NEW TECHNOLOGIES FOR CLEAN SHIPPING

NOVE TEHNOLOGIJE U SLUŽBI ČISTOG BRODARSTVA

Split, 03.10.2017.

OVERVIEW

Air pollution from ships

- Nitrogen oxides

Selective catalytic reduction (SCR)

Exhaust gas recirculation (EGR)

- Sulphur oxides and particulate matter

Freshwater closed loop scrubbers

Seawater open loop scrubbers

Hybride (seawater closed loop) scrubbers

OVERVIEW

Air pollution from ships

- Volatile organic compounds

Vapour recovery systems (condensation, absorption, carbon vacuum-regenerated adsorption)

- Shipboard incineration

Shipboard gasification waste to energy systems

OVERVIEW

Energy efficiency for ships

Design improvements:
- hull optimization
- superstructure optimization
- propeller optimization

Recovery of propeller energy:
- Coaxial contra-rotating propeller
- Free rotating vane wheel (Grim wheel)
- Ducted propeller
- Pre-swirl and post-swirl devices
- Split stern (twin skeg)

OVERVIEW

Energy efficiency for ships

Engine energy recovery:
- waste heat recovery system
- hybrid propulsion (such as diesel electric with batteries for energy storage)
- fuel cells

Hull resistance:
- low friction coatings
- polymer and air lubrication

Alternative fuels and energy:
- Gas fuels (LNG, ethane, methanol)
- Bio-fuels
- Wind power
- Solar power

SELECTIVE CATALYTIC REDUCTION

- IMO Tier III NOx limit (80% NOx reduction compared to Tier I)
- urea (ammonia)- NOx reduction to N_2 and water
- SCR inlet gas temperature 330- 350^{o}C for HFO
- urea mixer- liquid urea injection in exhaust stream via spray nozzle
- NOx measurements before and after SCR reactor

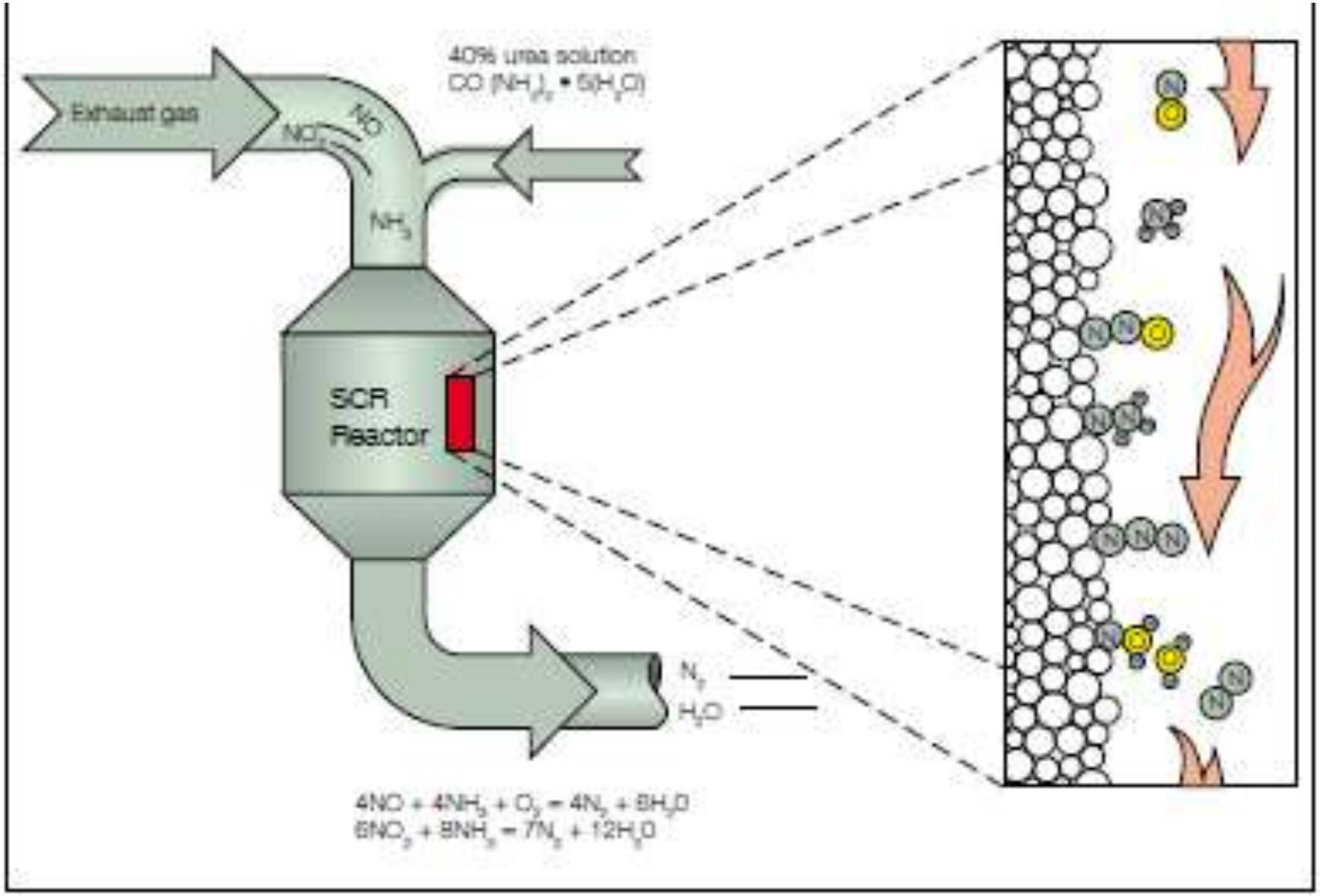


Fig. 1: Principles of the SCR system

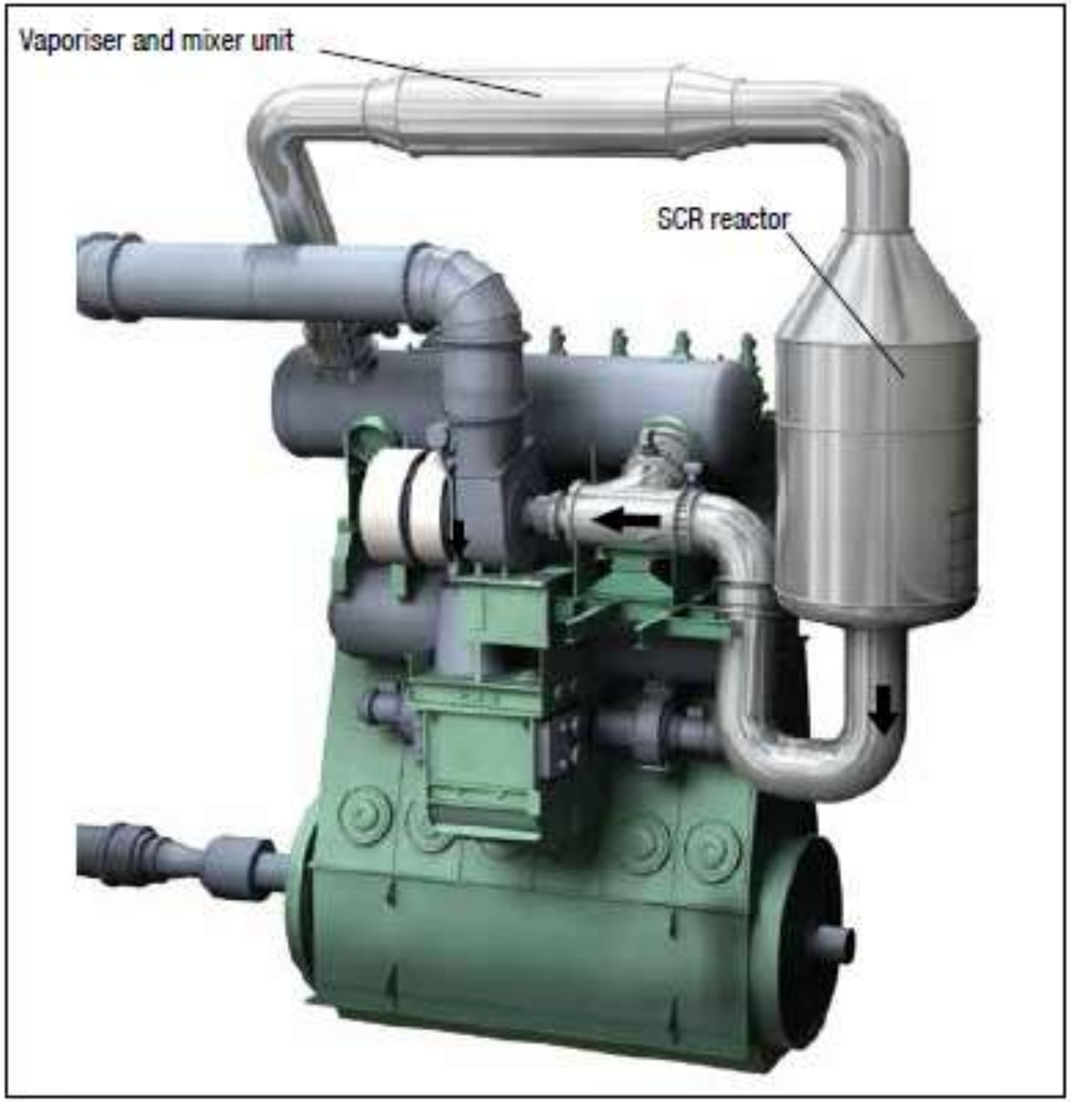


Fig. 2: Arrangement of a high-pressure SCR solution on a 6S46MC-C engine

ENGINE CONTROL SYSTEM (ECS)

- V1- controllable valve- controls turbocharger performance

- V2- controllable valve- controls engine performance

- V3- reactor sealing

- CBV- cylinder and SCR bypass- increase low load exhaust gas temperature

- auxiliary blowers- stabilize turbocharger

- dT=T1(exhaust gas receiver) -T2 (turbine inlet)= $50^{o}C$

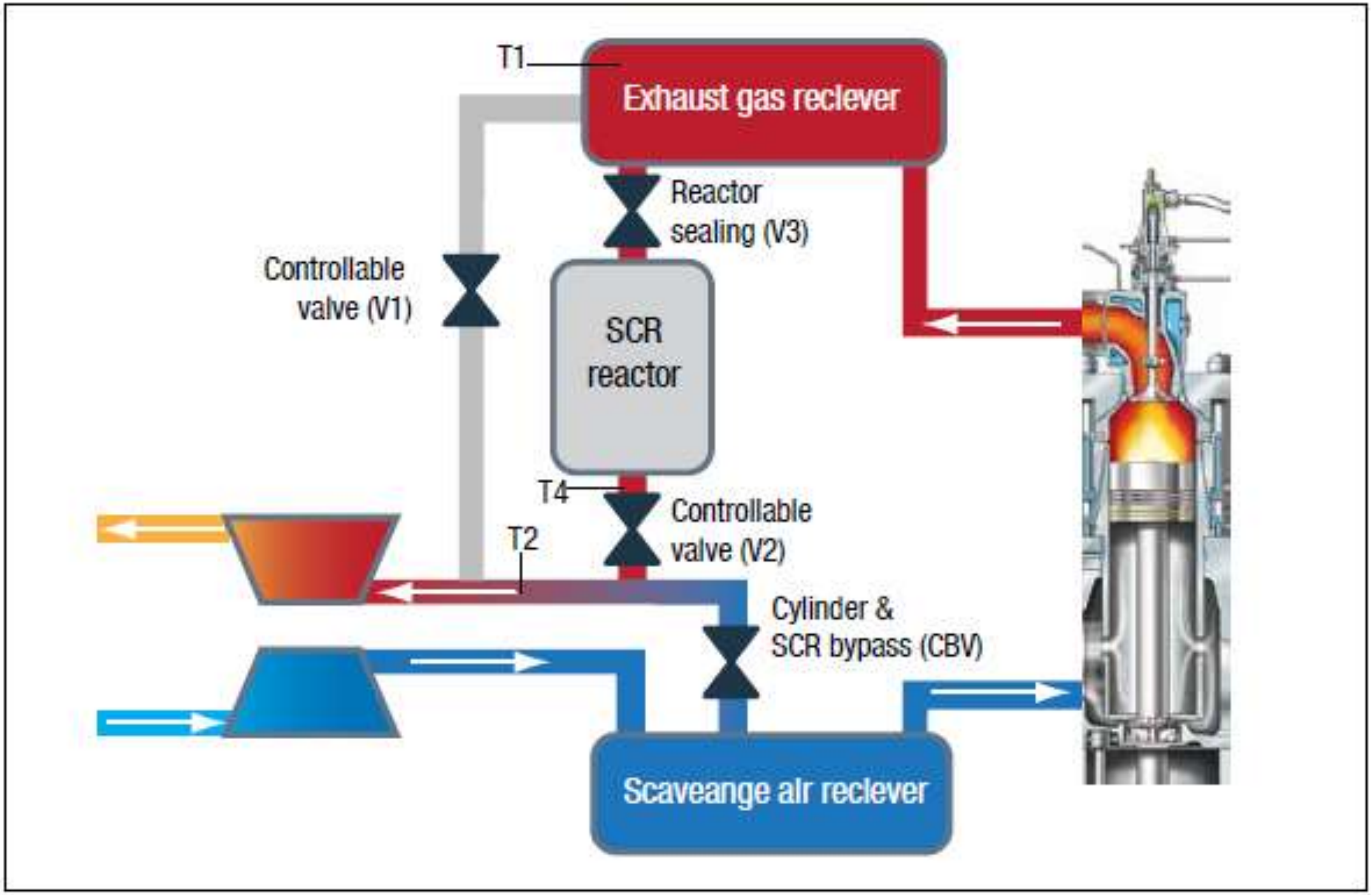


Fig. 4: Overview of bypass valves

EXHAUST GAS RECIRCULATION

- IMO Tier III NOx limit (80% NOx reduction compared to Tier I)
- part of exhaust gas flow is returned to engine inlet
- non ECA operation: both TC working in parallel
- ECA operation: small TC is cut out, EGR blower is running, scrubber cleans exhaust gas before entering scavenge air receiver
- scrubbing process removes up to 98% SO_2 and up to 92% PM
- combustion chamber components not negatively affected by EGR operation
- affected EGR system components- in stainless steel
- EGR washwater treatment system
- NaOH and EGR sludge tanks

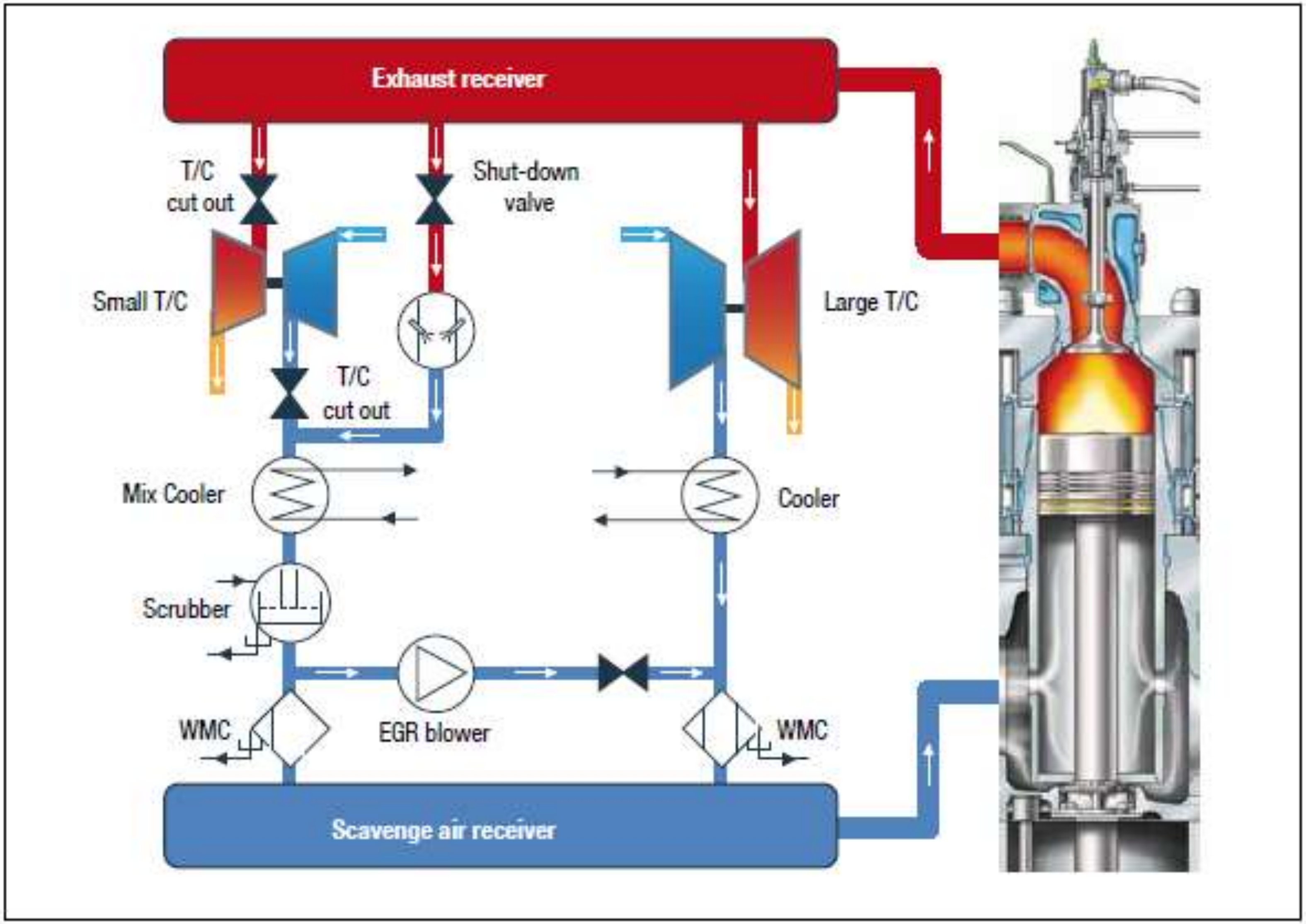


Fig. 19: EGR system diagram for a 6S80ME-C9 with two turbochargers

Fig. 21: Integrated design of EGR unit (orange) on a 6S80ME-C9 engine

WASTE HEAT RECOVERY SYSTEM

- standard engine, exhaust gas temperature after TC relatively low

- WHRS tuned engine- part of exhaust gas flow bypasses TC, total amount of intake air and exhaust gas is reduced, exhaust gas temperature increases

- electricity production from exhaust gas

System benefits:

- fuel cost savings

- emission reductions

- EEDI lowered

- total efficiency improved, slight reduction in main engine efficiency

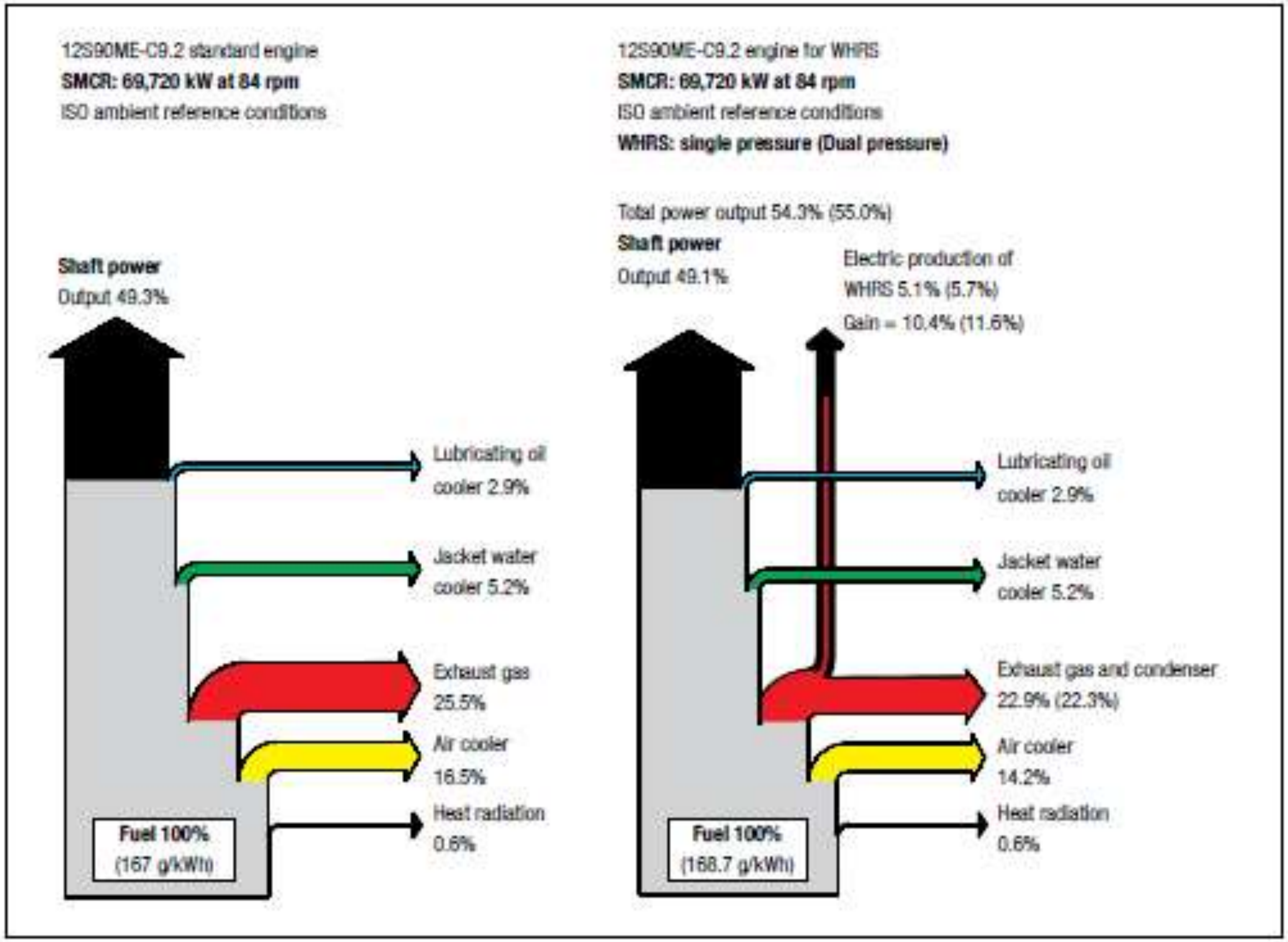


Fig. 1: Heat balance for large-bore MAN B&W engine types without and with WHRS

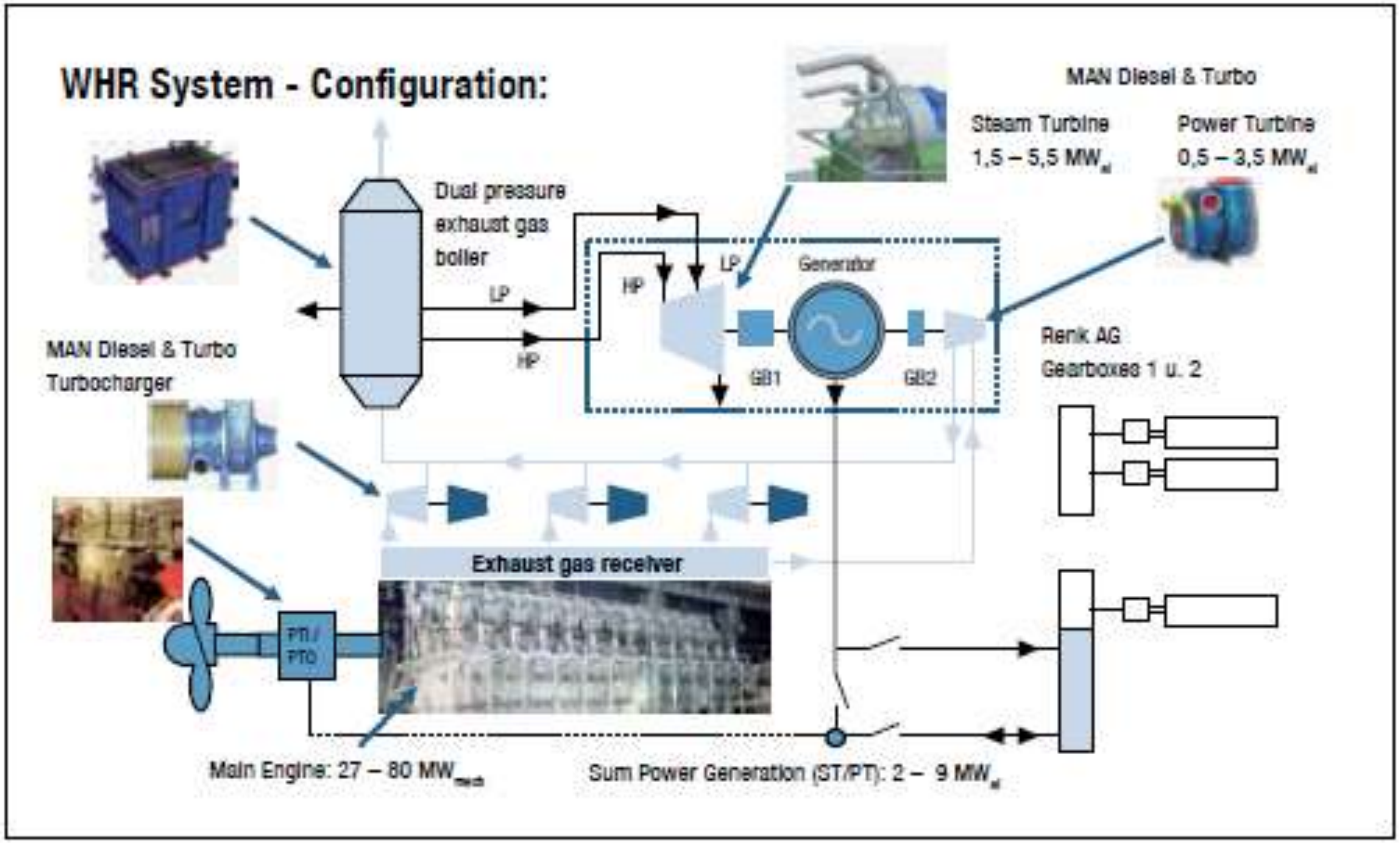


Fig. 2: Waste heat recovery system principles

WHR systems:

- ST-PT (steam turbine- power turbine generator unit, single or dual steam pressure)
- STG (steam turbine generator unit, single or dual steam pressure)
- PTG (power turbine generator unit)

- main engine power <15000 kW- PTG or organic rankine cycle
- main engine power <25000 kW- STG or PTG
- main engine power >25000 kW- combined ST and PT

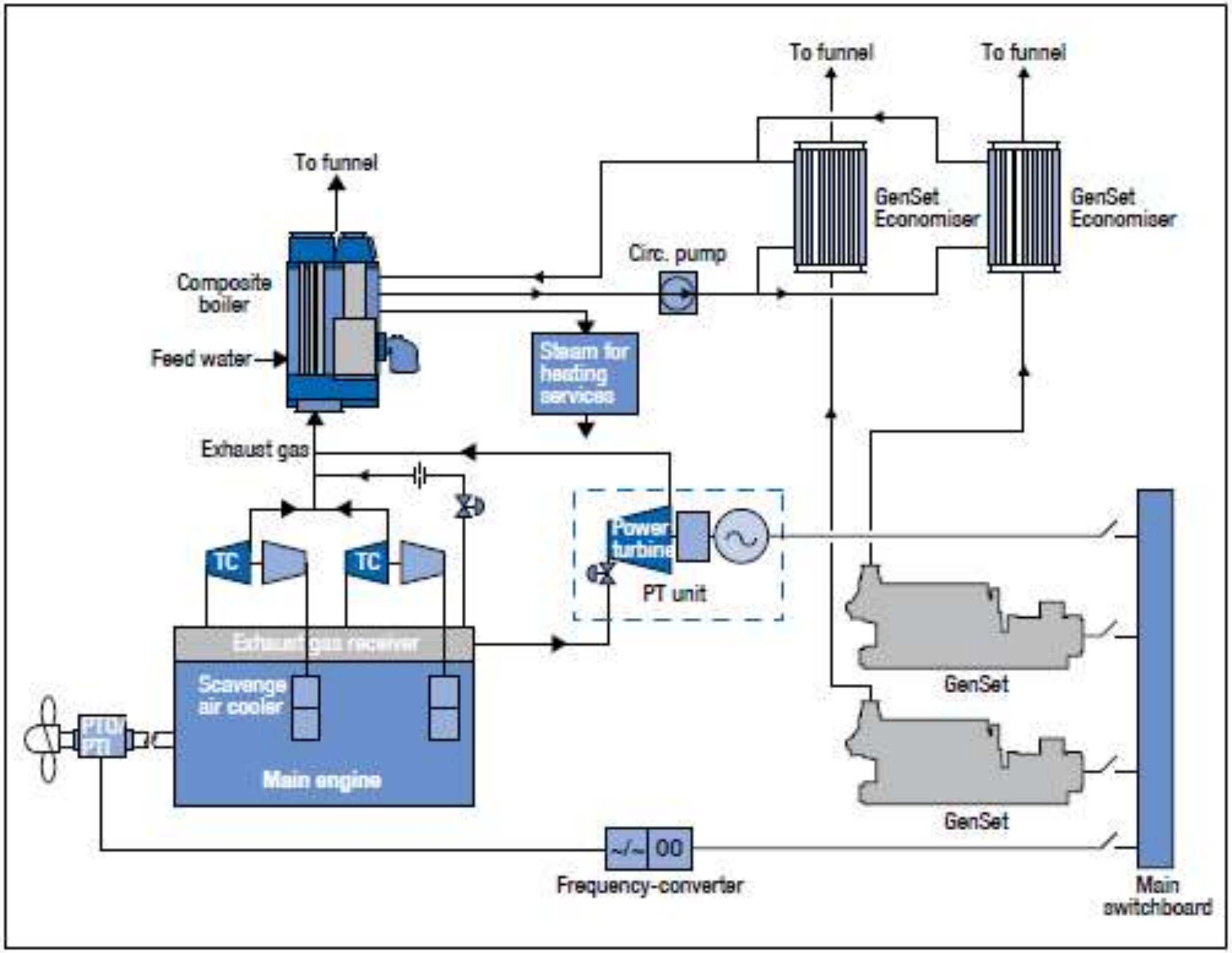


Fig. 4: Schematic diagram of the WHRS-PTG system

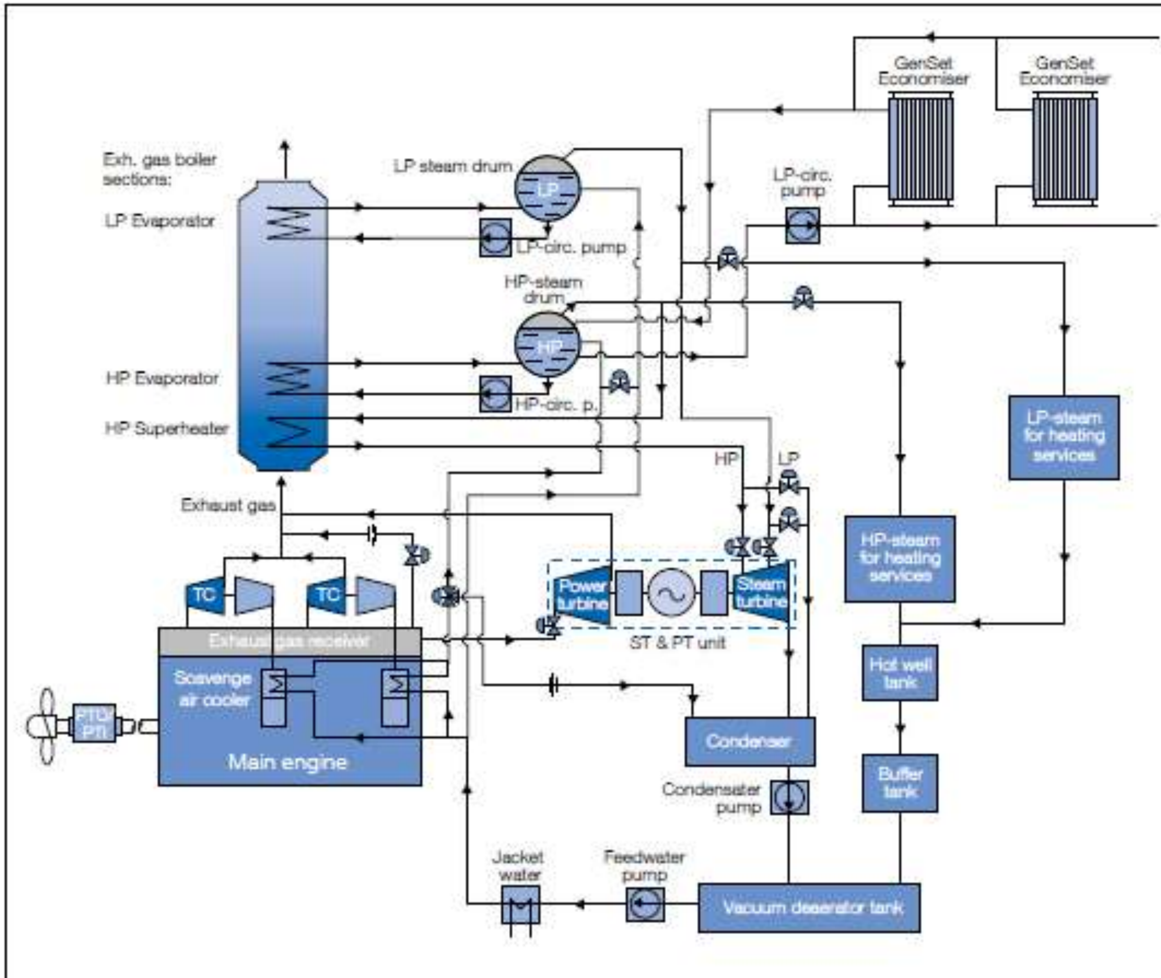


Fig. 8: Schematically diagram of the WHRS ST-PT system

- Dual pressure steam system
- Steam & power turbine unit
- ME scavenge air feed water heating
- Efficiency between 9 to 11% of main engine SMCR power depending on engine size and ships steam consumption

USE OF LNG AS FUEL FOR SHIPS

- Lower CO_2 emissions
- No sulphur content

- Diesel (diffusion) combustion- gas diesel (high pressure gas)- does not meet IMO Tier III

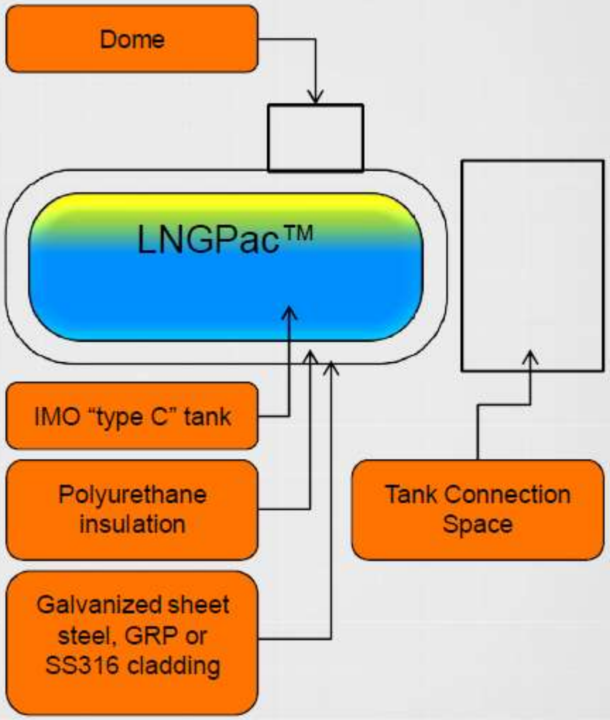
- Otto (premixed) combustion- dual fuel (low pressure gas), spark ignited- meets IMO Tier III

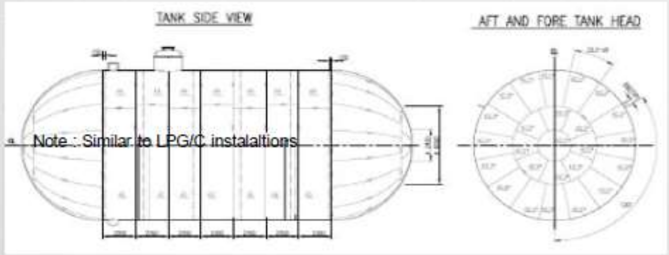
- International code of safety for ships using gases or other low flashpoint fuels (IGF Code)- takes effect on 01.01.2017.

- LNG bunkering

Tank design : Single wall type C

- Capacity range from 600-2500m³
- Tank material: 9% Ni steel or austenitic stainless steel
- Tank Saddles to be mounted at yard during installation
- Dome on top of Tank for all tank pipe connections above maximum liquid level
- Tank Connection Space separated from Tank





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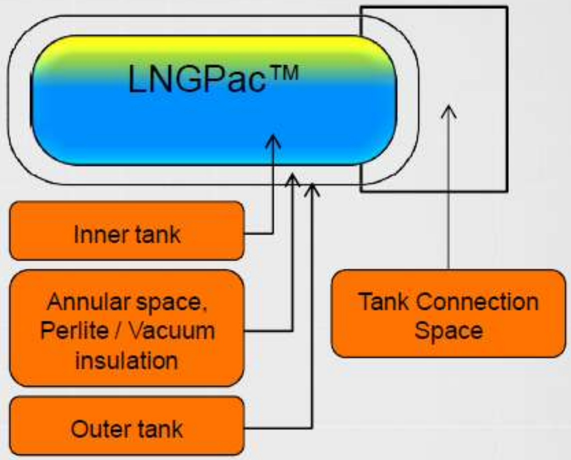
Tank design : Double wall type C

- Capacity range from 30-750m³
- Austenitic stainless steel or 9% Ni steel
- Outer tank: function of secondary barrier
- Perlite / Vacuum insulation or optional Multi Layer Insulation (MLI) / Vacuum
- Class acceptance of bottom pipe connection
- Tank CS directly attached



Tank design : ISO LNG containers

Fast and easy bunkering

- ISO LNG tank designed for marine applications and Class

Docking station designed for multiple, horizontal and vertical stacked container

- Easy bunkering quick connection/disconnection coupling.
- Each ISO LNG container with its own process and safety equipment

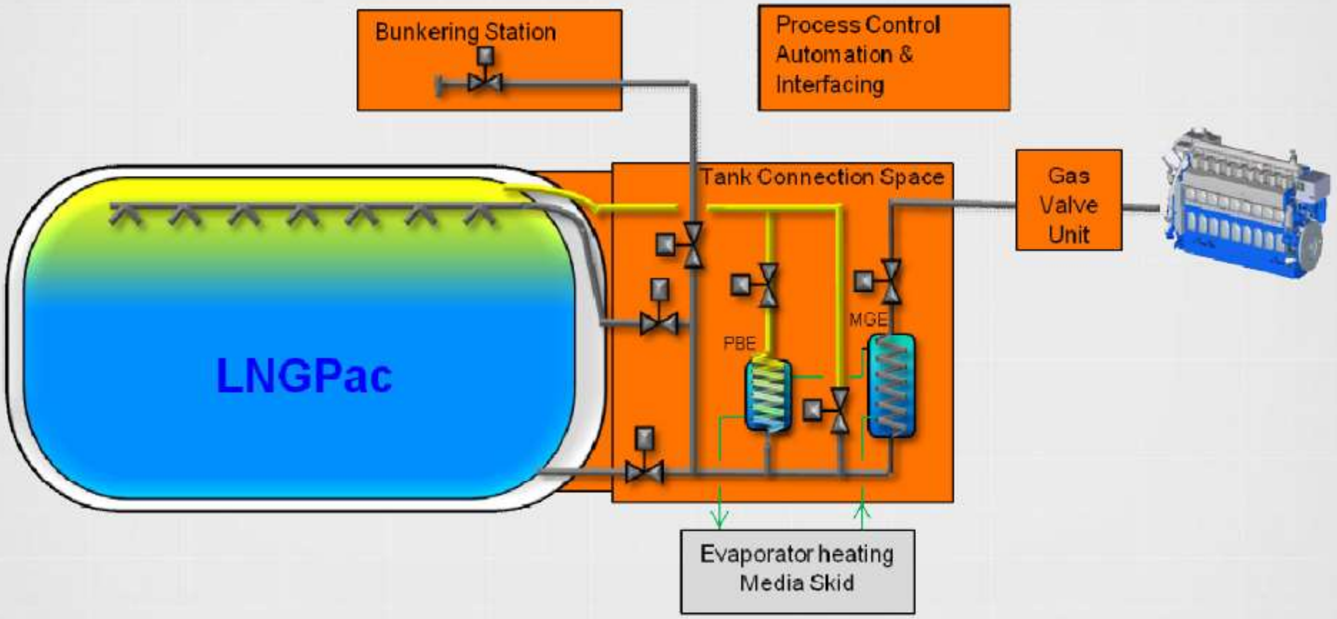
Ideal for Ro-Ro /Ferry and container vessels

LNG fuel tank container		20 ft	(30 ft)	40 ft	45 ft
Frame dimensions (external)					
Length	m	6.058	9.125	12.192	13.716
Width	m	2.438	2.438	2.438	2.438
Height	m	2.591	2.591	2.591	2.896

Maximum geometric volume with a containerized solution is 46 cubic meters with one 45 ft container.

Process control

Typical 2 -Stroke solution (like 4-stroke solution) for tanks below 750 - 500 m3



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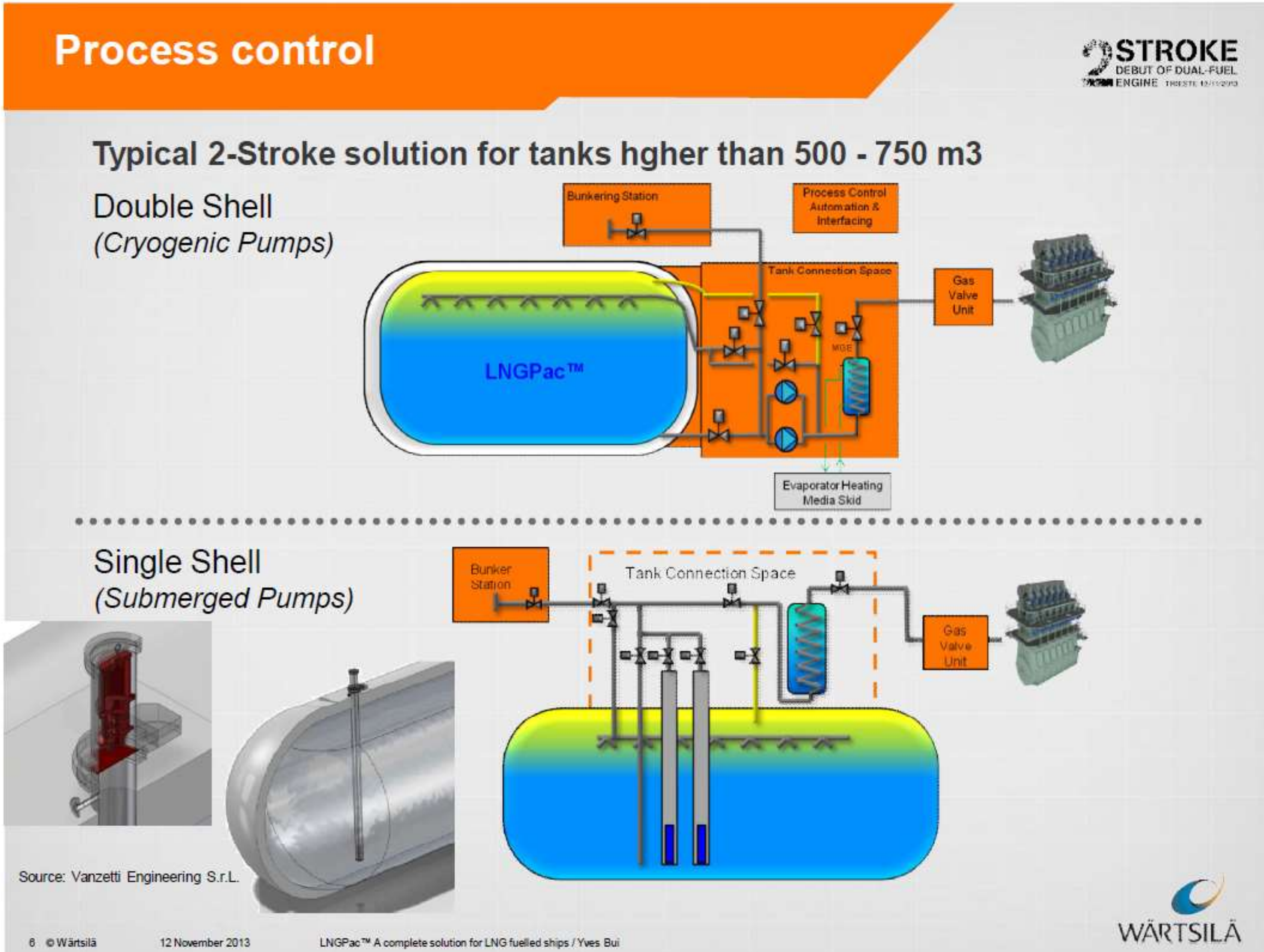
Process control
STROKE
DEBUT OF DUAL-FUEL
ENGINE
Typical 2-Stroke solution for tanks hgher than 500 - 750 m3
Double Shell
(Cryogenic Pumps)
Bunkering Station
Process Control
Automation &
Interfacing
Tank Connection Space
Gas
Valve
Unit
LNGPac™
Evaporator Heating
Media Skid
Single Shell
(Submerged Pumps)
Bunker
Station
Tank Connection Space
Gas
Valve
Unit
Source: Vanzetti Engineering S.r.L.
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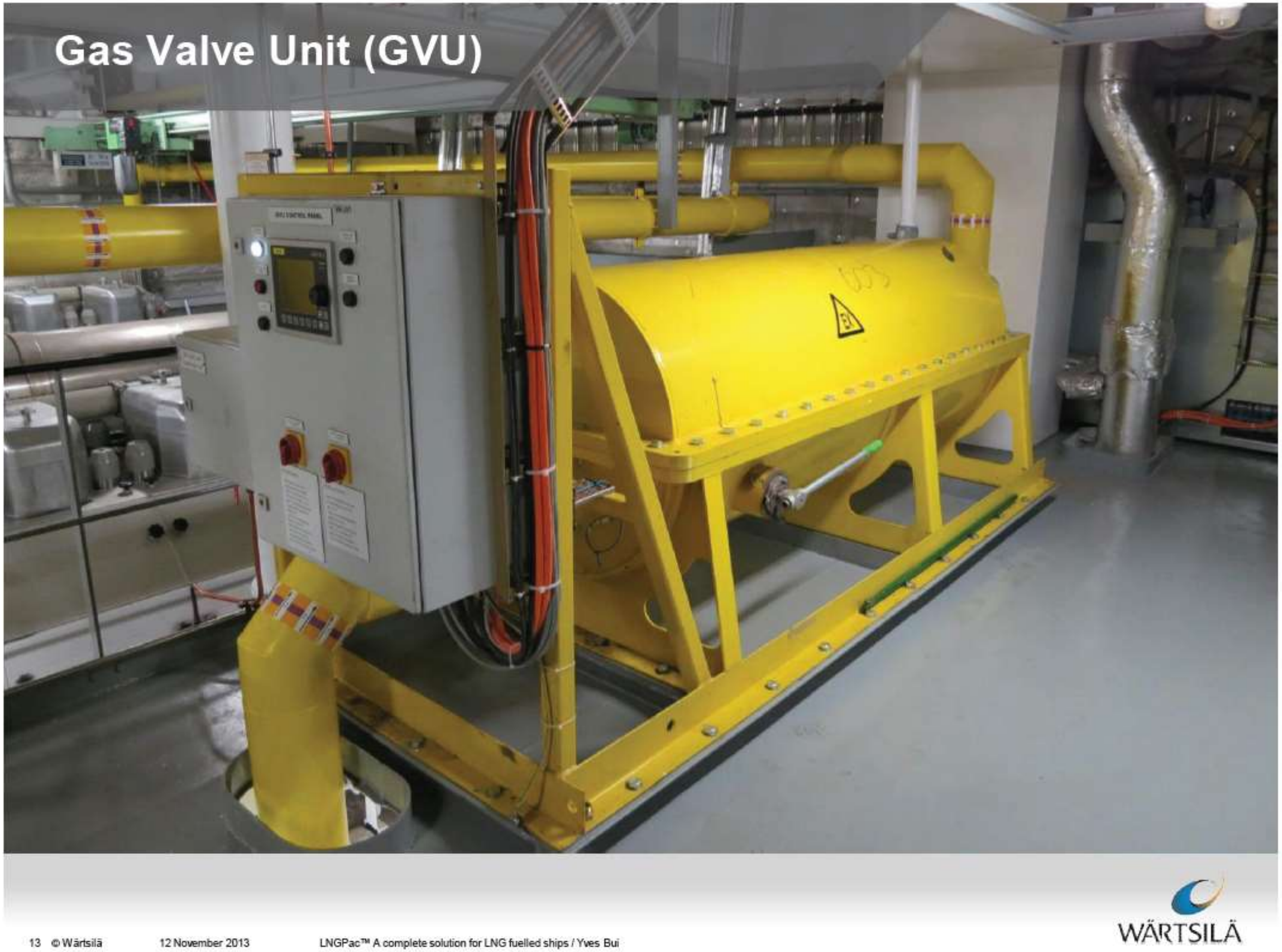
Gas Valve Unit (GVU)
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GVU – General Description

2 STROKE DEBUT OF DUAL-FUEL ENGINE TRIESTE 12/11/2013

- Gas Valve Unit (GVU) is a module between the LNG storage system and the DF engine :
  - To regulate the base gas pressure
  - To ensure the safety dis-connection of the gas system and putting it in inert mode if needed
- A gas valve unit is required for each engine
- Wartsila GVU can be integrated into the LNGPac Tank Connection Space to make easy the installation if the distance betwen the GVU and the DF engine is reduced.

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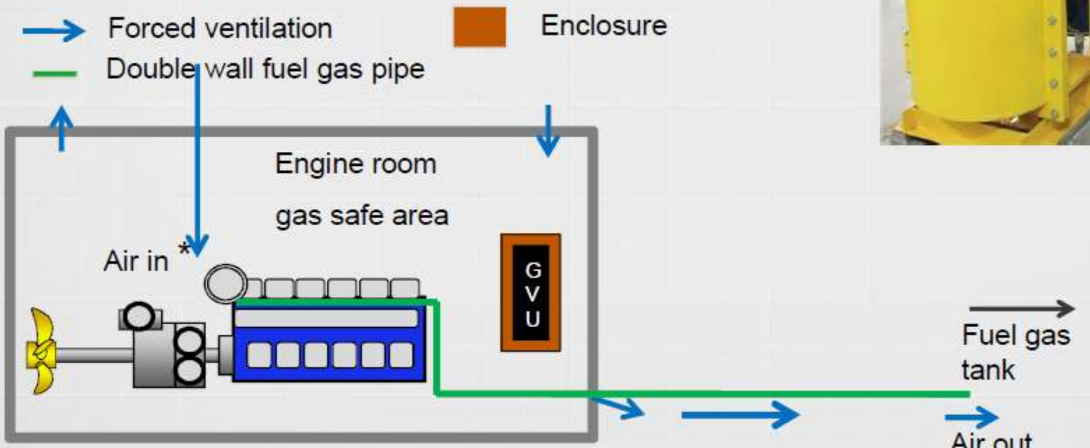
GVU and GVU-ED™

Installation with Enclosure

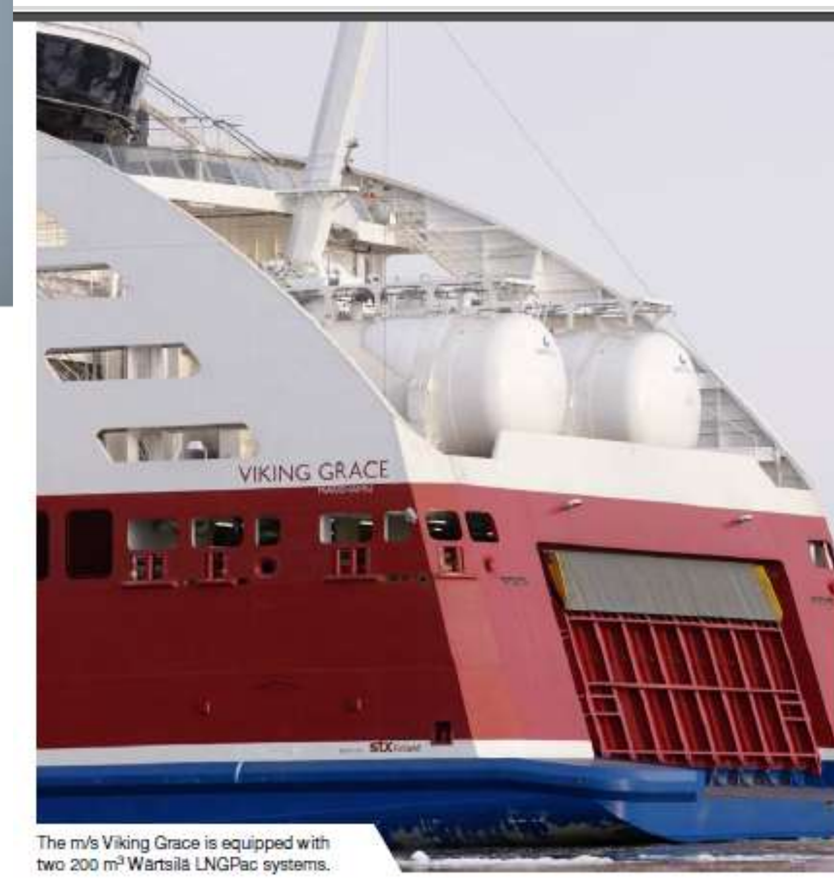
Saved space:
- GVU room can be avoided
- Airlock between the GVU room and the engine room not needed

Savings :
- Less Ex certified equipment
- Easy installation at yard, ready module



* to double wall fuel gas feed pipe annular space

The LNG fuelled Aframax Tanker featuring Wärtsilä's WSD42 IIIK design, is best in its class for fuel efficiency.



The m/s Viking Grace is equipped with two 200 m^3 Wärtsilä LNGPac systems.