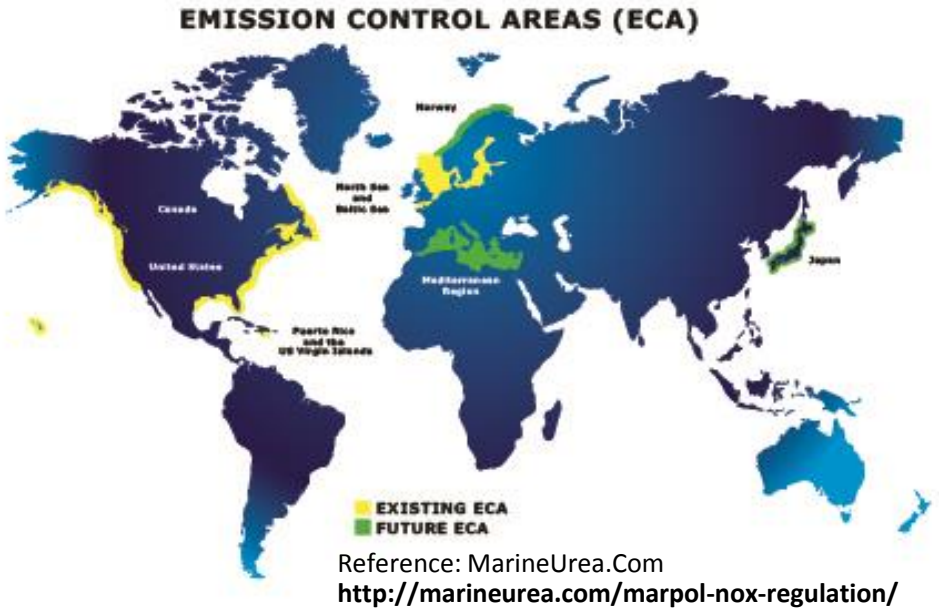
Development of Direct Drive Marine Propulsion Dual Fuel Engine "Niigata 28AHX-DF"

Zhide XU

Niigata Power Systems Co., Ltd.

Marine field regulations



Reference: MarineUrea.Com
http://marineurea.com/marpol-nox-regulation/

ECA: Baltic sea (SOx)

North sea (SOx)

North america - US coast 200 miles (NOx, SOx and PM), 2012

Puerto Rico - Adjacent sea (NOx, SOx and PM), 2014

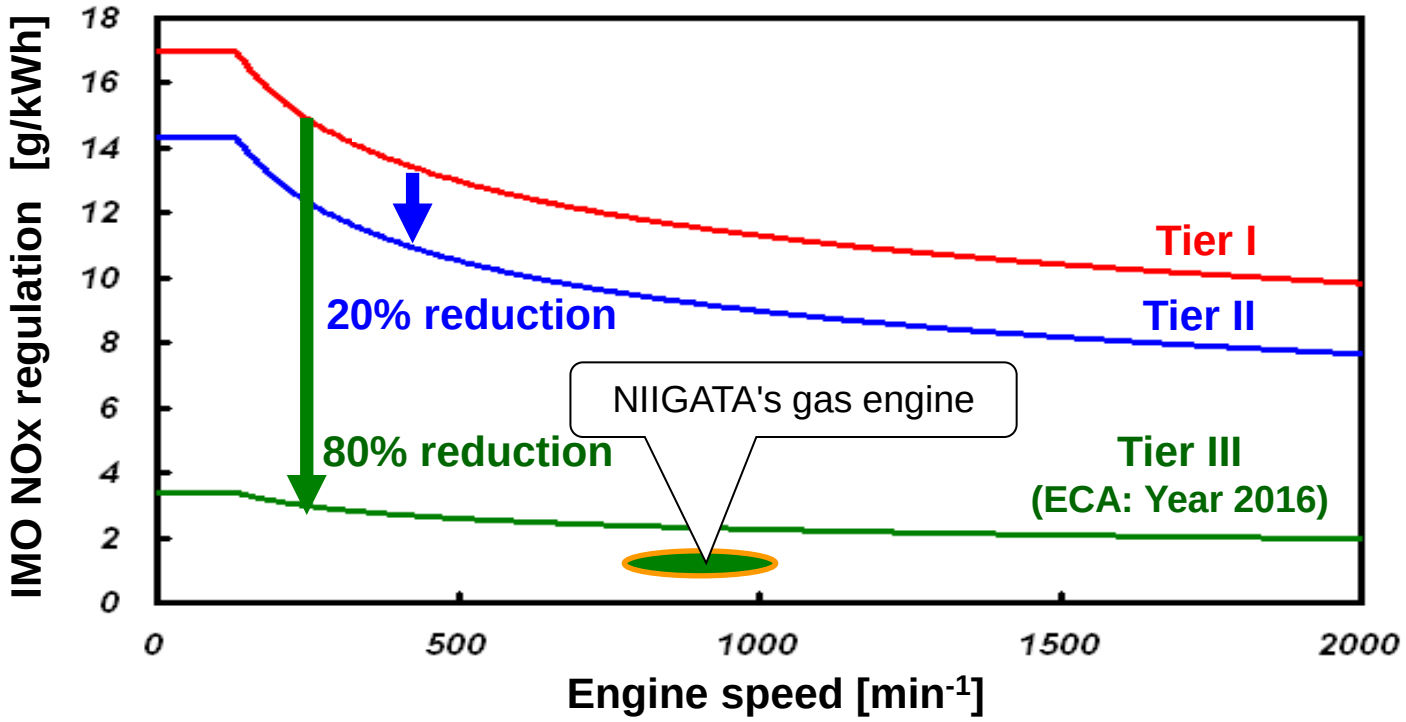
US Virgin Islands - Adjacent sea (NOx, SOx and PM), 2014

			Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Annex of MARPOL	NOx				Tier II (Global)					Tier III in Emission Control Area									
	SOx (Sulfur limit % m/m)	GLOBAL		4.5		3.5								0.5 *					
		SOx (SECA)		1					0.1										
2012/33 /EU	SOx (Sulfur limit %			1.5%:Passenger Ships ,2006										0.5 (EU All sea area),2020					
				0.10% : All ships at berth, 2010															

*** alternate date of application 2025, depending on the outcome of a review, to be concluded by 2018**

Background

Gas fueled engines emit low NOx, therefore, it is possible to meet IMO Tier III by the engine itself.



Gas fueled engine for marine application

Gas Engine Category		4SC HS	4SC MS	2SC LS	Merit	Demerit
Spark Ignited	Otto cycle	×	×	—	Mono fuel Cost effective Low NOx, Tier III compliance	Redundancy
Low Press. Dual Fuel	Otto cycle	—	×	×	Redundancy Lower cost than HPDF	Two sources of fuel
High Press. Dual Fuel	Diesel cycle	—	×	×	Redundancy Knock resistance Fuel variation other than NG	Two sources of fuel High press. compressor Initial cost Higher NOx than LPDF

Propeller Drive		4SC HS	4SC MS	2SC LS	Merit	Demerit
Direct Drive Propeller	FPP CPP	?	×	×	Cost effective High fuel efficiency	Quick load change may be difficult(esp. FPP)
Electric Drive Propeller	FPP CPP Inverter	×	×	—	Capability of quick load change	Higher cost Lower fuel efficiency

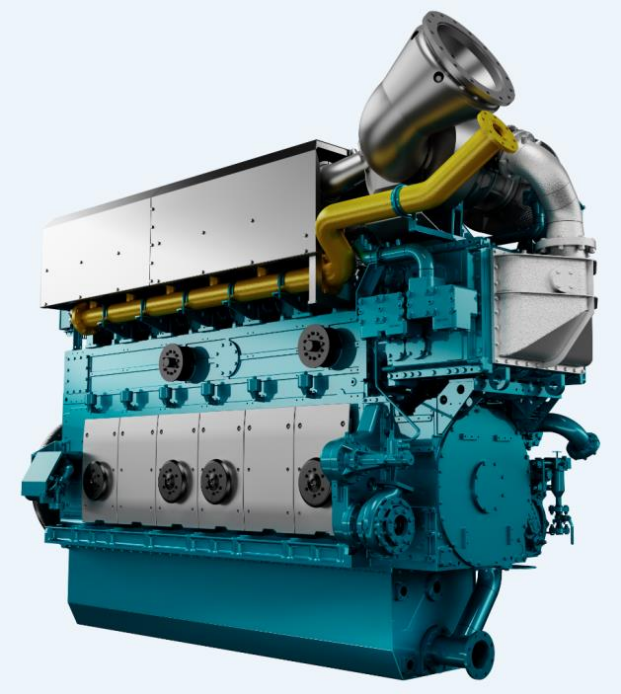
4SC: 4 stroke cycle
2SC: 2 stroke cycle

HS: High Speed
MS: Medium Speed
LS: Low Speed

The most cost effective, with highest fuel efficiency and redundancy / safe navigation solution is;

Low Pressure Dual Fuel Engine with Fixed Pitch Propeller (FPP)

Specification of marine gas engine



The base model is latest diesel engine, 28AHX.

Items	Specification
Developed engine	28AHX-DF Dual fuel engine
Bore	280mm
Stroke	390mm
Engine speed	800min^{-1}
Ignition method (gas mode)	Direct injection Micro pilot ignition
B.M.E.P.	2.0 MPa
Fuel gas	LNG, NG (gas phase) MN = 65
Fuel oil	MDO

Target engine performance

Gas mode

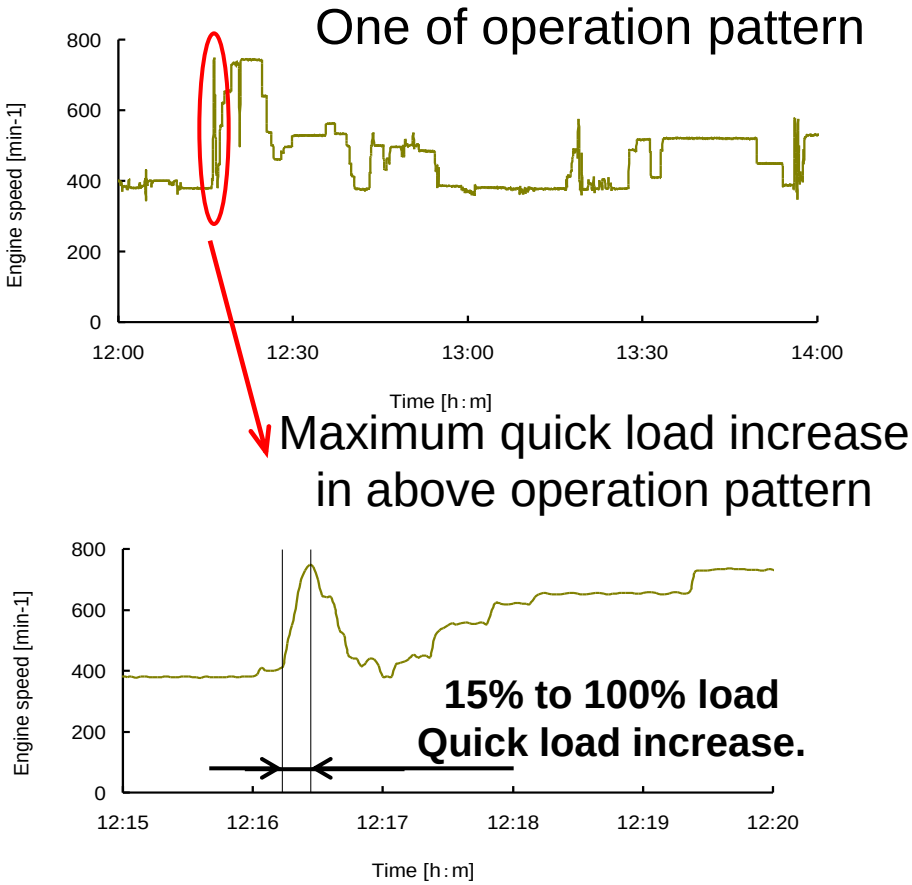
- ✓ IMO NOx Tier III compliant
- ✓ Same transient performance as current diesel engine
- ✓ Same output and flexible mode change between diesel and gas mode at any load
- ✓ Quick mode change to diesel in case of emergency
- ✓ Knocking free operation

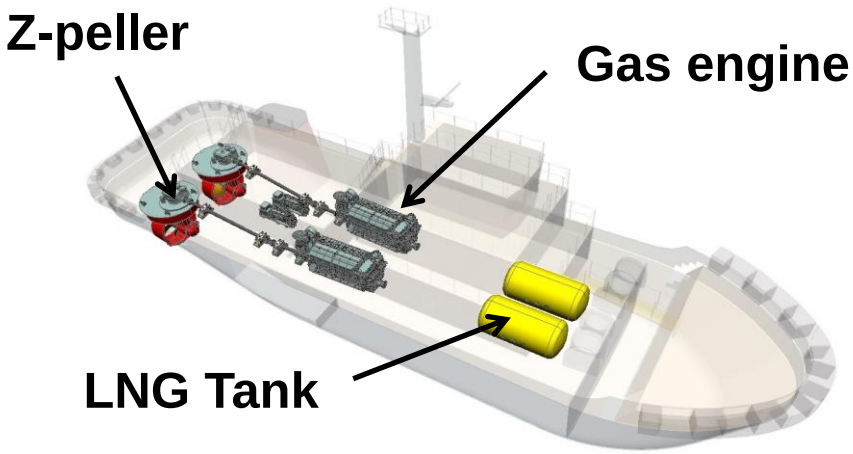
Diesel mode

- ✓ IMO NOx Tier II compliant

Target transient performance

Target of ships





Tugboat with direct drive in harbor is target. This is the biggest challenge for gas engine.
However, it can also be applied to other marine applications if the direct drive propulsion is possible.

Quick load increase is demanded at tugboat operation.

Development of 28AHX-DF engine

28AHX Diesel
(Base model)

Experience in
Niigata gas engine

Safe and redundant operation
Exhaust emission reduction

Ignition method
(micro pilot)

Experience in
tugboat market

Transient performance
Knocking free operation

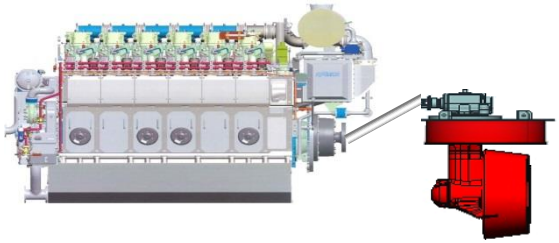
Air-fuel ratio
control

Market Demand

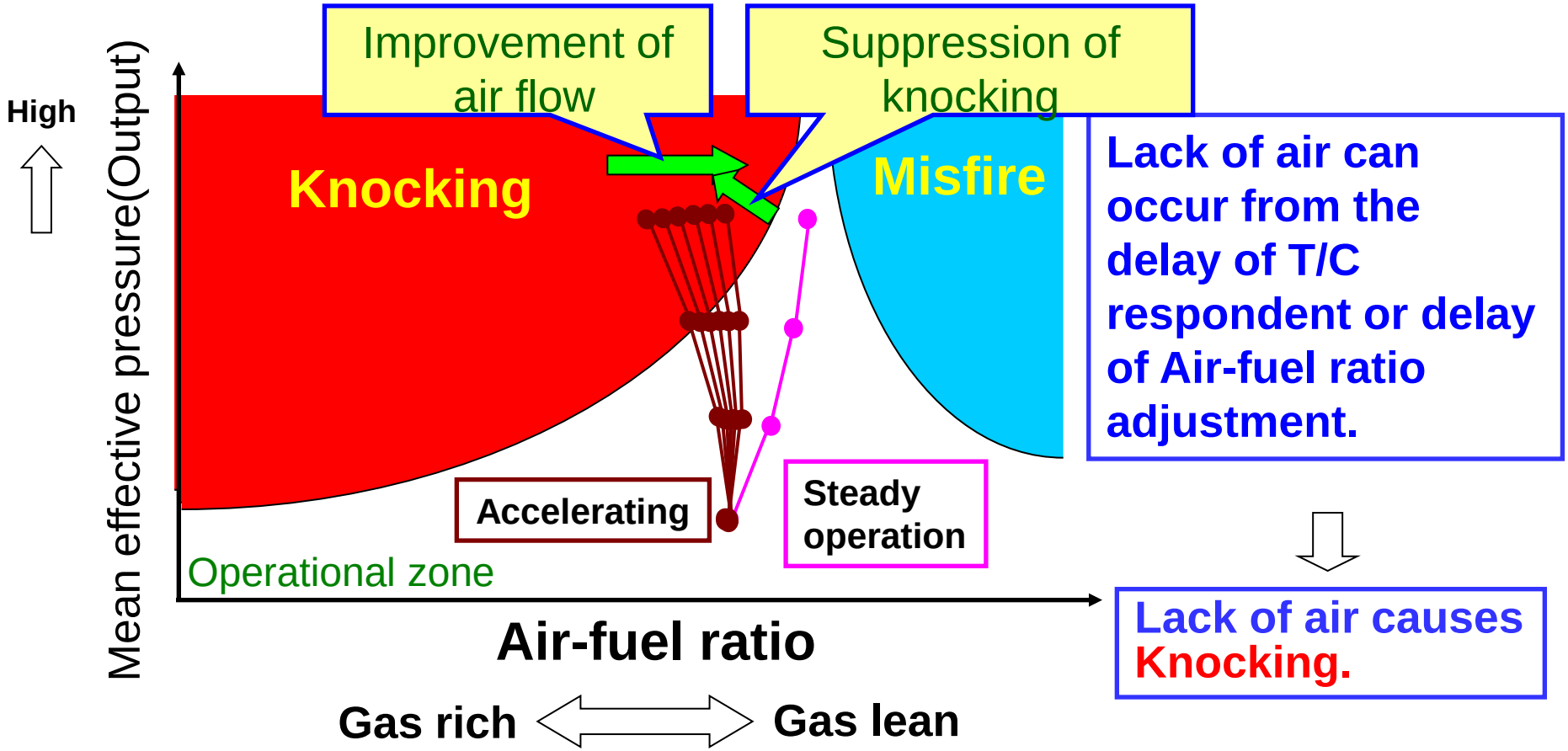
Development Target

Key development factor

28AHX-DF

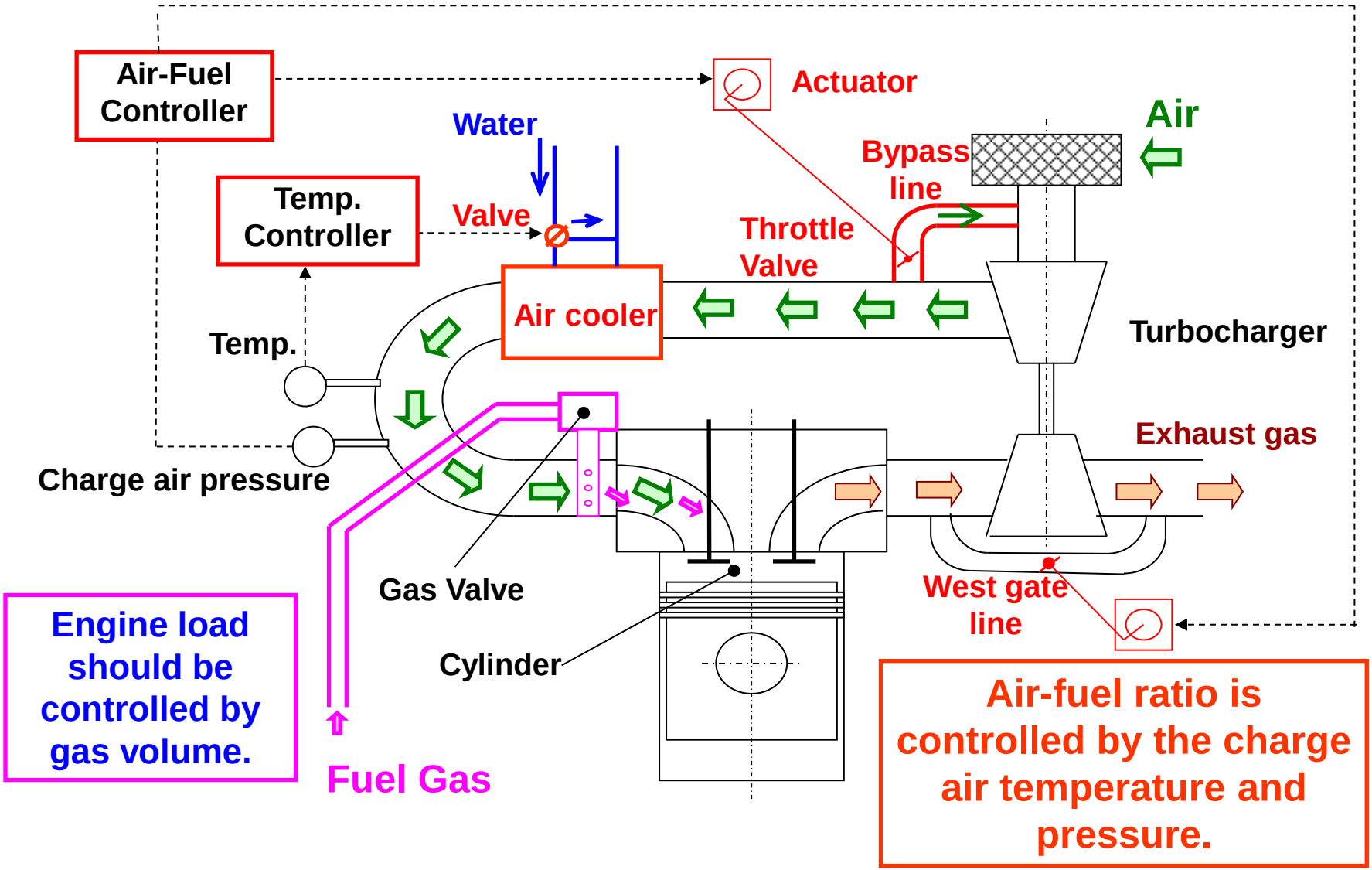


Transient performance (air-fuel ratio during acceleration)



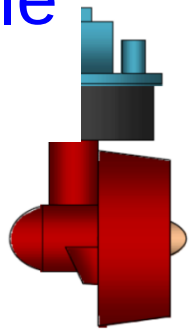
To improve transient performance, secure of sufficient air flow and suppression of knocking is necessary

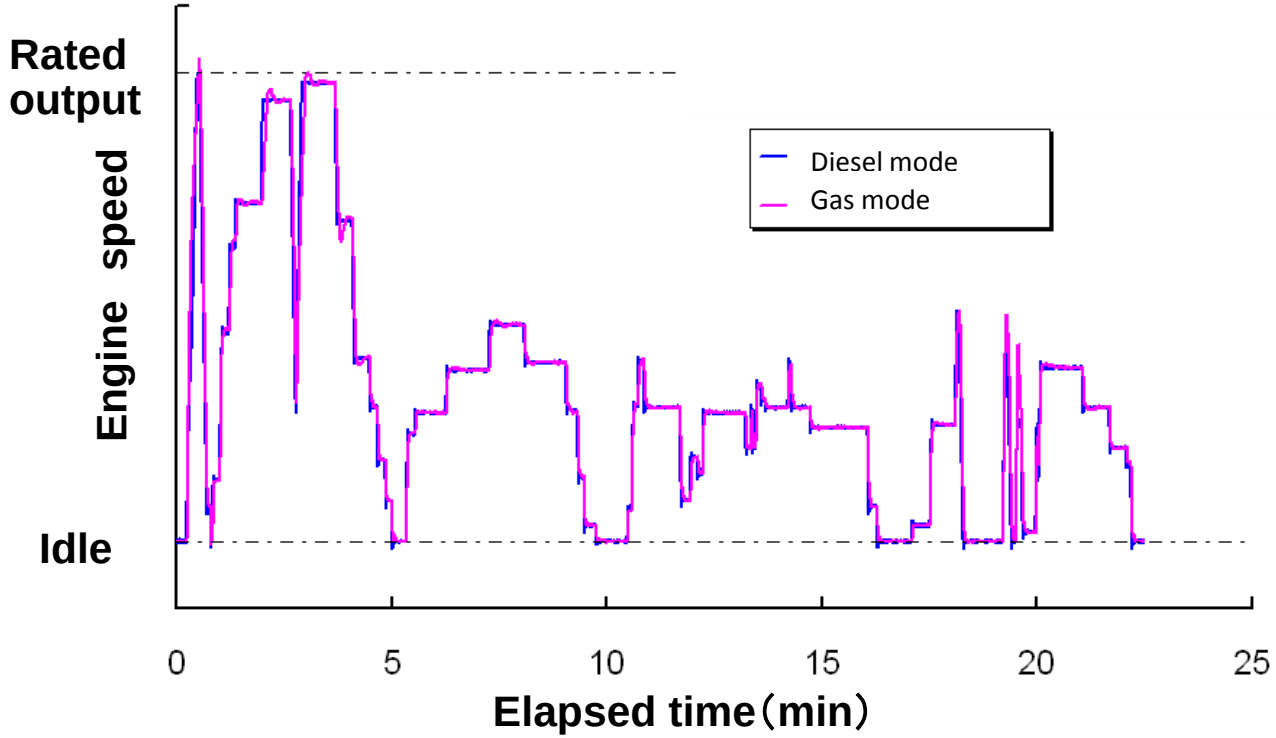
Optimized air-fuel control



Ship handling demonstration (tugboat)

In gas mode, transient performance comparable to diesel engine was achieved.

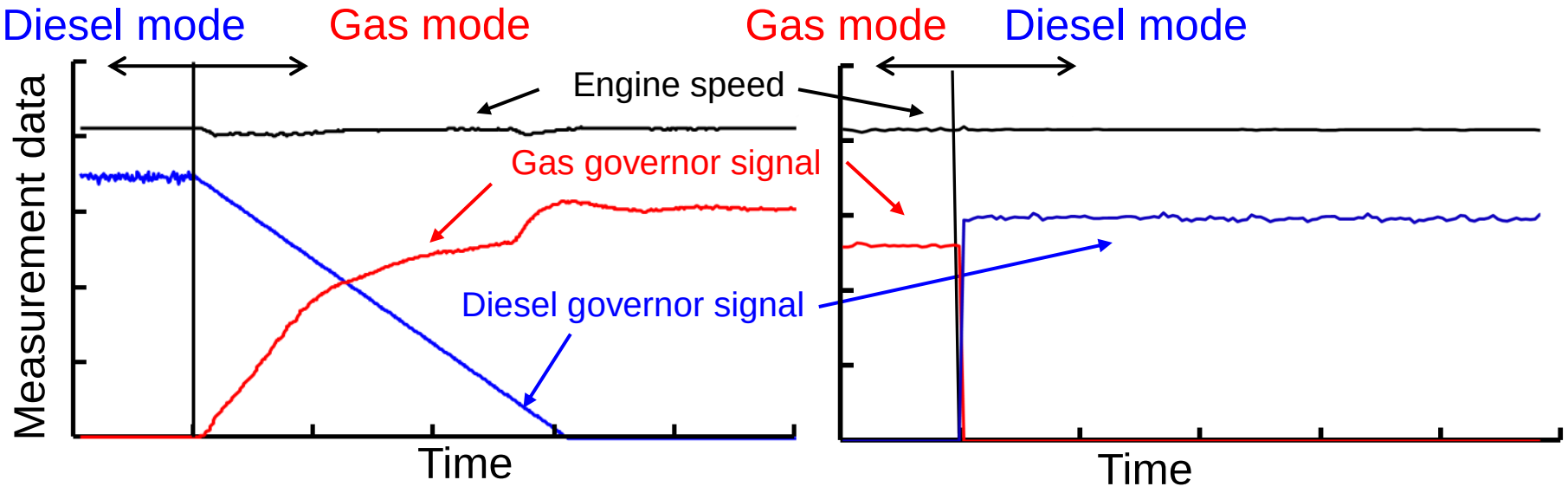




Switching of engine operation mode

Normal gas mode change

Emergency diesel mode change

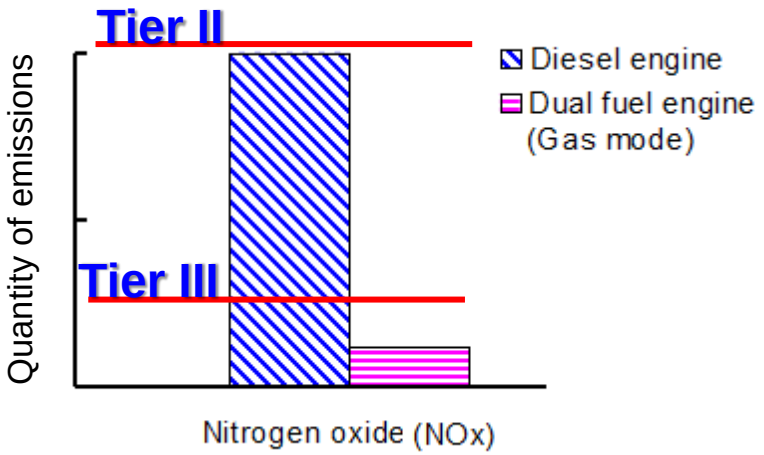


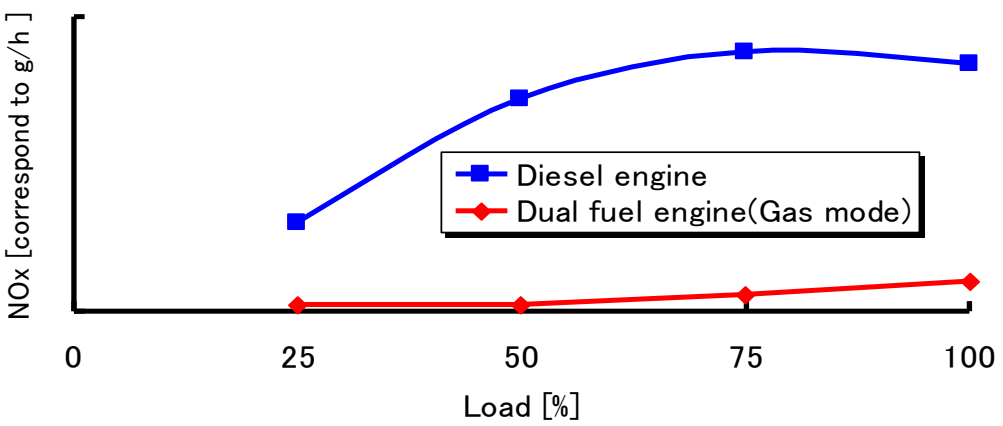
Realized mode change at 100% load

Exhaust emission characteristics

IMO NOx emission standards

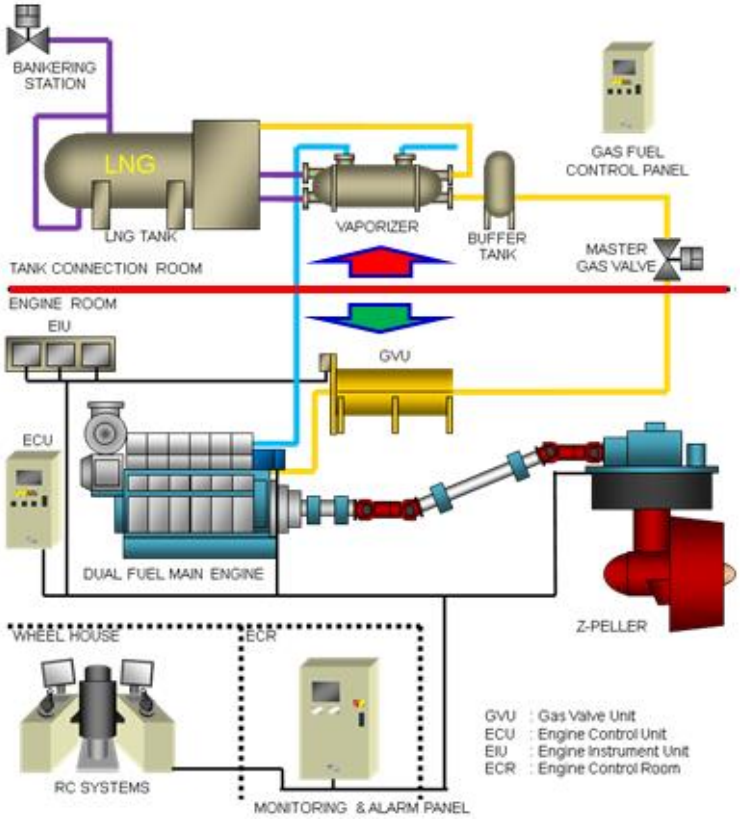
New engine meets NOx regulation of IMO Tier III in gas mode and Tier II in diesel mode.





First delivery of 28AHX-DF

Niigata delivered two sets of 28AHX-DF



Soruce : http://www.nyk.com/release/3560/004044.html

Two sets of 28AHX-DF have been delivered last December as key hardware of direct drive marine propulsion system for the tugboat. This September, the tugboat has been put into operation.

Conclusion

28AHX-DF has great success

- In gas mode, it meets NOx regulation of IMO Tier III.
- Transient performance comparable to diesel engine was achieved in gas mode.
- Redundancy of safety operation was verified in switching operation mode test.
- Reliability and durability of engine components were verified in endurance test.
- Niigata delivered newly developed dual fuel engine to Japan's first LNG fueled ship. This is the world's first built direct drive FPP LNG fueled ship.

Thank you for your attention.

Acknowledgement

The Dual Fuel marine propulsion engine 6L28AHX-DF introduced today uses part of technology from the research development which was selected as a supported project of "Research project of CO_2 reduction from marine vessels" by Ministry of Land, Infrastructure, Transport and Tourism, selected as a supported project by Nippon Kaiji Kyoukai(Class NK), selected as a joint research with Japan Ship Technology research association and financially supported by the NIPPON Foundation.

NIIGATA expresses sincere appreciation to these associations and foundation.