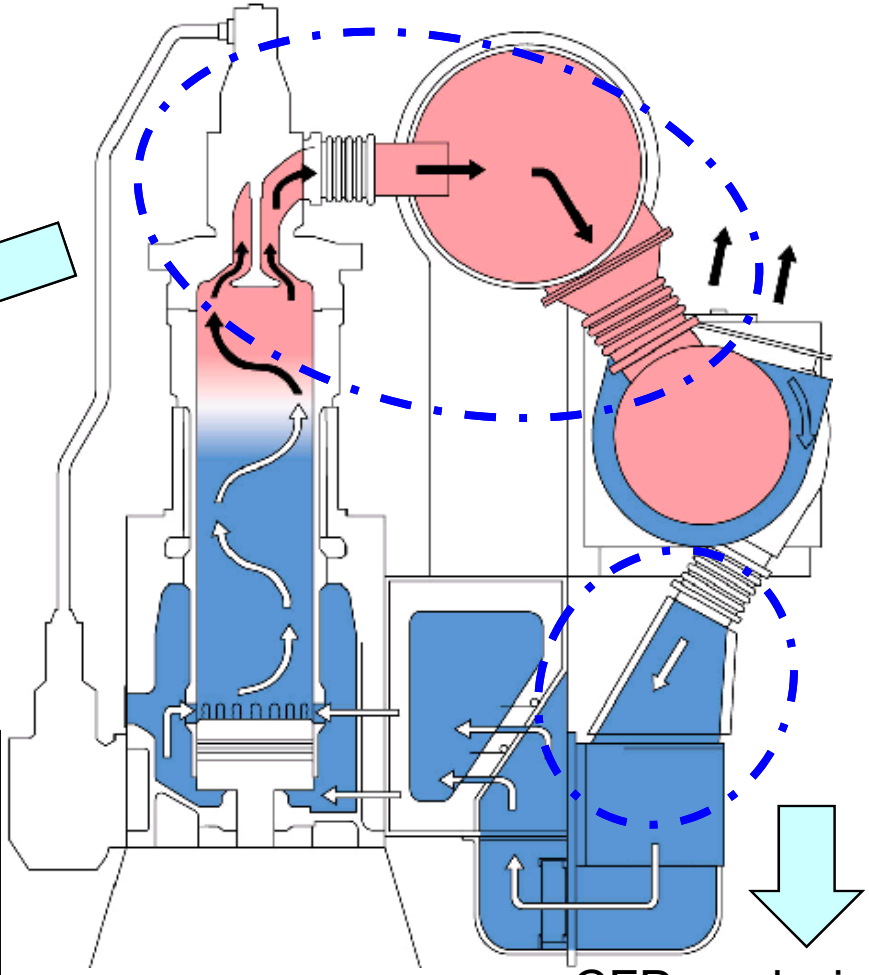
UEC42LSH-Eco Principle structure and advantages

Exhaust Gas and Scavenge System



CFD analysis

CFD : Computational Fluid Dynamics



CFD analysis for scavenging passage

Achieve **lower fuel oil consumption** thanks to reduction of pressure loss by optimization for scavenging air and exhaust gas passage.

Application of "JUMP" technology

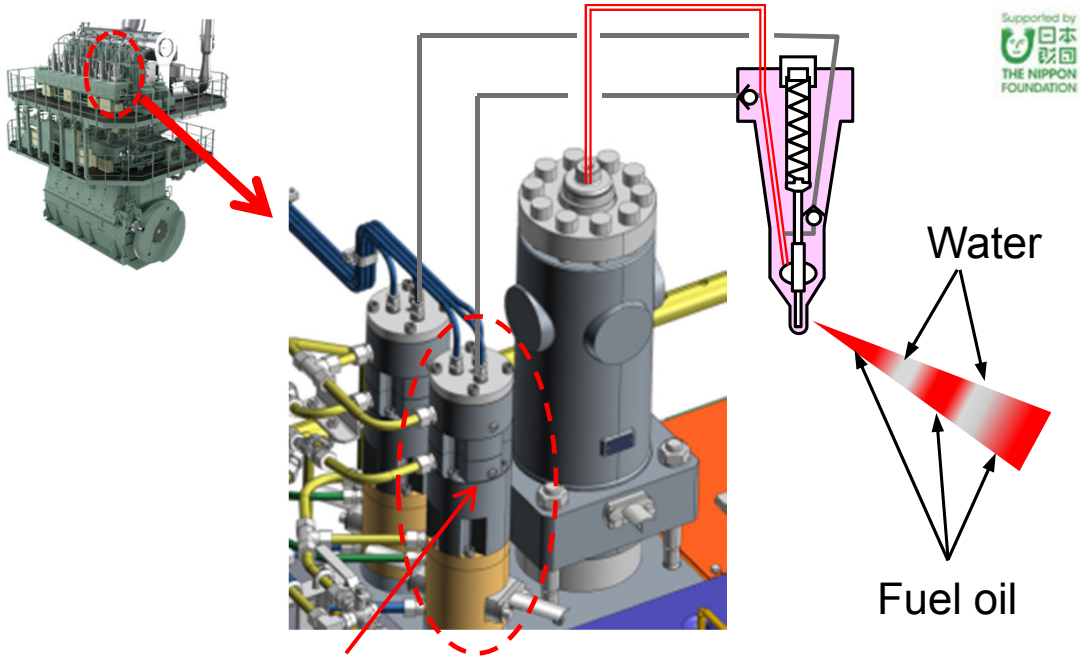
J-ENG Japan Engine Corporation

Concept of JUMP

J-ENG Unique Marine Power

Solution to three environmental issues of NOx, SOx, EEDI(CO2) simultaneously

UEC-LSJ
-Environmental impact reduction engine



Schematic diagram of water injection system

- Insert water in fuel injection valve during standstill period of injection at each cycle
- Fuel and water can be injected by layers according to actuation of fuel pump

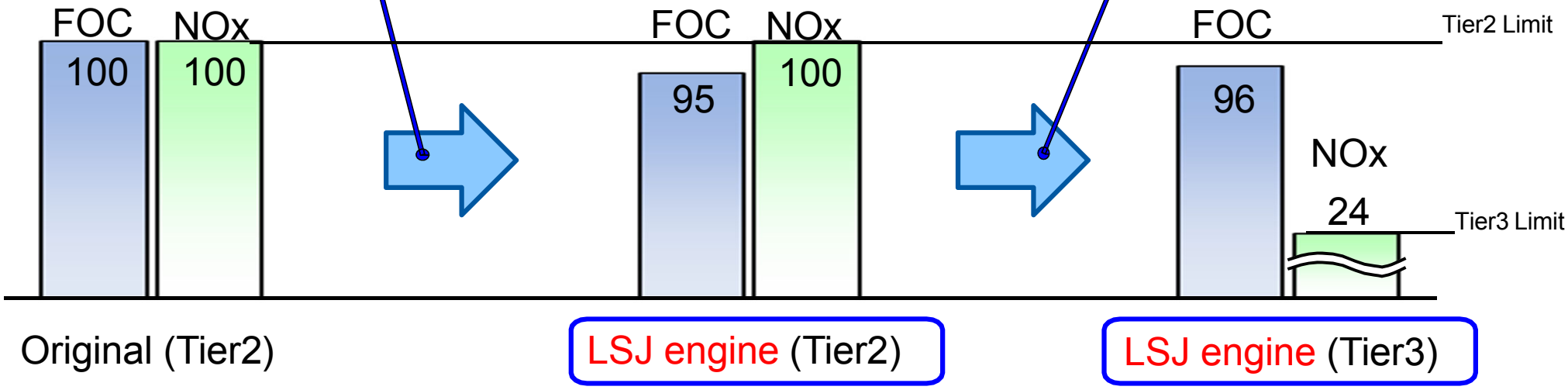
Environmental impact reduction engine “UEC-LSJ”

Technical features of “UEC-LSJ”

Realize low FOC meeting with NOx regulations by comprehensive UE engine technology and mixture of existing technology

- Ultimate low FOC
  - Combustion tuning to prioritize low FOC
- Reduction of NOx
  - Application of water injection system

- Compliance with Tier3 LP-EGR or LP-SCR



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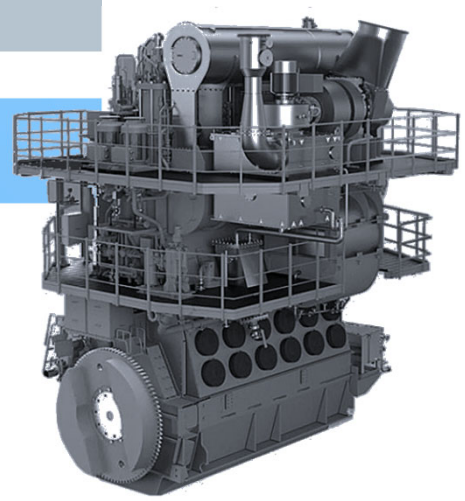
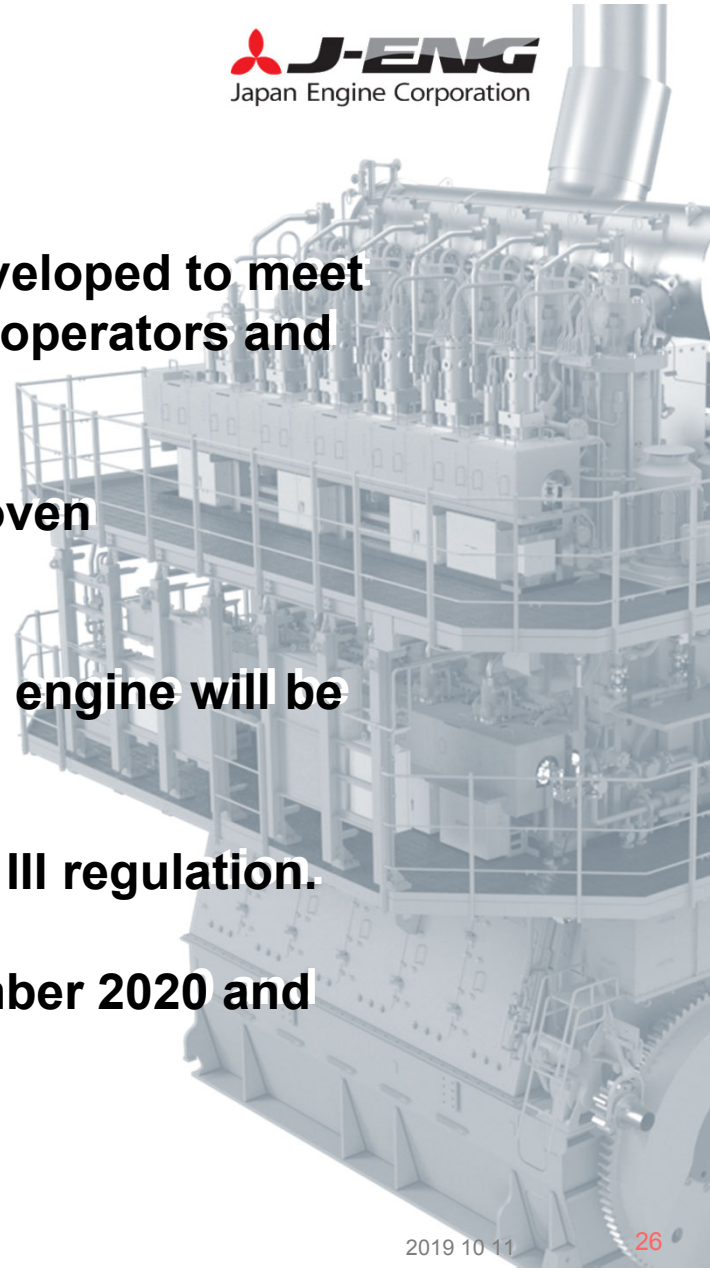


UEC42LSH-Eco Conclusion

Japan Engine Corporation



- The latest type of UE engine, UEC42LSH-Eco, is being developed to meet worldwide needs and will contribute to ship owners, ship operators and shipyards to cut operating costs and installation cost.
- UEC42LSH-Eco is being designed on the basis of well-proven conventional UE engines and with further improvements.
- Experiences of excellent operating condition of in-service engine will be fed back to new buildings.
- UEC42LSH-Eco is ready for complying with IMO-NOx Tier III regulation.
- The first "UEC42LSH-Eco" will be manufactured in December 2020 and tested and launched soon.

Thank you

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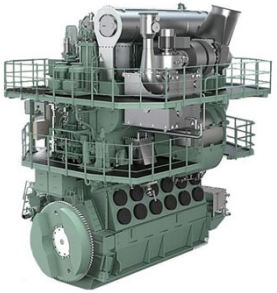

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