NOx reduction technology focused on compact high pressure system development

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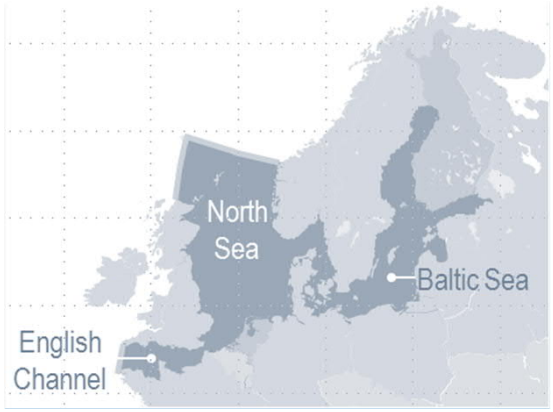
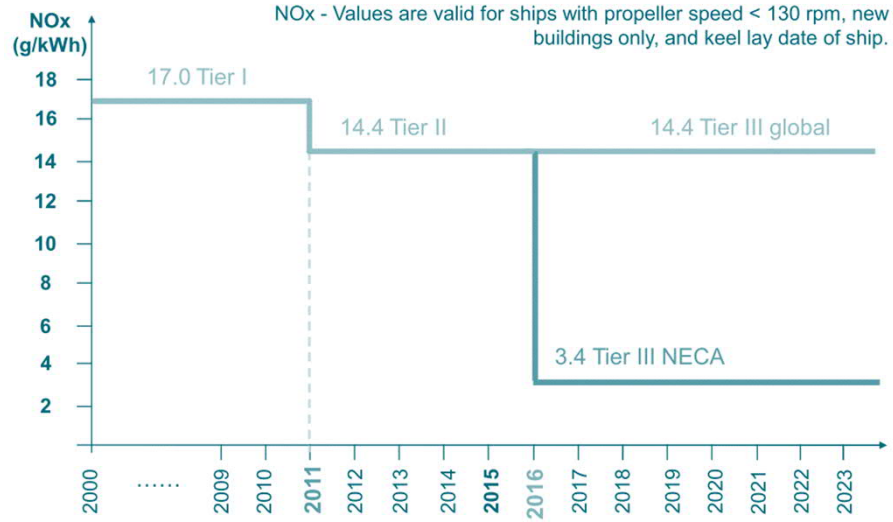
Introduction & Background

Focus Area: NOx Control

IMO/MARPOL Annex VI regulation 13 (NOx)

- The global Tier II NOx limit is 14.4 g/kWh at date.
- The NOx ECA (NECA) limit is 3.4 g/kWh.
- Effective date (keel lay of ship) 1.1.2016 for American NECA,
  1.1.2021 for North Sea & Baltic
  others after designation





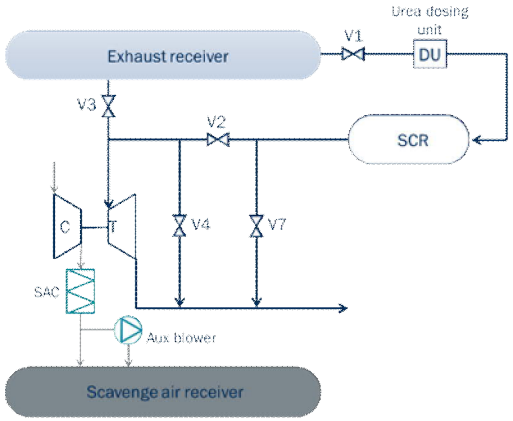
Tier III NOx Compliance

Current solutions applied for WinGD engines

HP-SCR

- The SCR system is placed on the **high-pressure side, before the TC turbine.**
- Arrangement of the SCR system in the engine room close to the engine is required.

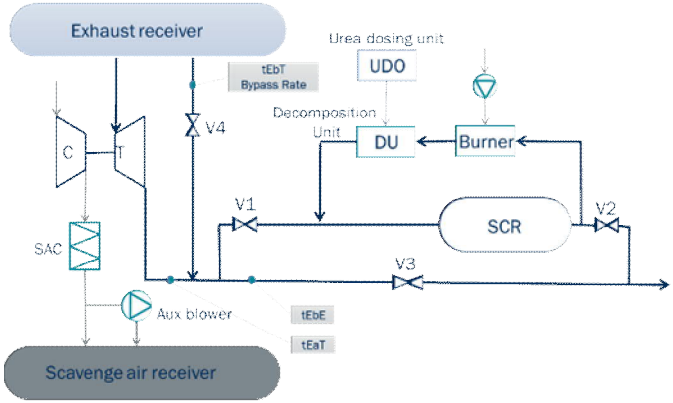
- **WinGD provides valve interface, control specifications and guidelines**



LP-SCR

- The SCR system is placed on the **low-pressure side, after the TC turbine.**
- This arrangement gives higher flexibility to place the SCR system anywhere in the funnel of a vessel.

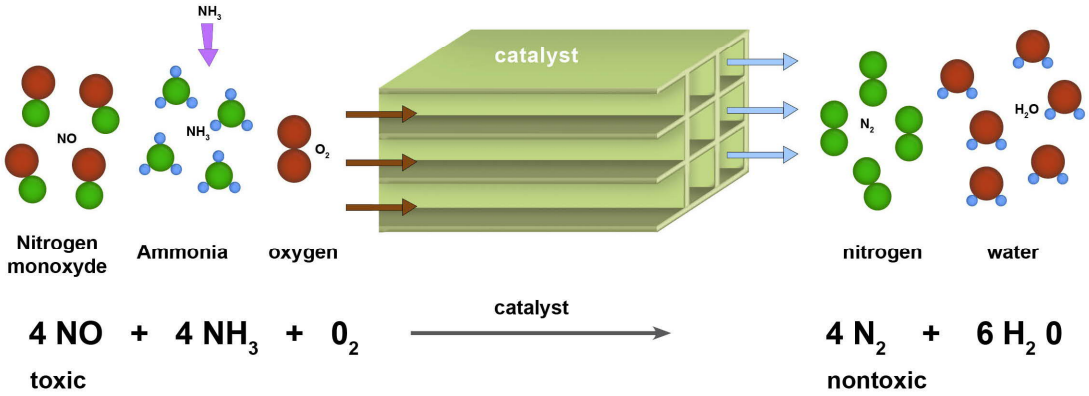
- **WinGD provides interface specifications**

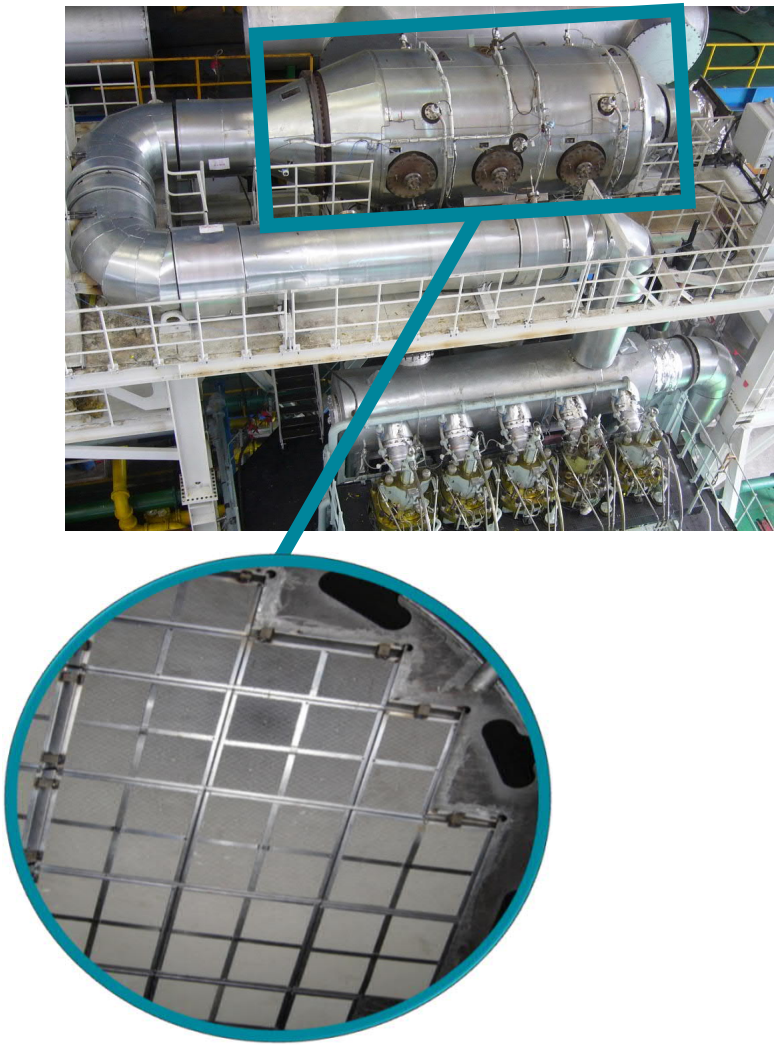


SCR

Basic Chemical Reaction Process

NOx Reduction

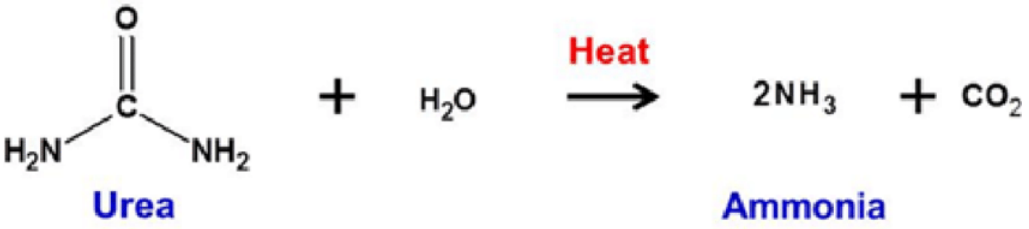


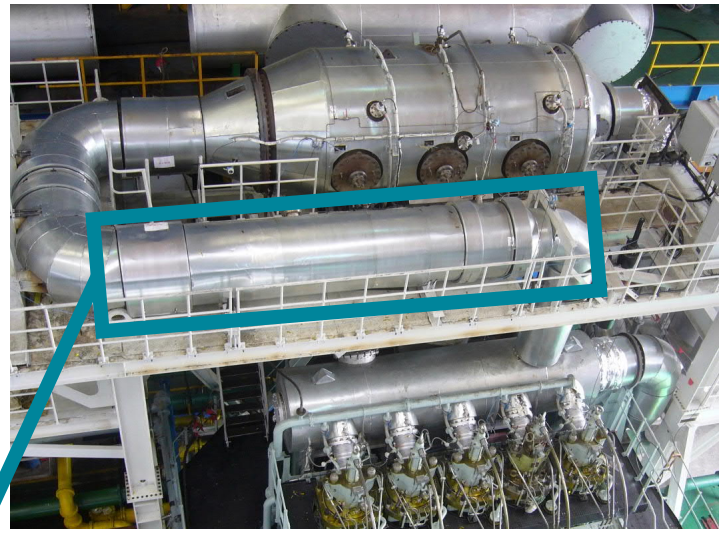


SCR

Basic Chemical Reaction Process

Urea Decomposition

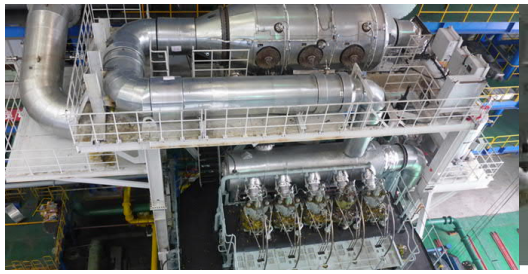


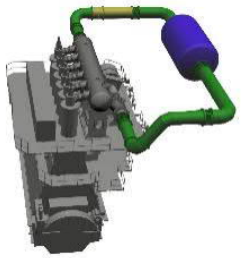


SCR Reference and Orderbook

Total 302 engines with SCR on order or delivered

- 142 WinGD Tier III engines are on order with high-pressure SCR and 160 with low-pressure SCR.
- These SCR's are fitted on engine size between 52 to 92 cm bore - foreseen to power Tankers, Bulkers and Container Vessels of different sizes.
- Of the 142 installations with HP SCR some 33 installation are in service.
- Of the 160 installations with LP SCR some 28 installation are in service.



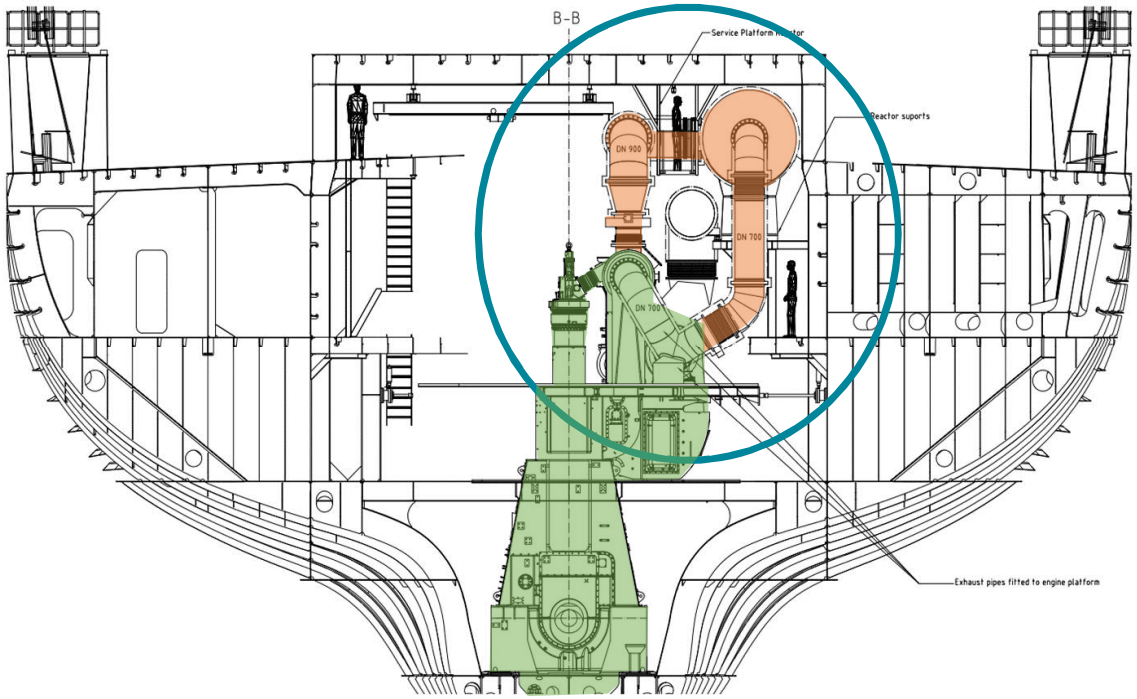

Status: 08.2019

Development
Compact integrated HP-SCR system (iSCR)

Compact SCR for 2-s marine engines

Challenges “off-engine” solutions

- Space requirements in engine room or funnel
- Special requirements for high-pressure exhaust piping (HP-SCR)
- Pipe dimensions of low pressure exhaust pipes (LP-SCR)
- Multiple suppliers and interfaces



SCR off-engine on MV “P.C.”

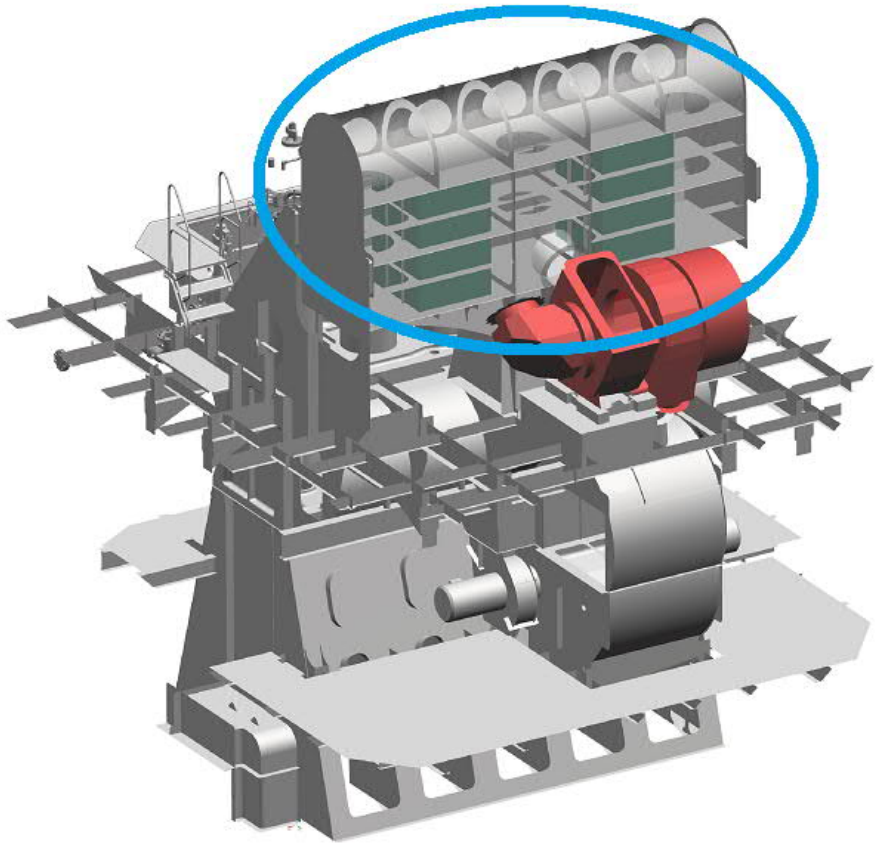
SCR installation in workshop

High Pressure SCR

Low Pressure SCR

Compact SCR for 2-s marine engines

“on-engine” concepts



Key technology development:

- Integration of exhaust gas flow control
- Compact reductant supply system
- Compact and robust catalysts
- Integration of SCR reactor on engine

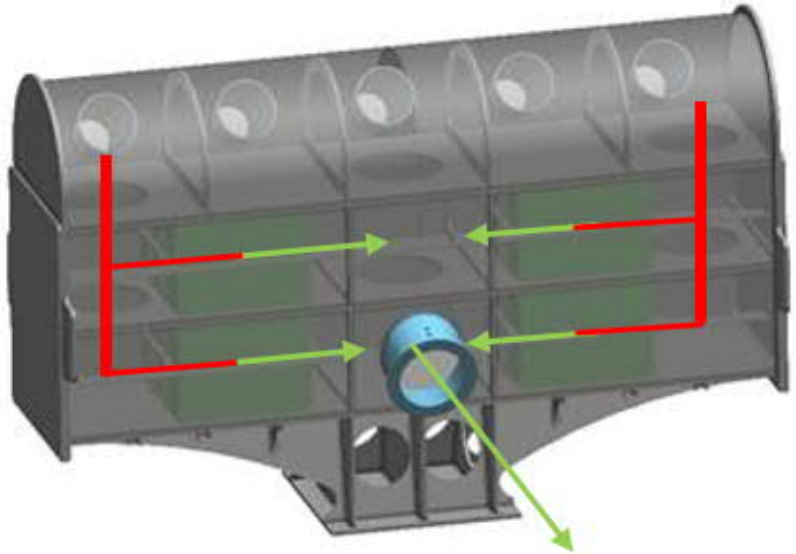
Chosen concept: **“Mailbox”** design

⟶ same footprint as Tier II engine

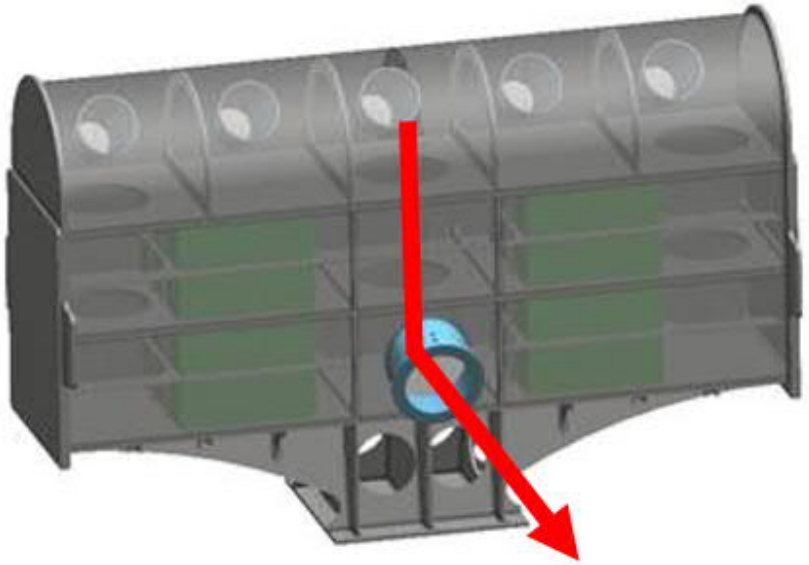
Overview / flow concept

Flow control concept enables

- Guidance through catalysts for Tier III

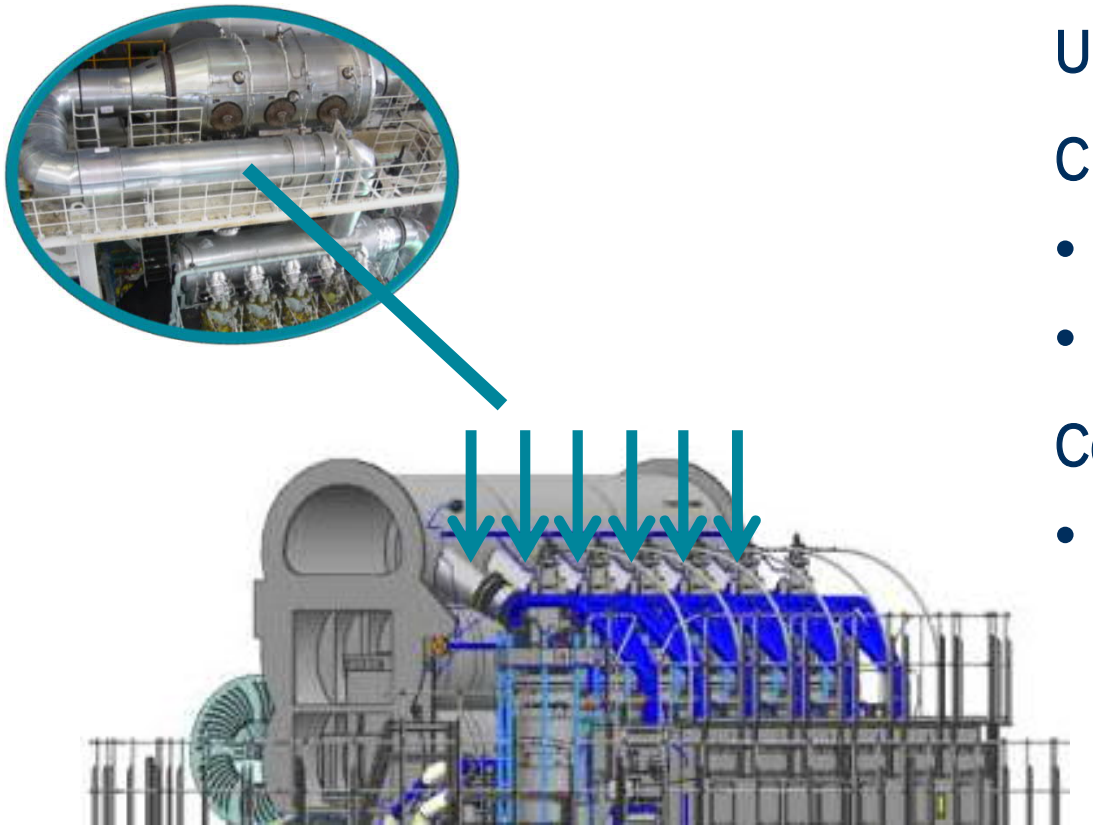


- SCR bypass for Tier II operation



Compact reductant injection

Challenges and concept



Urea Water Solution → Ammonia (NH_3)

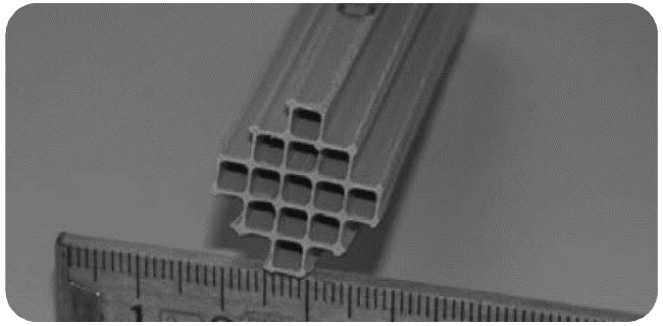
Challenge (restricted space):

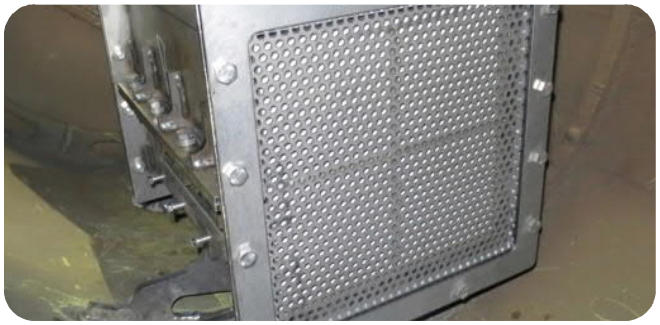
- Residence time
- Mixing

Concept:

- Optimal injection position
  → Downstream of cylinder

Compact and robust catalyst





Compact catalyst

- High pressure installation
  → “model exhaust gas tests”
- Increased active catalytic surface

Improved catalyst framing

Hot shaker test bench

- Accelerated load test for full service life-time assessment

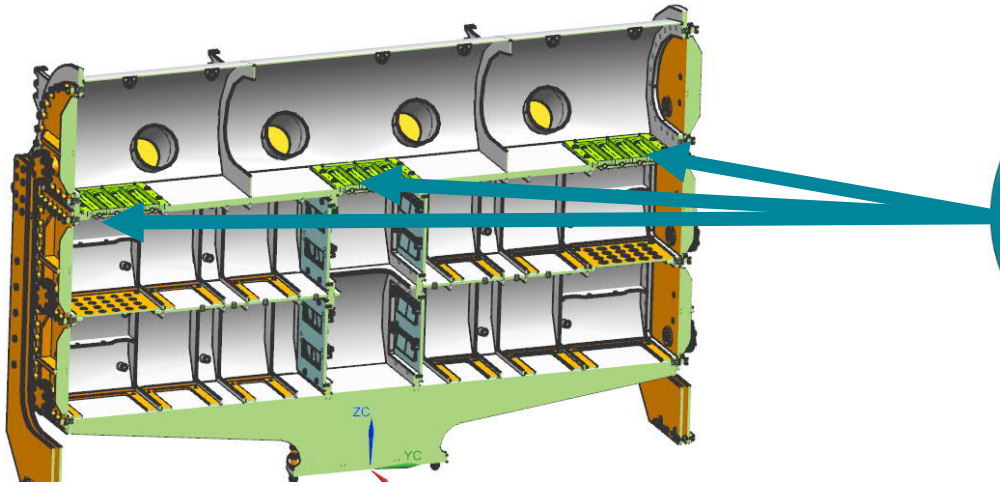
Long term tests

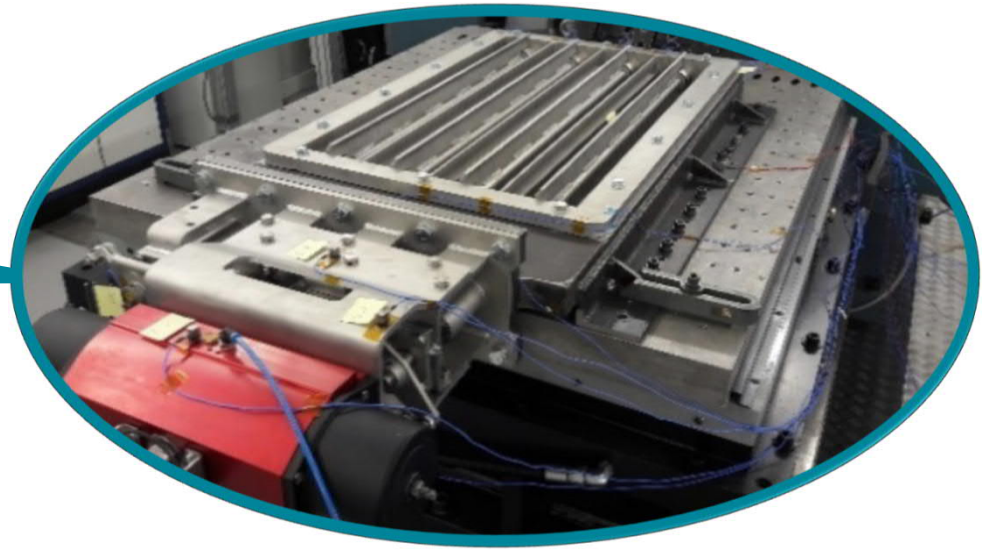
- in manifold on field test
- 3000 hours operation
  → No severe damages
- Tests ongoing

Engine integration

Integration concept

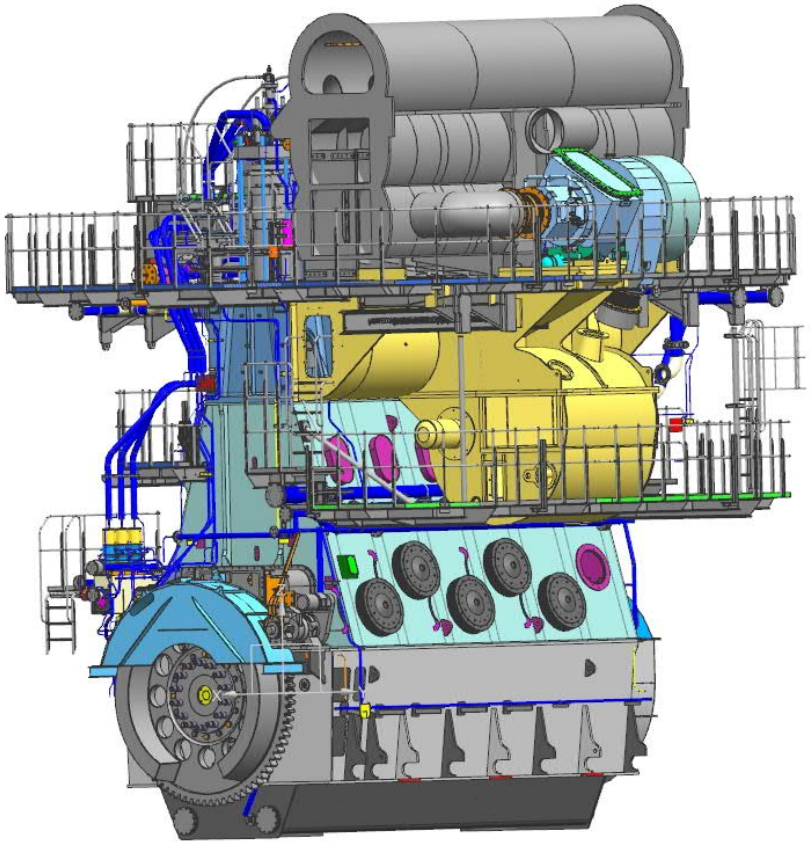
- Flow concept by integrated valves
- Integrated louver valve development
  - Bearings (T, fouling, corrosion)
  - Sealing and linkage
  - Vibration resistance -> “accelerated load tests”
- Assessment of mechanical strength and durability
- Modularity and scalability for broad range of engine sizes

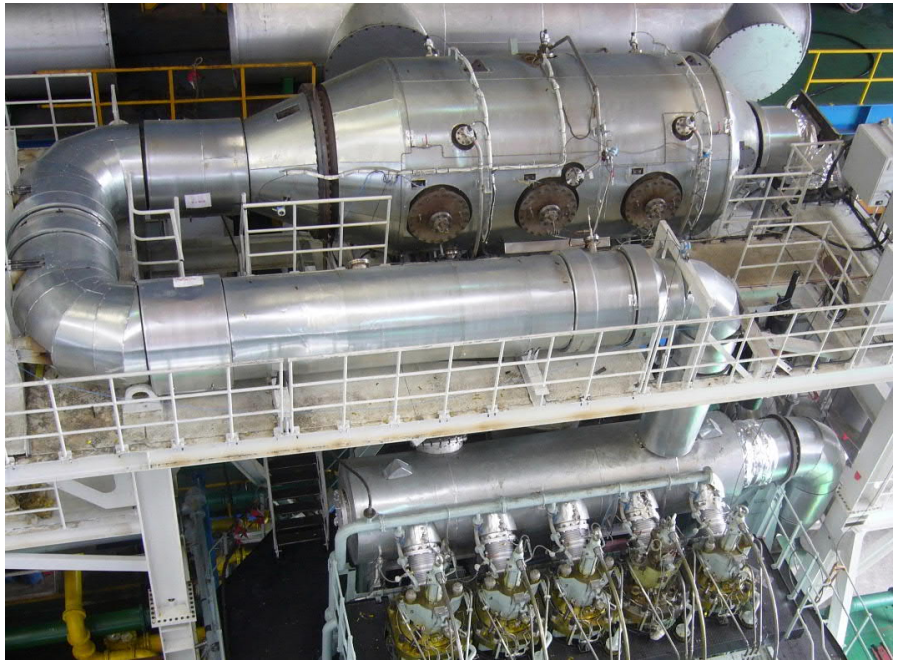




Benefits & Example

Example X52





FOR INTERNAL USE ONLY

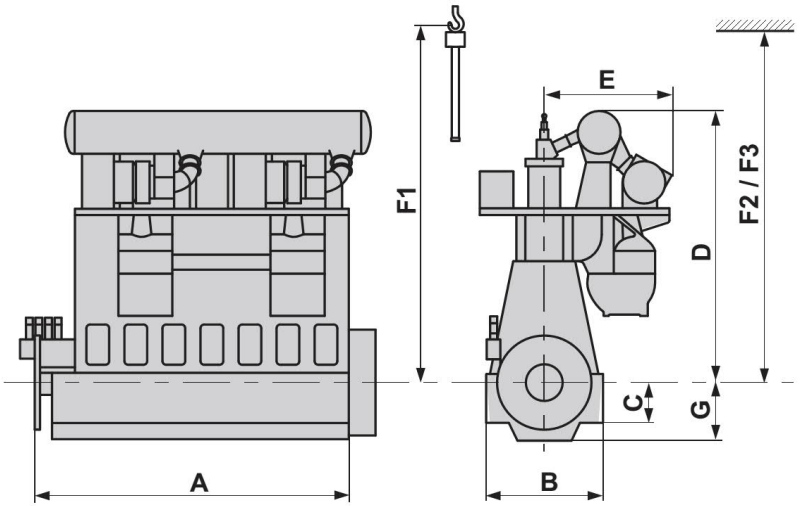
Example X52

Dimensions - Draft

			6X52	6X52 iSCR
stroke	mm		2315	2315
A	mm		6831	6831
B	mm		3630	3630
C	mm		1205	1205
D	mm		8550	8902
E	mm		4420[1)]	5070[2)]
F1	mm		10350	10350
F2	mm		9800	9800
weight	t		251	255

F1 Normal lifting procedure
F2 Reduced lifting procedure

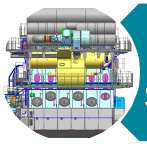
[1)] based on ABB A265
[2)] based on ABB A270



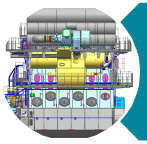
X52 with iSCR (on-engine system) only the height & width is slightly increased

Example X52

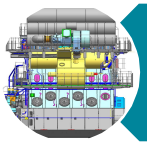
Benefits



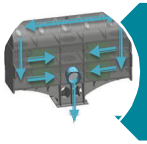
Meet Tier III with slightly increased engine size（slightly increased in the height&width）



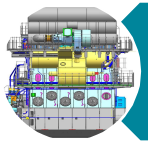
Smaller install space requirement, compact and easy for ship layout



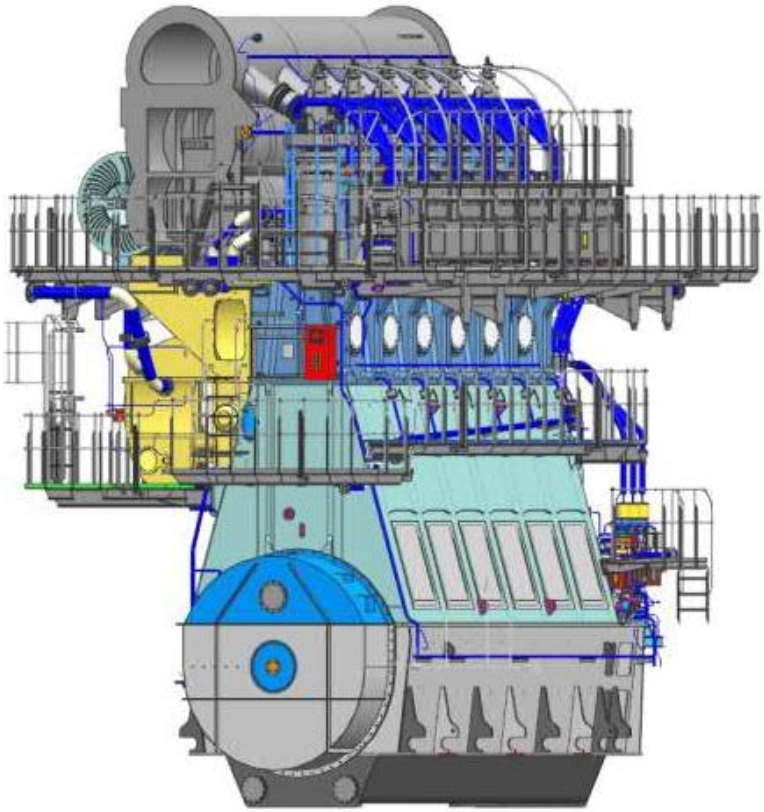
Lower heat loss



Make full use of the lower space of exhaust manifold



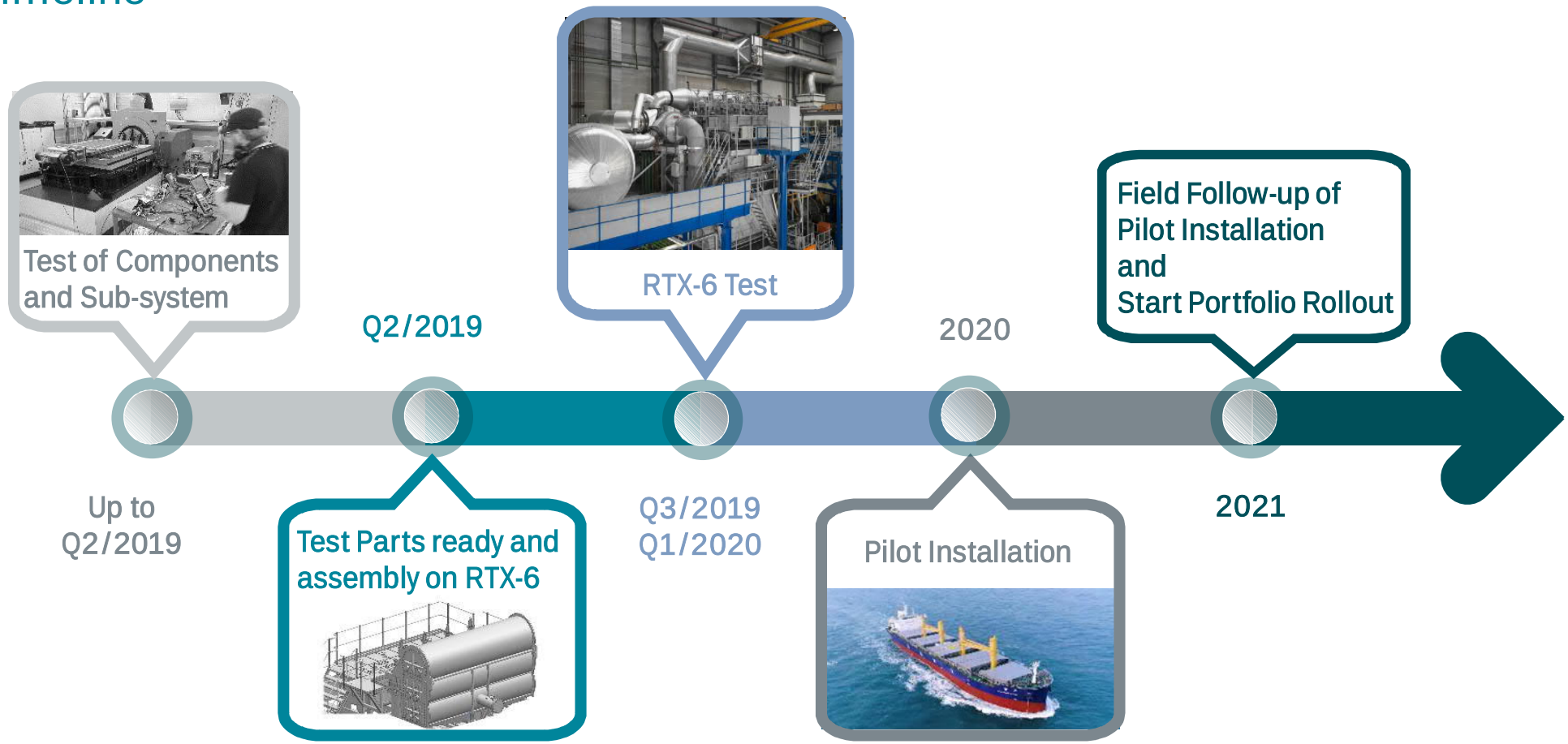
No additional SCR supplier



Summary & Timeline

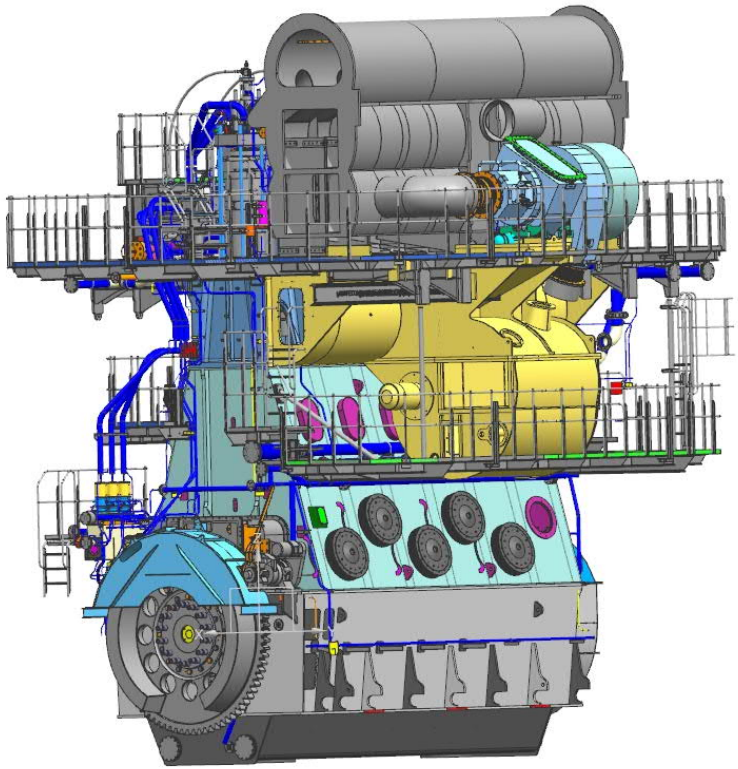
Integrated SCR (iSCR)

Timeline



Summary

- Development of compact integrated SCR system “Mailbox”
- Key technologies
  - Compact integrated reductant injection system
  - Compact and robust catalyst design
  - Integration concepts for structural design and flow
- Applicable for broad range of engine sizes
  - Enabling roll-out for engine portfolio
- iSCR has major benefits for shipayrds
  - compact and easy for engine room layout



Thank you
Questions and answers