



Environmental Technology Seminar

11.04.2014

環境に優しい三井 MAN-B&Wエンジン

開発の最新状況

Upgrade on Environmentally-friendly
Mitsui MAN-B&W Engine

Mitsui Engineering & Shipbuilding Co., Ltd
Diesel Design Department

Ichiro Tanaka

Contents



1. Introduction

2. MES R&D Activities 2009 - 2012

2.1 Development Outcome

2.2 THS (Turbo Hydraulic System)

2.3 What is EGS (Exhaust Separation System) ?

2.4 EGR (Exhaust Gas Re-circulation)

2.5 VPC (Variable Phase Cycle)

3. Latest R&D Activities / Low-carbon Fueled Engine

3.1 ME-GI (Electronically-controlled Dual Fuel
Gas Injection Diesel Engine)

3.2 ME-LGI (Electronically-controlled Dual Fuel
Liquid Gas Injection Diesel Engine)

International Shipping NOx, NOx and CO2 emissions



IMO emission legislation

– the big challenge for international shipping

SOx : Regulation adopted

NOx : Regulation adopted

PM : Regulation under discussion

ECAs : Being expanded

GHGs

CO2 : Regulation adopted
Design Index EEDI
Operational Index EEOI
Economical instruments



**More Environmentally-friendly
Engine is Required !**

3

Outline of CO2 Reduction Technologies

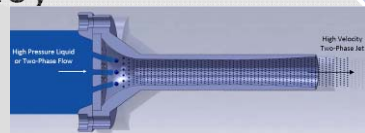
EEDI-abatement measure

Improvement in engine efficiency

- Latest engine
→ dot2, Mk9, G type engine
- Derating
- Part load improvement of fuel efficiency
→ dot3, VT, EGB, ECT, HPT
- Waste Heat Recovery
→ THS

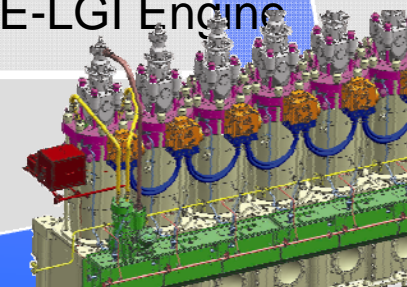
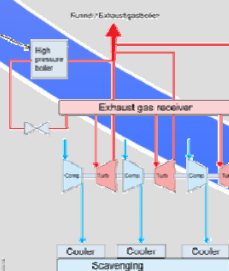
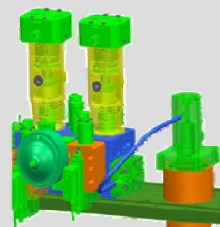
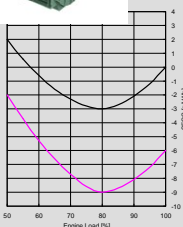
Fuel consumption reduction

- Slowdown operation
- Waste Heat Recovery
→ VPC

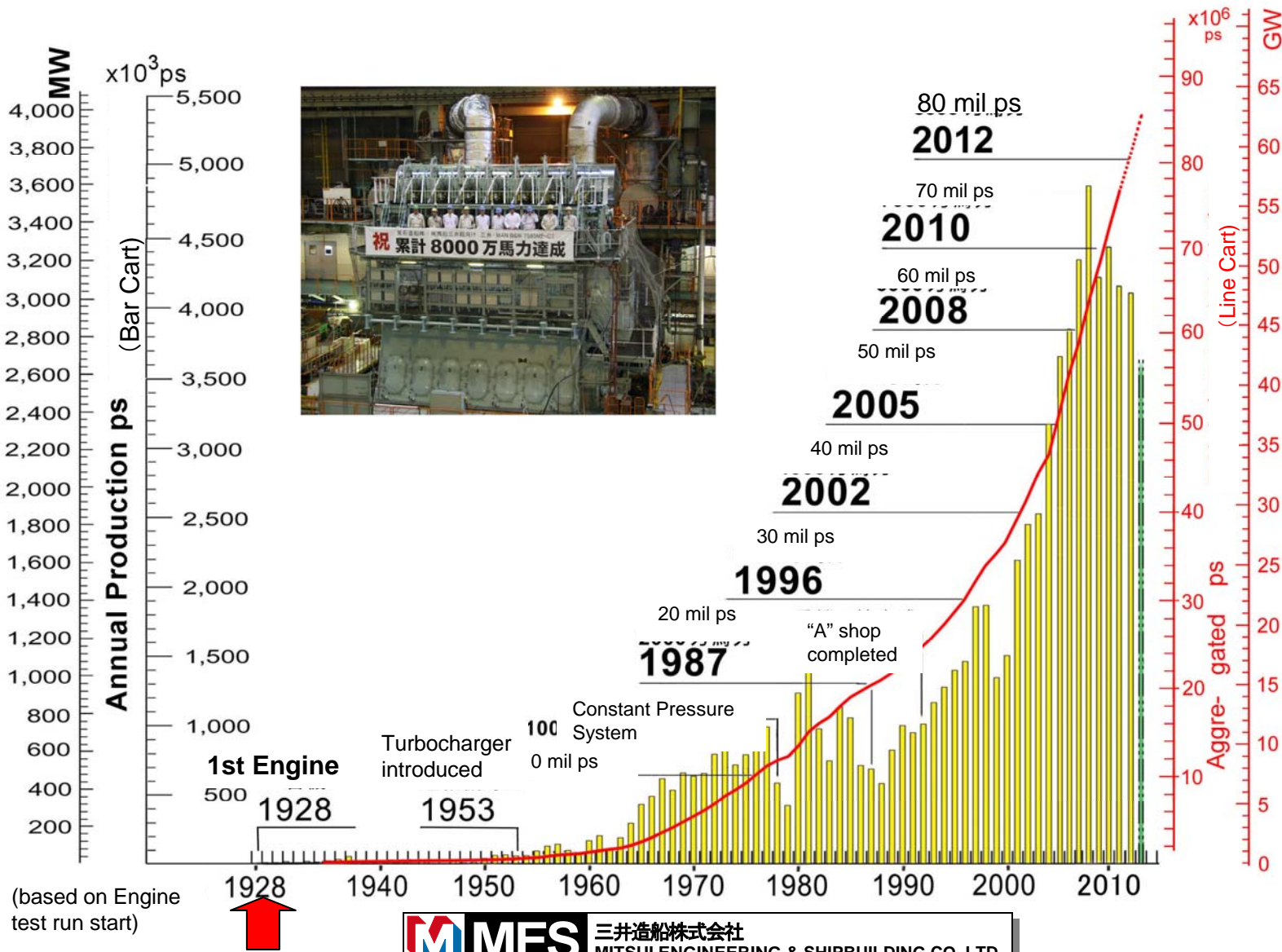


Fuel conversion (Low-carbon Fuel)

- ME-GI / ME-LGI Engine



Production Results of MITSUI-MAN B&W Diesel Engine



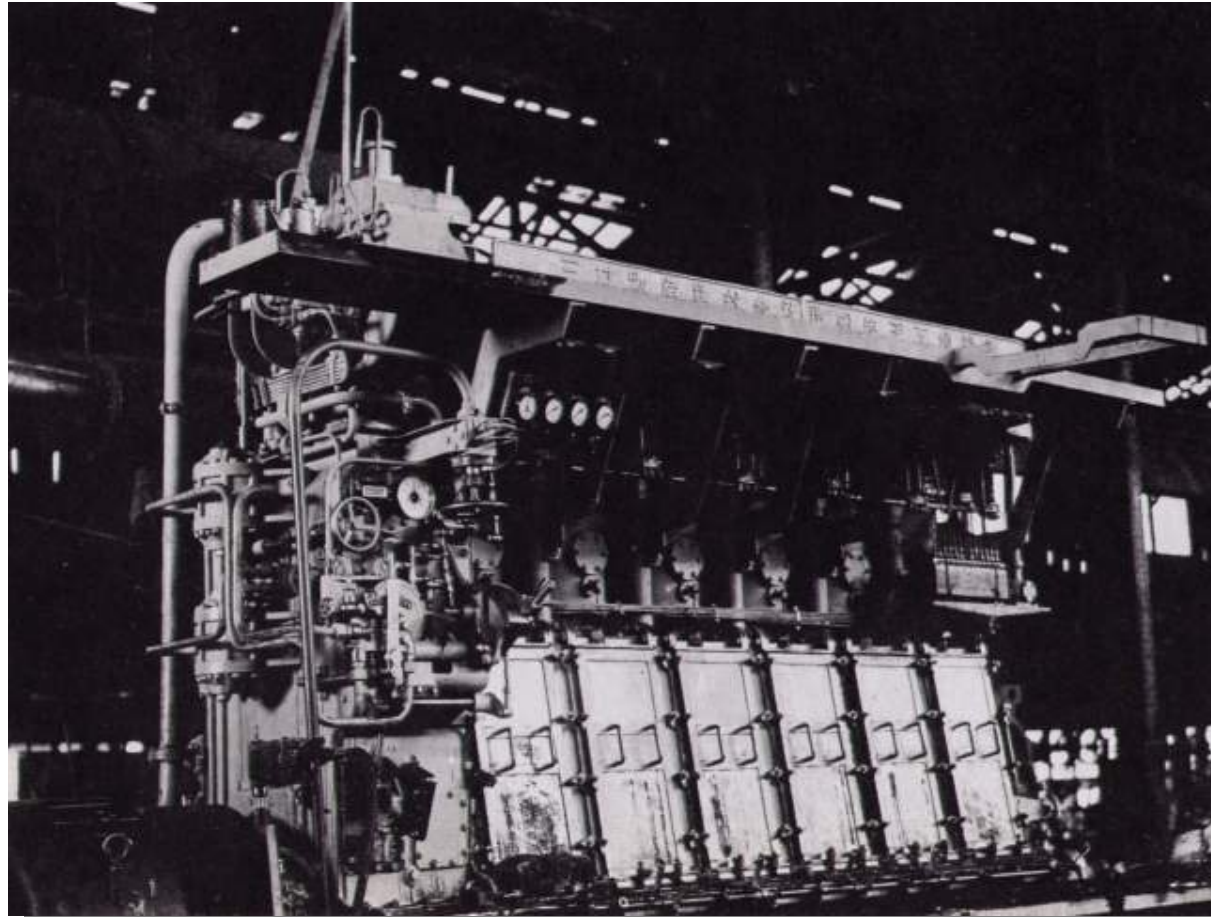
(based on Engine test run start)



Mitsui- B&W type First Engine 6125M

(950 BHP x 160 RPM)

1928



Installed in
Mitsui-made ship
'Takamisan'

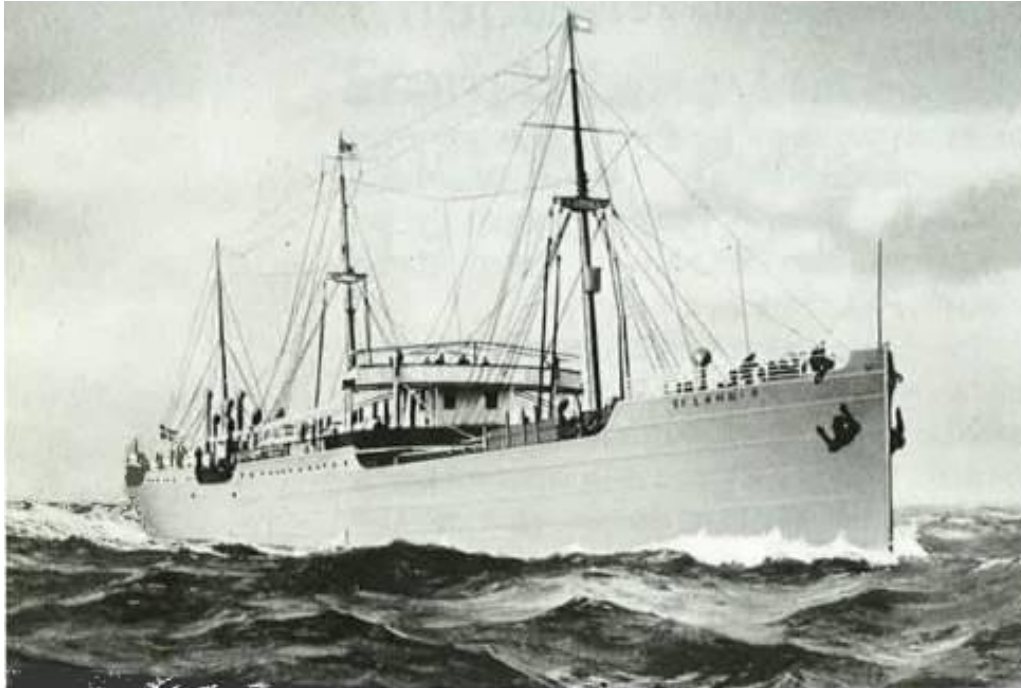
Latest engine
"6S50ME-B9"
output : 14,520
BHP

Bore/Stroke : 500/900 (mm)

15 times!!

6

Selandia changed the world



Selandia 1912

Rudolf Diesel's test engine was completed in 1897

Selandia in 1912
The First Ocean Going Ship with Diesel Engine

Engine :
8cylinders / 4 stroke
2 x 1,250HP x 140rpm

Made by Burmeister & Wain in Denmark

Steam engine

-> Diesel engine !!

Gas-Fueled Low Speed Diesel Engine

April 17, 2013

Demonstrational operation for Electronically Controlled Gas- Injection Diesel Engine (ME-GI) held in cooperation with Mitsui OSK Lines, Ltd. for Marine Use.



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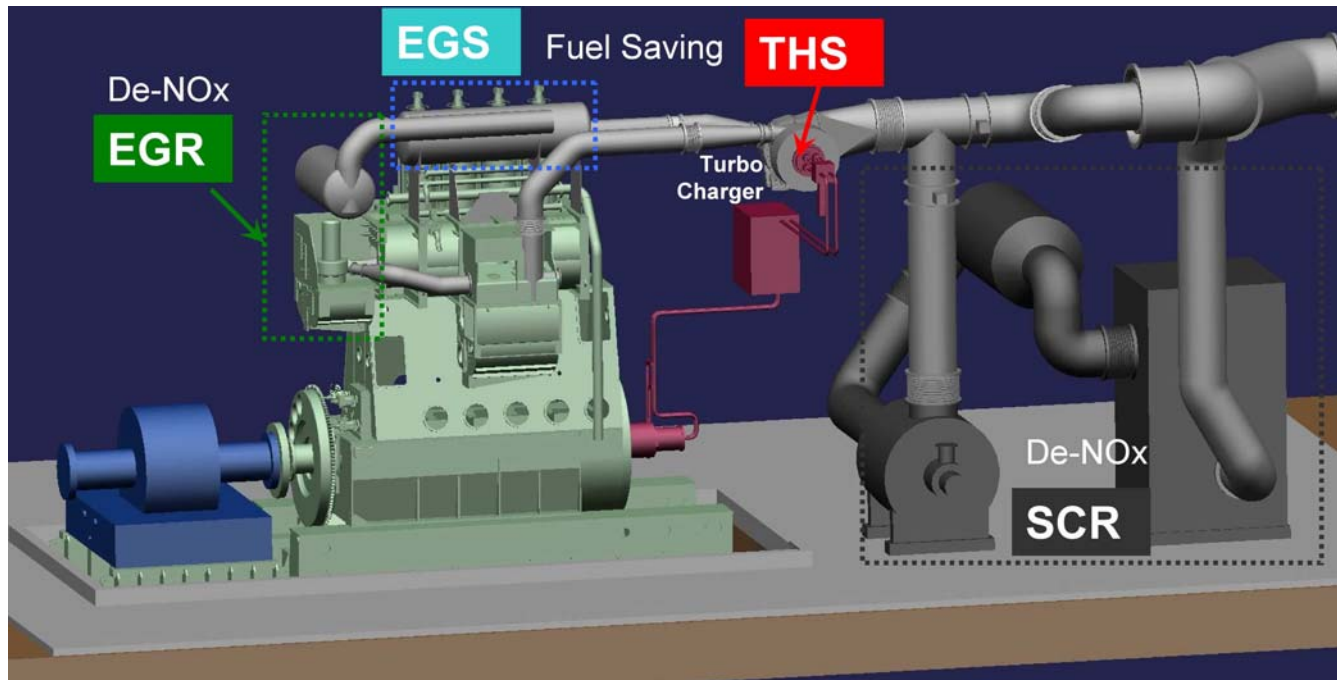
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3.2 ME-LGI (Electronically-controlled Dual Fuel
Liquid Gas Injection Diesel Engine)

2. MES R&D Activities 2009 - 2012

Development of fuel saving technology
under complying with IMO NOx Tier III



The development of the technologies has been supported by the Ministry of Land, Infrastructure, Transport and Tourism and has been supported by Nippon Kaiji Kyokai (ClassNK) and the Nippon Foundation through a joint research scheme.

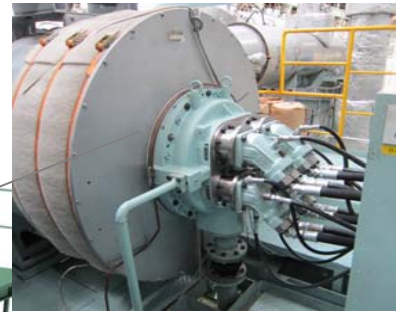
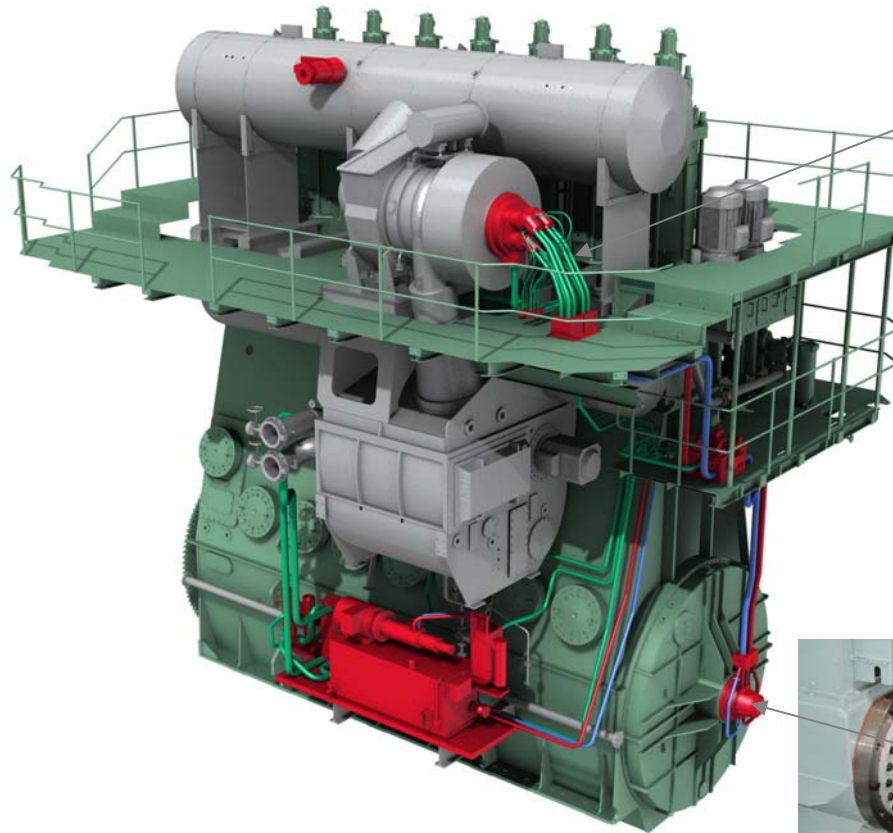


2.1 Development Outcome

- under complying with NOx Tier III Regulation
- **5%** : By applying WHR system “THS” and “EGS”
under high load operation
- **2%** : By applying EGR
under low load operation

- **More than 20%** : By applying ME-GI with gas fuel
Establish gas injection system and safety system

2.2 THS (Turbo Hydraulic System)

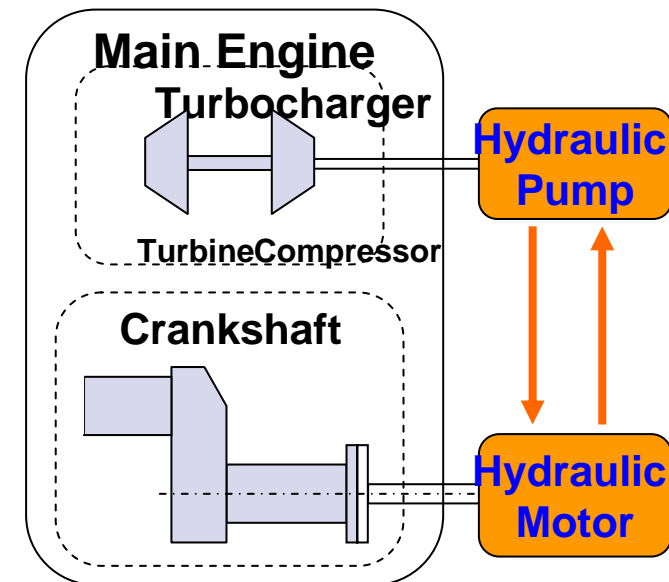


Hydraulic Pumps



Hydraulic Motor

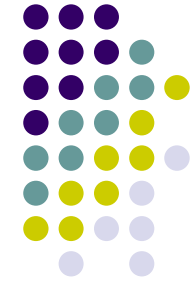
Already ordered



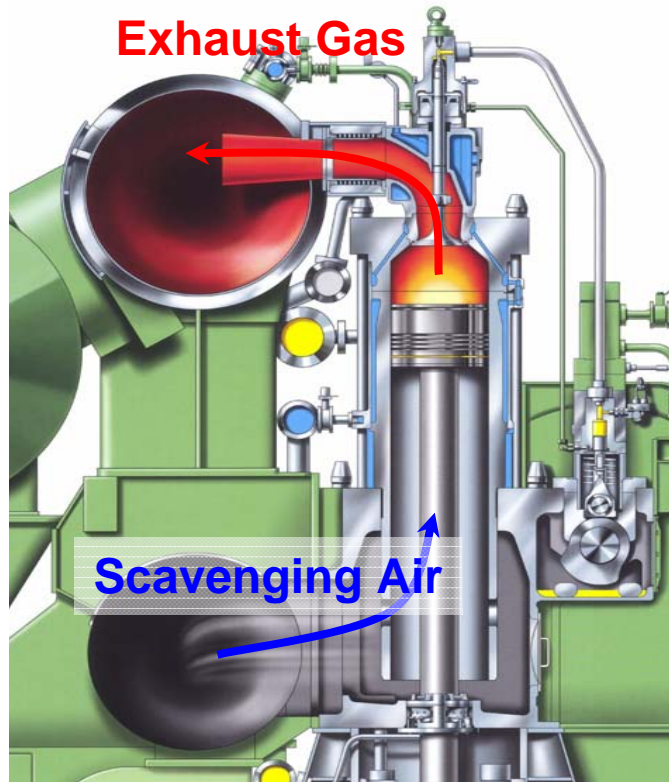
Hydraulic pump : Take out excess energy of exhaust gas from Turbocharger

Hydraulic motor : Assists rotation of crank shaft with recovered hydraulic power

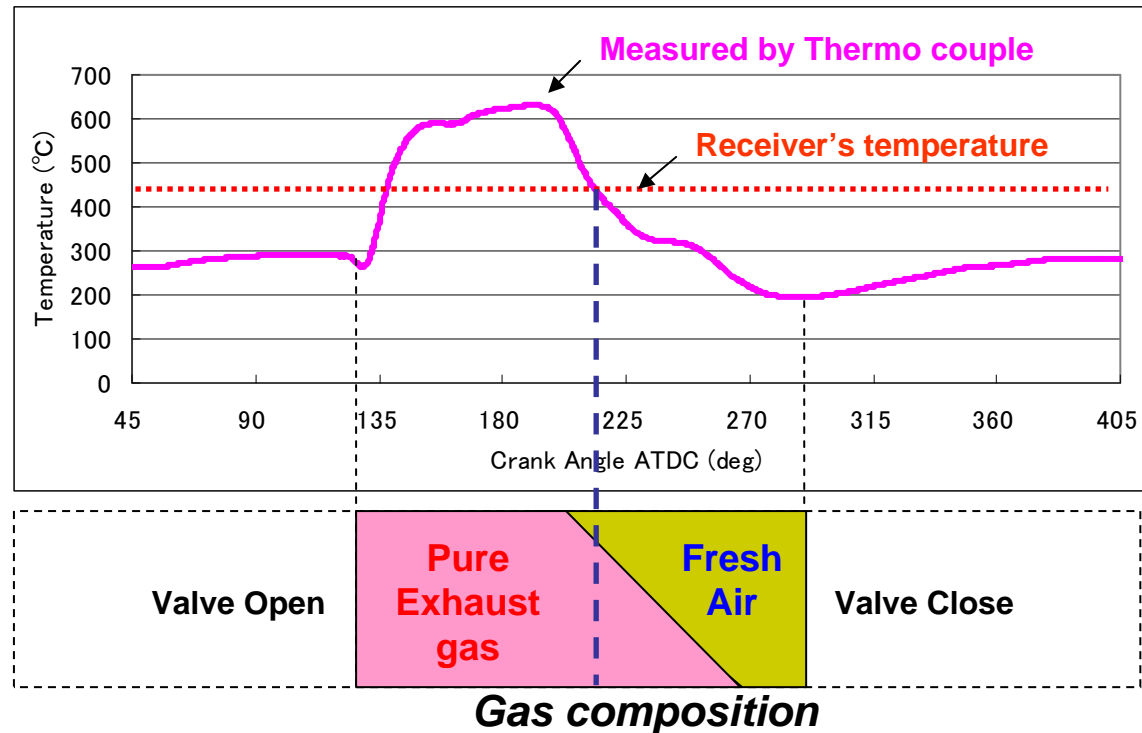
2.3 What is EGS ?



EGS : Exhaust Gas Separation System

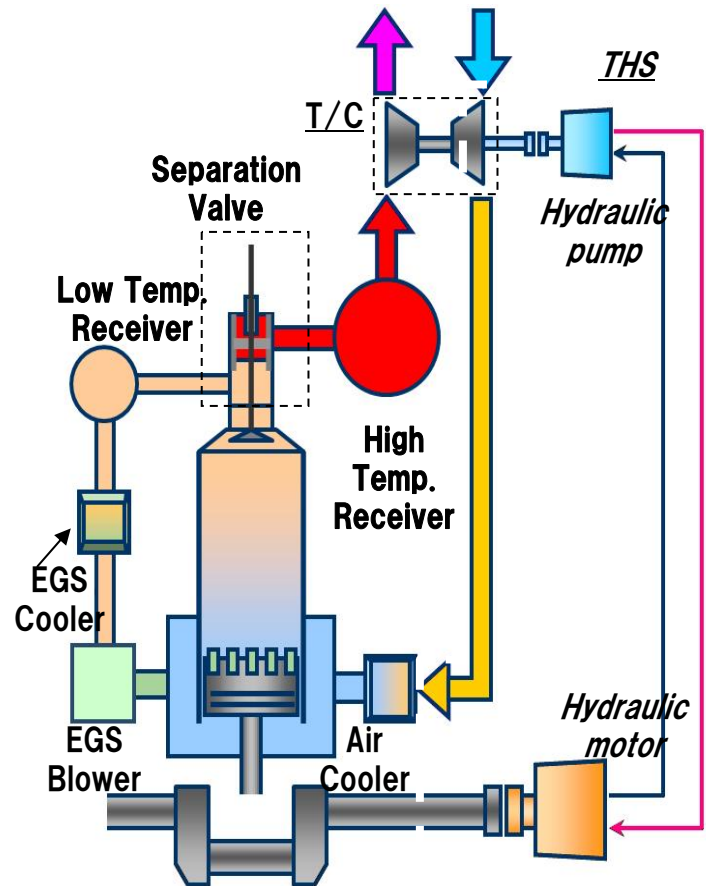


Temperature history of cylinder outlet (one cycle)
Engine Load : 75%



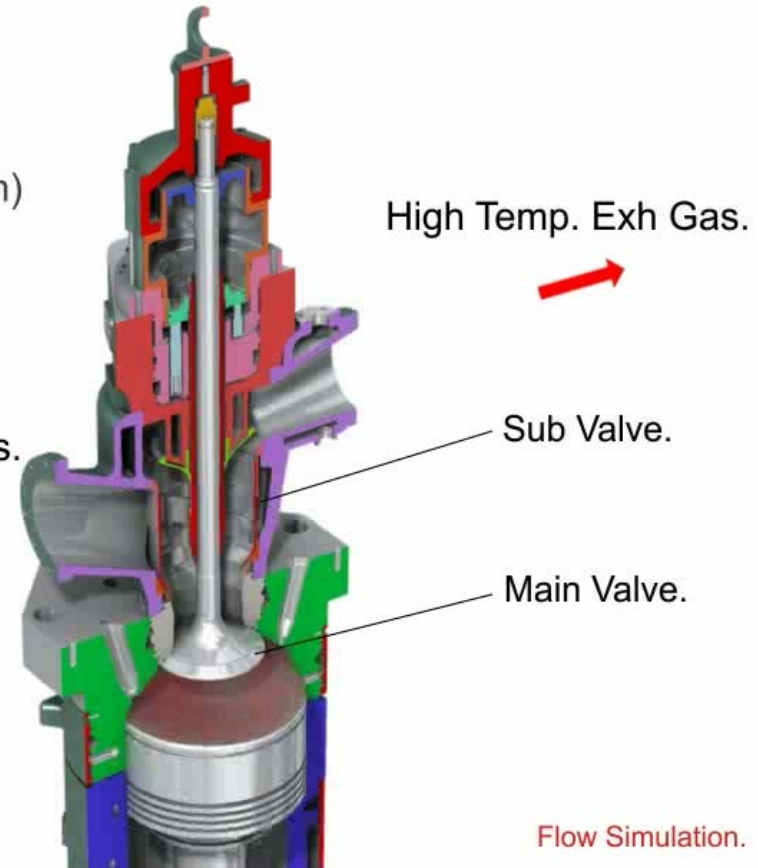
Averaged Temperature in Exhaust gas receiver decreased
by mixing with fresh air
→ Gas separation is effective for utilization of heat energy

How to Separate Exhaust Gas?



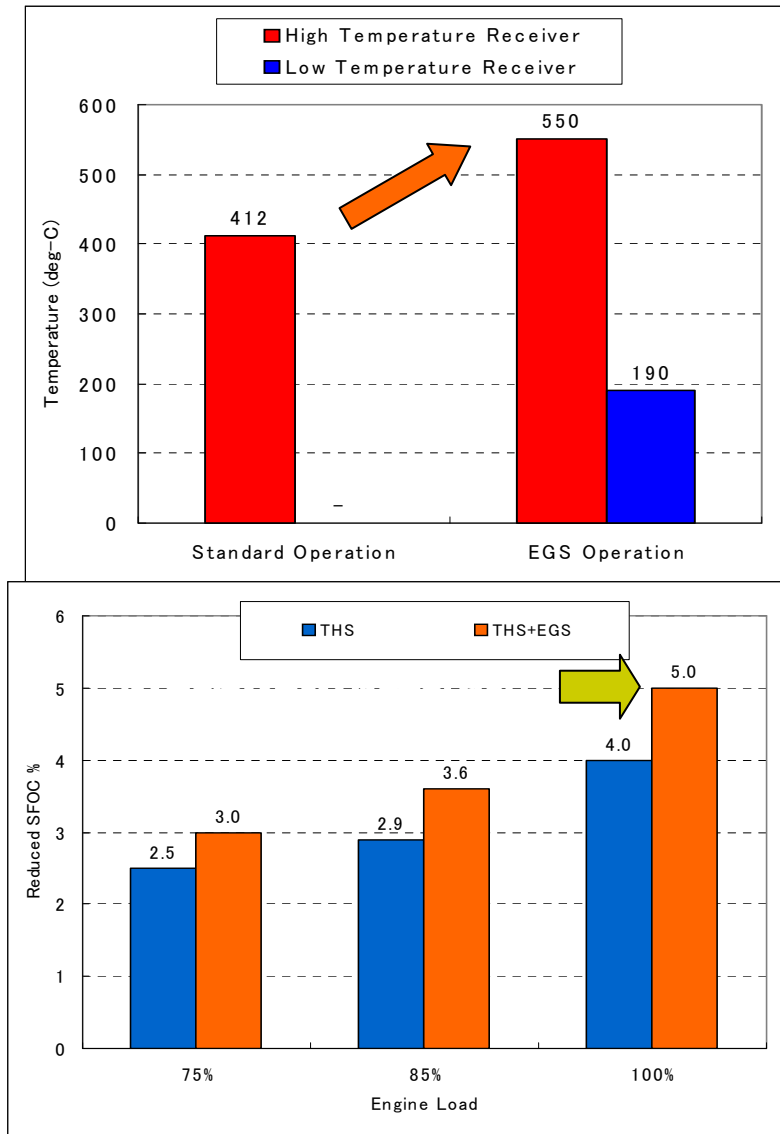
EGSS
Exhaust Gas
Separation System)

Low Temp. Exh Gas.



Cross section of separation valve

EGS Advantage



Performance

1. More energy can be recovered

→MAX. 5%

2. T/C can be downsized

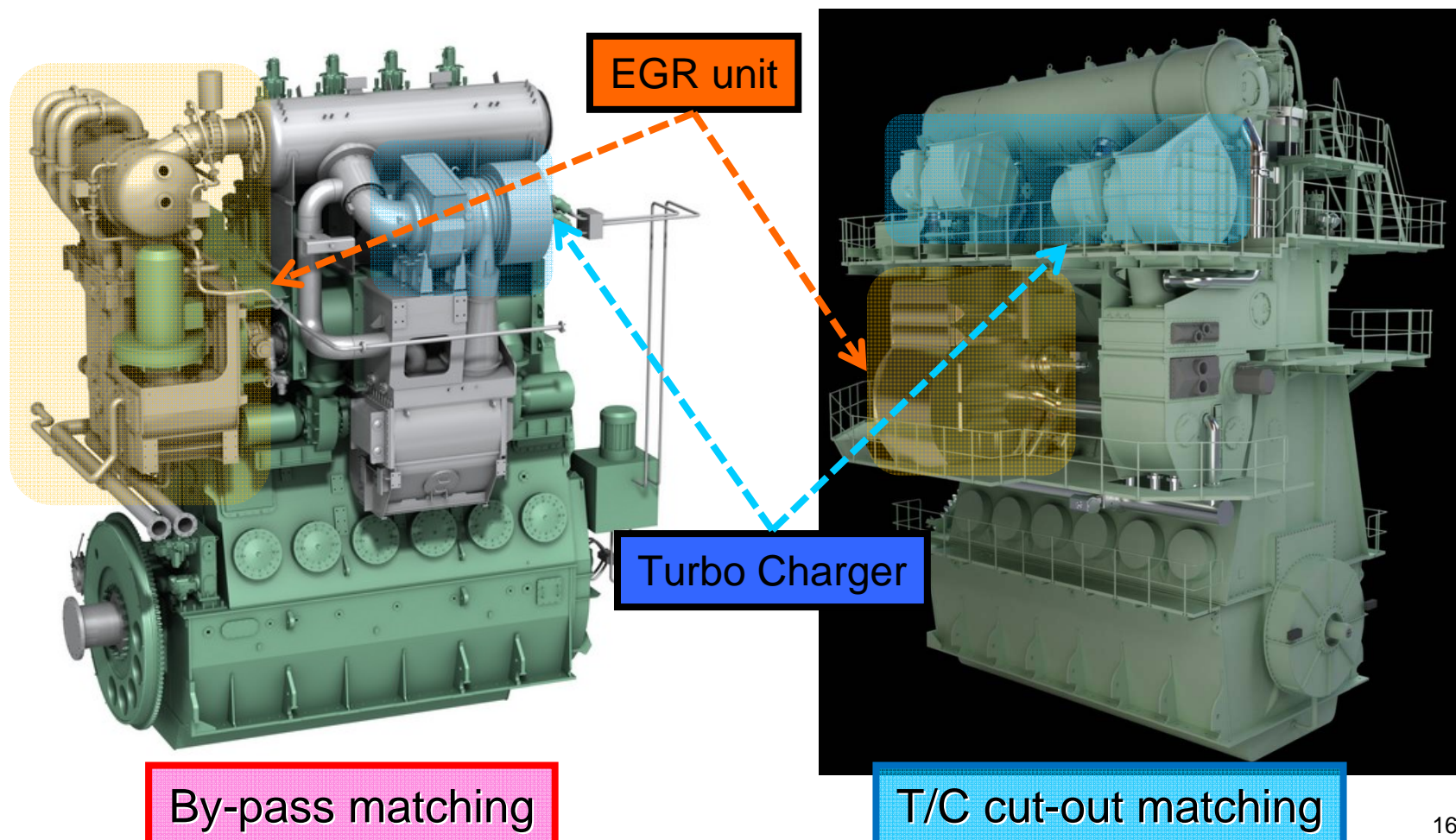
By recirculation system of low temperature exhaust gas (similar to EGR)

3. Increased exh. gas temperature

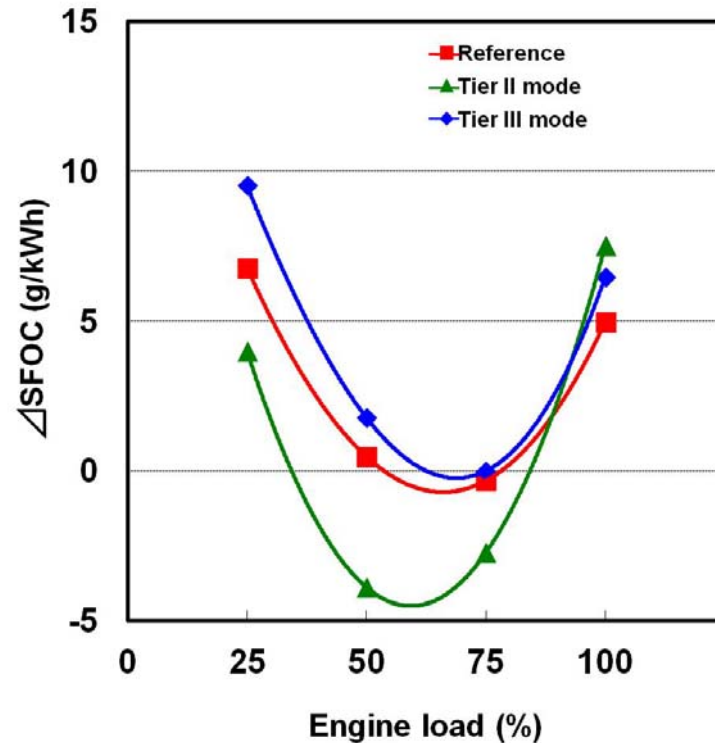
- Downsized SCR system
- Possibility of increased heat recovery rate through boiler

2.4 EGR (Exhaust Gas Re-circulation)

- Compliance with NOx Tier III
- Reduction of CO2 under NOx Tier II



EGR Advantage



EGR can reduce SFOC under Tier II by adjusted engine parameter



Full-scale test of EGR will be made on a actual vessel.

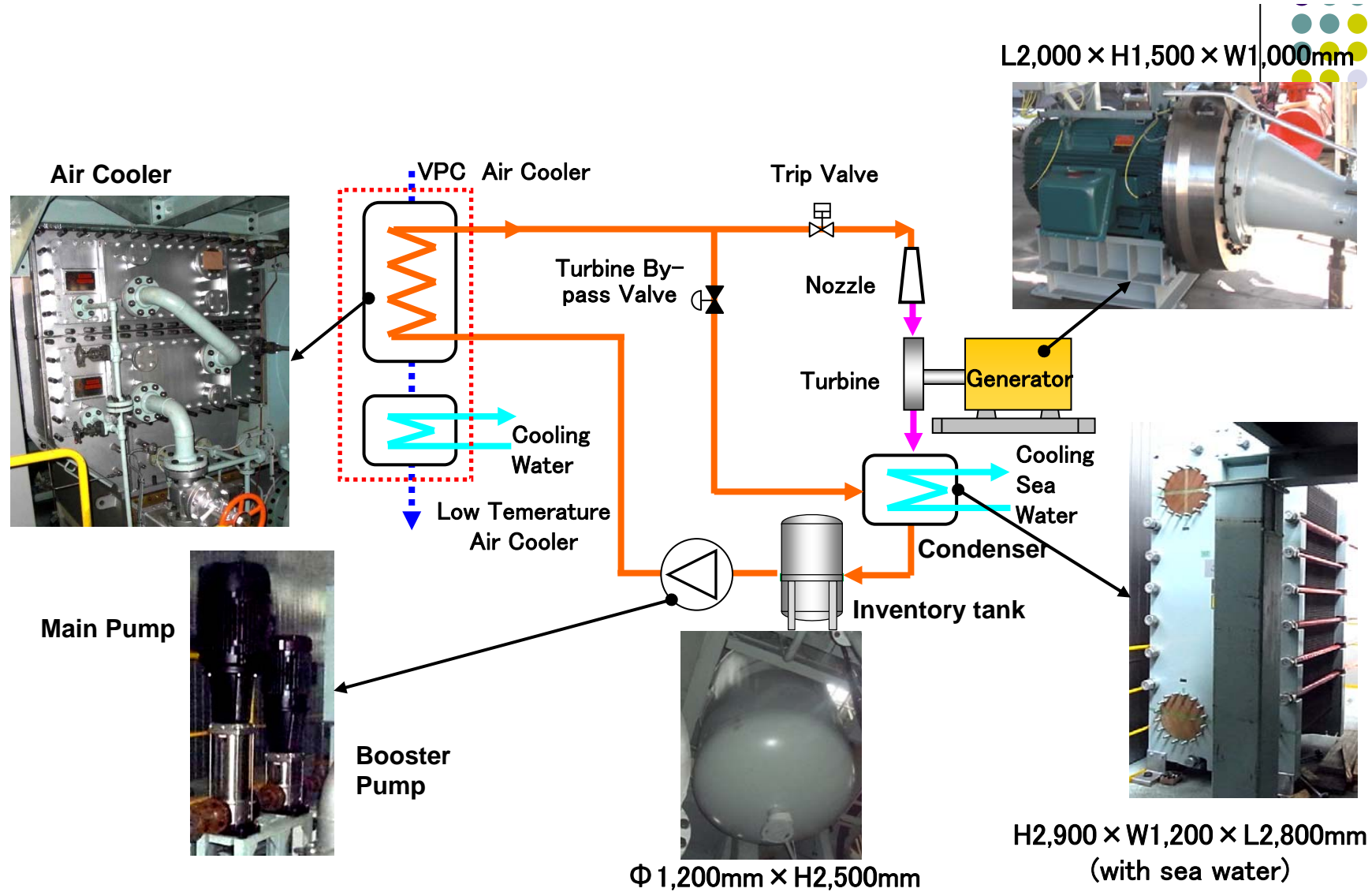
SFOC

Tier III mode: 0 ~ 3 g/kWh up

Tier II mode: 3 ~ 5 g/kWh down

(Power of EGR blower is not included)

2.5 VPC (Variable Phase Cycle) System



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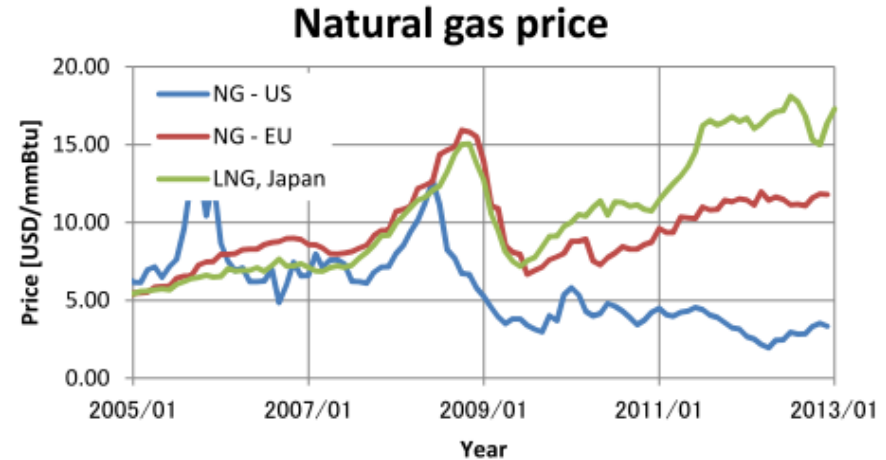
2.5 VPC (Variable Phase Cycle)

3. Latest R&D Activities / Low-carbon Fueled Engine

3.1 ME-GI (Electronically-controlled Dual Fuel
Gas Injection Diesel Engine)

3.2 ME-LGI (Electronically-controlled Dual Fuel
Liquid Gas Injection Diesel Engine)

3.1.1 Why ME-GI?



Potential of Gas Burning Engines

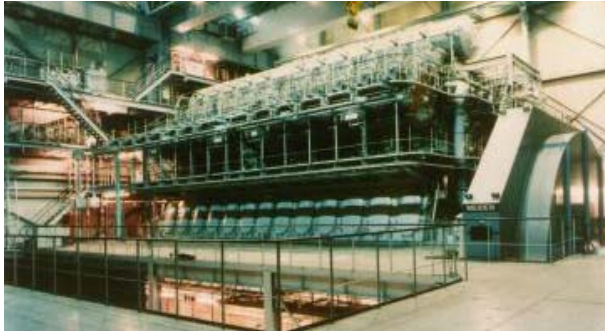
- **Increasing Natural gas demand**
Import of North American shale gas will be able to drastically reduce Natural gas price.
- **Tightening of regulations (NO_x, SO_x, CO₂ emission regulations)**
Natural gas : Environment-friendly fuel
(Sulphur free, CO₂ emission : more than 20% reduction against heavy fuel oil)
↔ Price of low-sulphur-HFO may boost up

Adapting natural gas as marine engine fuel makes it possible to achieve both economical efficiency and global environment.

3.1.2 Operation History of ME-GI



1994 12K80MC-GI-S / MES



World's first low speed 2 stroke GI engine
Total running hour: 20,000 hrs

2011 4T50ME-GI-X / MDT



World's first low speed 2 stroke ME-GI engine Proto type

2012 8S70ME-C8.2-GI / HHI



World's first commercial version ME-GI engine
Type Approved by major classification societies

2013 6S70ME-C8.2-GI / MES



The latest commercial version ME-GI engine was demonstrated.

The mechanical gas components have enough operating hours!

3.1.3 Orders of ME-GI



1st order



8L70ME-C8.2-GI for 3,100TEU Container Vessel
1st Vessel Delivery: Q4, 2015 (2+3 options)

2nd order



2 x 5G70ME-C9.2-GI for 173,400m³ LNG Carrier
1st Vessel Delivery: early 2016 (5+5 options)

3rd order



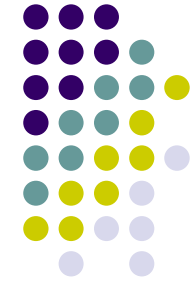
7S90ME-C10.2-GI for 3,600TEU Container Vessel
1st Vessel Delivery: Q3, 2018 (2+3 options)

4th order



8S50ME-B9.3-GI for 1,431TEU Container Vessel
1st Vessel Delivery: late 2015 (2+2 options)

3.1.3 Orders of ME-GI



Orders of ME-GI

5th order



8S70ME-C8.2-GI for 2,400TEU + 400 Vehicle
ConRO Vessel
1st Vessel Delivery: Q2, 2017 (2)

ME-GI Conversion



2 x 7S70ME-C-GI for 260,000m³ LNG
Carrier
Start: April, 2015
Completion : June, 2015

The contract for the conversion of
ME-C to ME-GI was established.

The first vessel to sail with ME-GI!

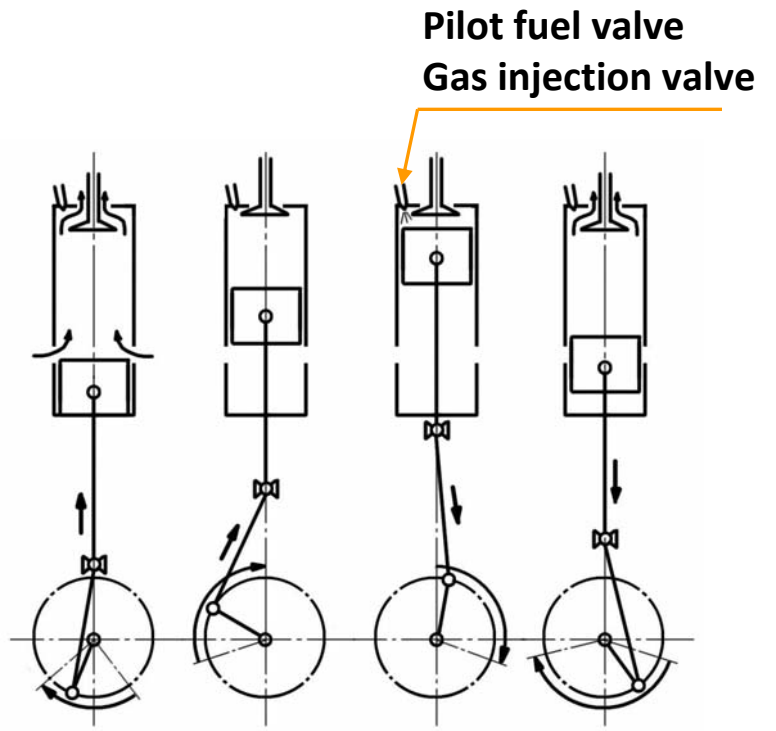
The service experience can be obtained in 2016!

3.1.4 Outline and Feature

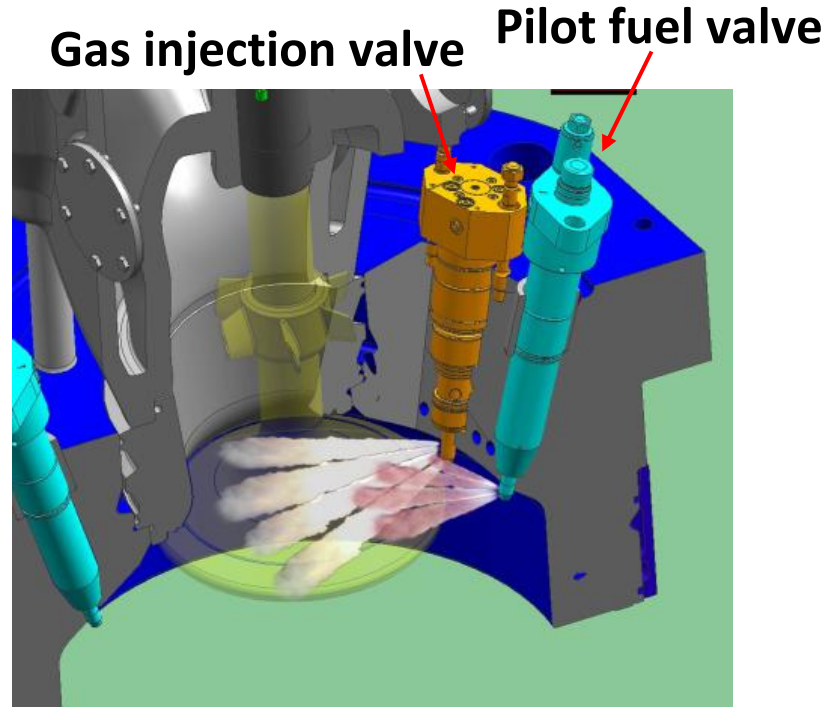


- No knocking due to diffusive combustion (Diesel cycle)
- Unburnt HC (methane slip) emission significantly low
- Insensible to gas property change

The high pressure gas of 30MPa is injected in the cylinder.



1. Intake → Compression stroke 2. Combustion → Exhaust stroke



3.1.4 Outline and Feature



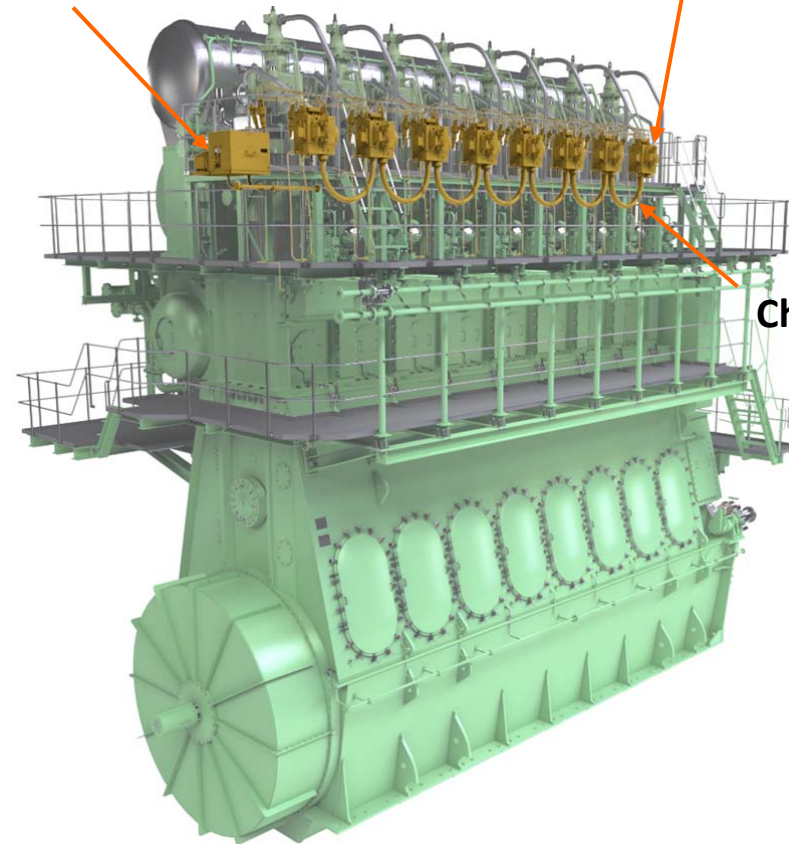
ME + GI

- Gas components are added on highly reliable ME engine.
- Gas components are installed mainly on the engine top platform area.
- Easy retrofit



Seal oil pump unit

Gas control blocks



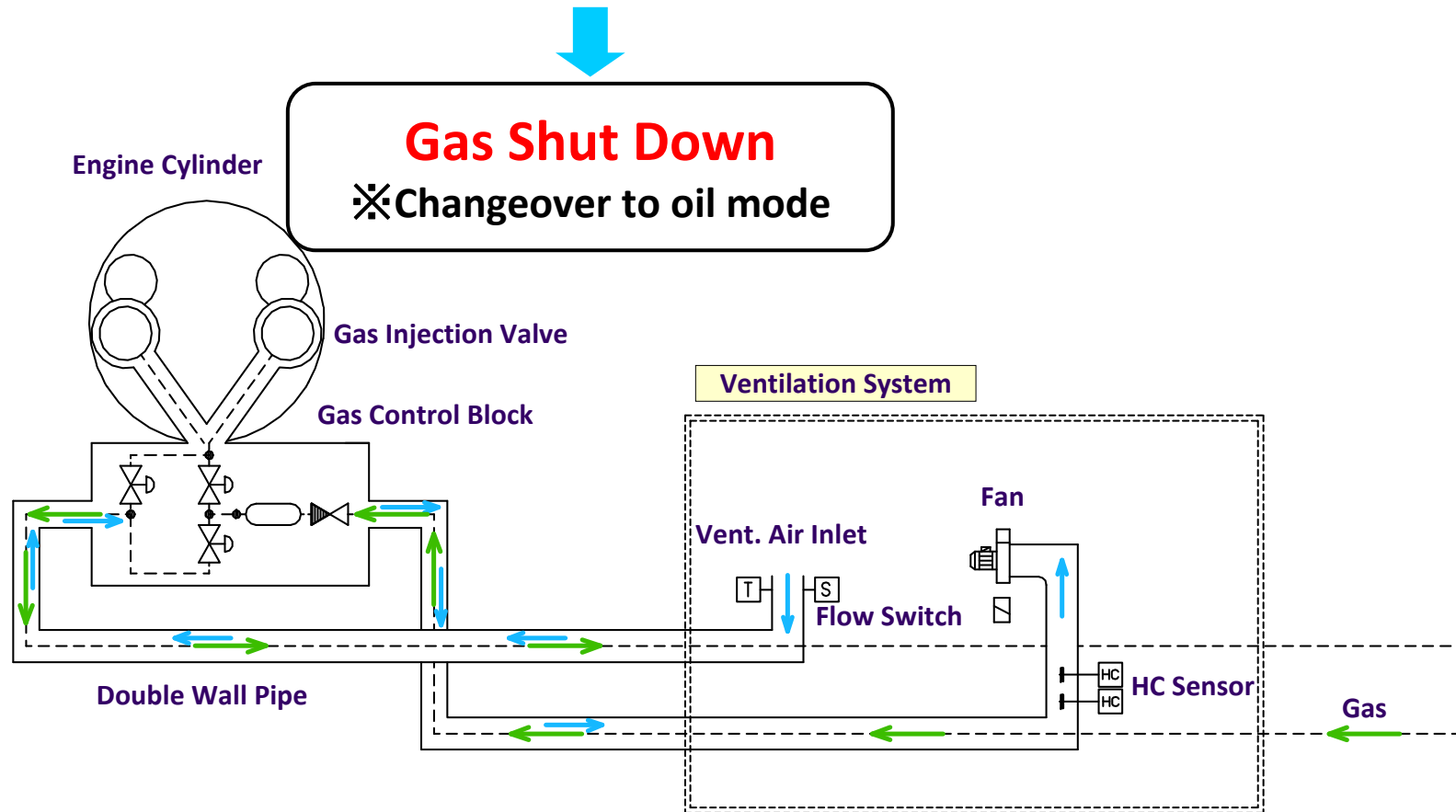
Chain pipes

3.1.5 Safety System

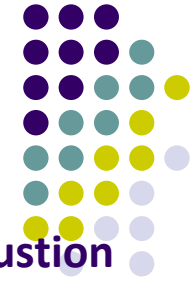


Double Wall Pipe and Ventilation System

Gas leakage can be detected by HC (Hydro Carbon) sensor which is located at end of ventilation line.



Supervision of Gas Pressure & Cylinder Pressure



Gas Pressure

Function of gas injection valve and window valve is checked by monitoring gas pressure between gas injection valve and window valve.

- ✓ Gas leakage in gas injection valve or blow-off valve (pressure decrease)
- ✓ Gas leakage in window valve (pressure increase)
- ✓ Failure of pressure sensor

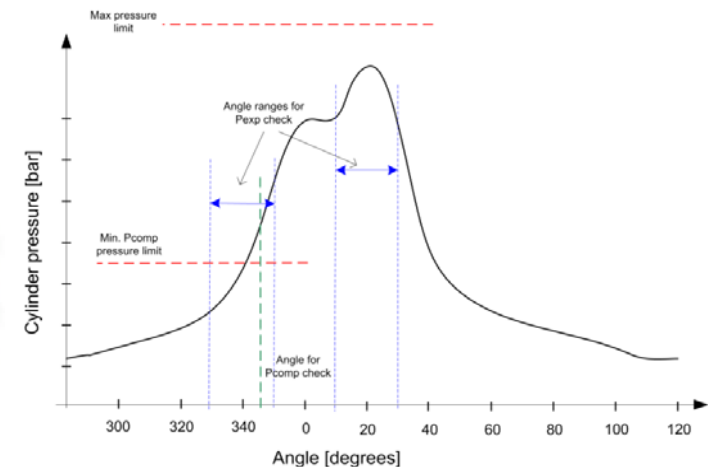
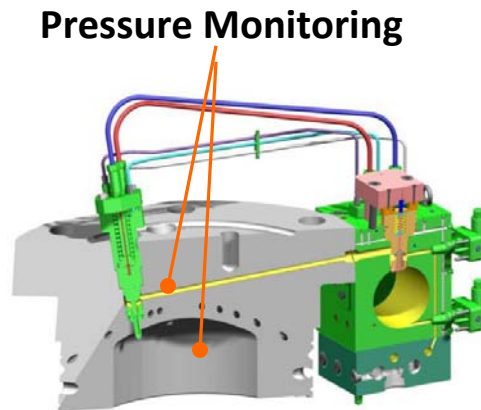
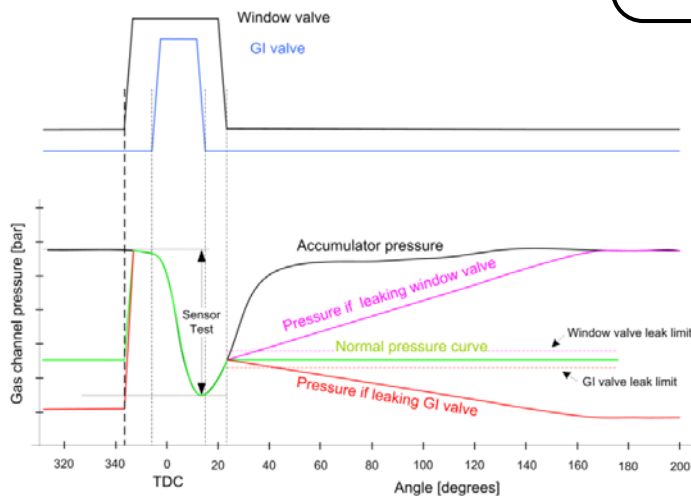
Cylinder Pressure

Misfiring and abnormal combustion can be detected by monitoring cylinder pressure.

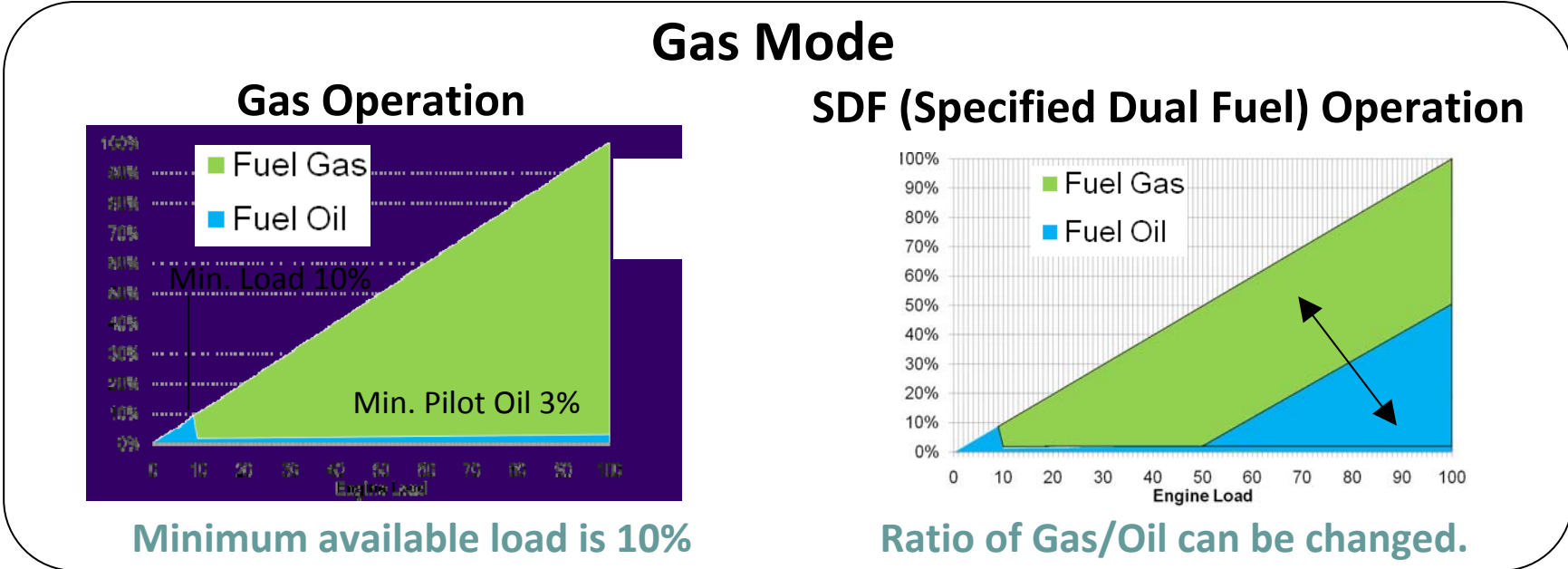
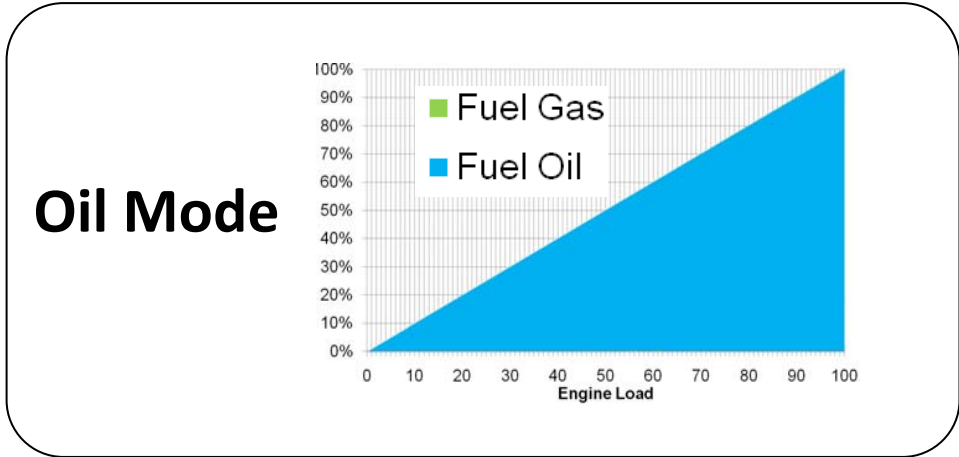
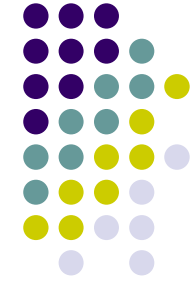
- ✓ Compression pressure, Low
- ✓ Maximum pressure, High
- ✓ Expansion pressure, Low



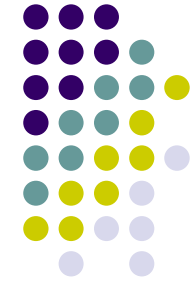
Gas Shut Down
✘ Changeover to oil mode



3.1.6 Operation Mode

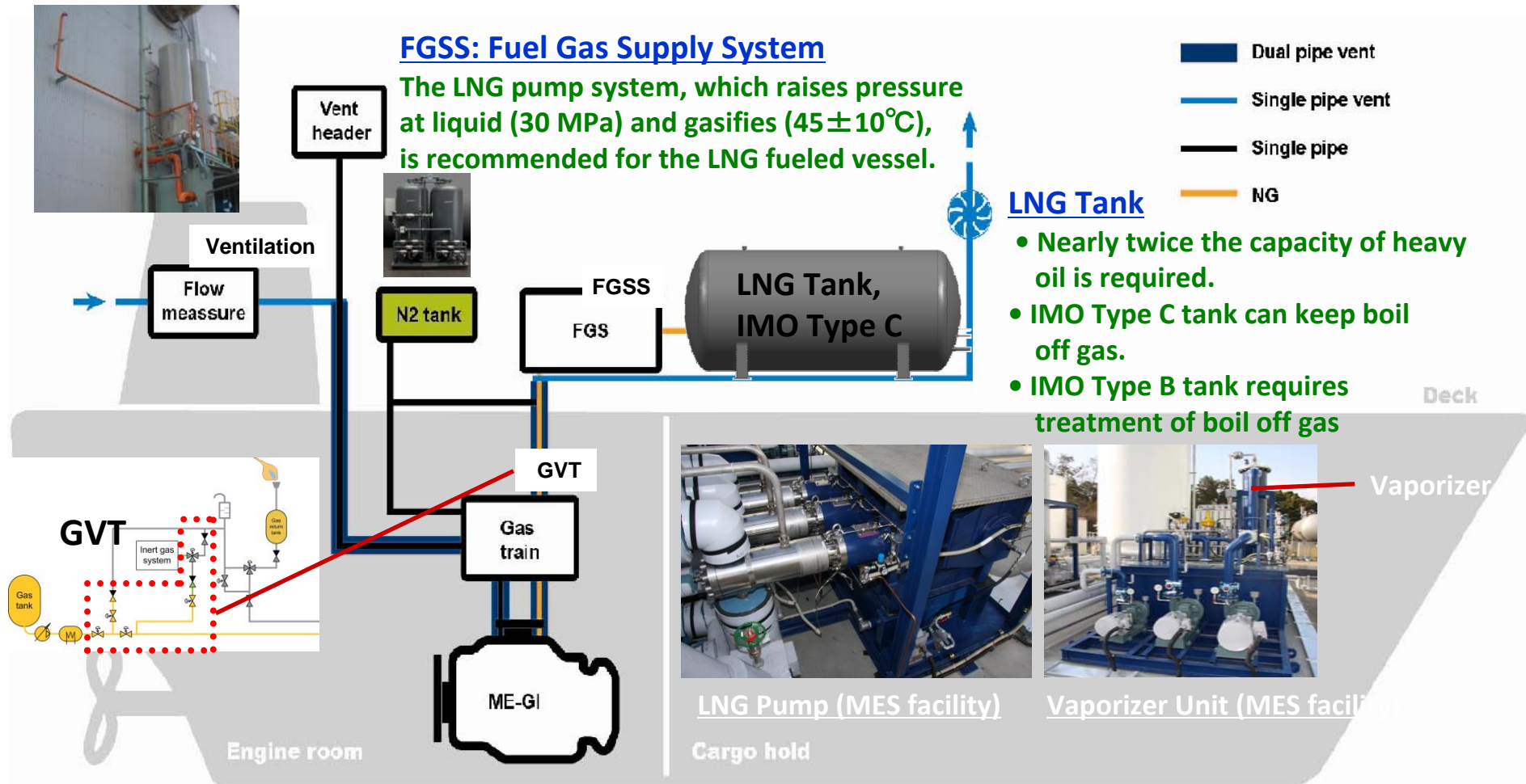


3.1.8 Hull Side Equipments



LNG Fueled Vessel

To be designed according to guideline for gas fueled vessel (IGF Code)
 The double wall gas pipe should be applied in the engine room.



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3.2.1 What is ME-LGI ?



ME-LGI engines Designed for Liquid Gas

Why Liquid Gas?

Liquid Gas is Low Flash Point Fuel (LFL)

To meet SOx Limits

- 1) Low Sulphur Fuels ▪ ▪ ▪ Expensive
 - 2) HFO with SOx scrubbers ▪ ▪ ▪ Large space
 - 3) Low Flash Point Fuels ▪ ▪ ▪ Lower emission (CO2 PM etc.)**
- All ME-C/B engines are available in the LGI version capable of using LPG or methane
 - ME-GI technologies applied (Dual Fuel)
 - Same power output and efficiency as the ME C/B engines.
 - LGI use Diesel Cycle -> Negligible gas-fuel slip



3.2.2 LNG & LFL



Gas Fuels	Know as	Supply condition	Supply pressure	Supply temperature
CH ₄	LNG, NG Methane	Gas	300 bar	Appox. 45 deg C
C ₂ H ₆	LEG Ethane	Gas	600 bar	Appox. 70 deg C
Propane & Buthane	LPG	Liquid	30-40 bar	Appox. 45 deg C
C ₂ H ₅ OH	Ethanol	Liquid	8 bar	Appox. 35 deg C
CH ₃ OH	Methanol	Liquid	8 bar	Appox. 35 deg C

We have a dream for our earth.

Thank you for your attention.

