

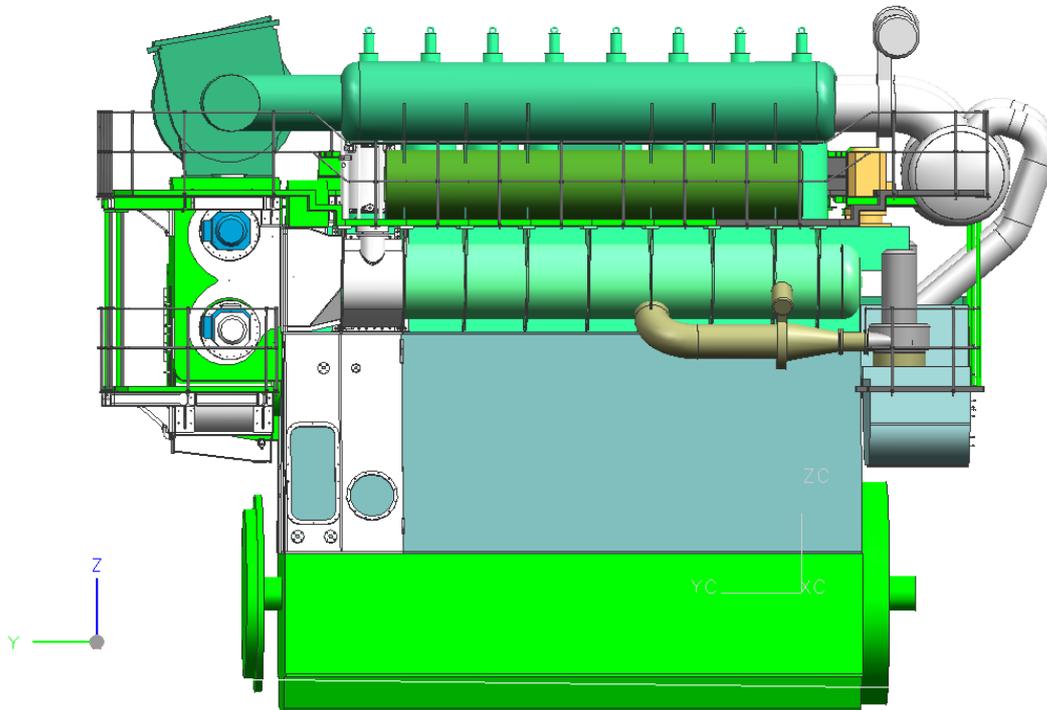
EGR on New Building

8S40ME-B9.2

Preliminary specification

MAN Diesel & Turbo

Draft version 1



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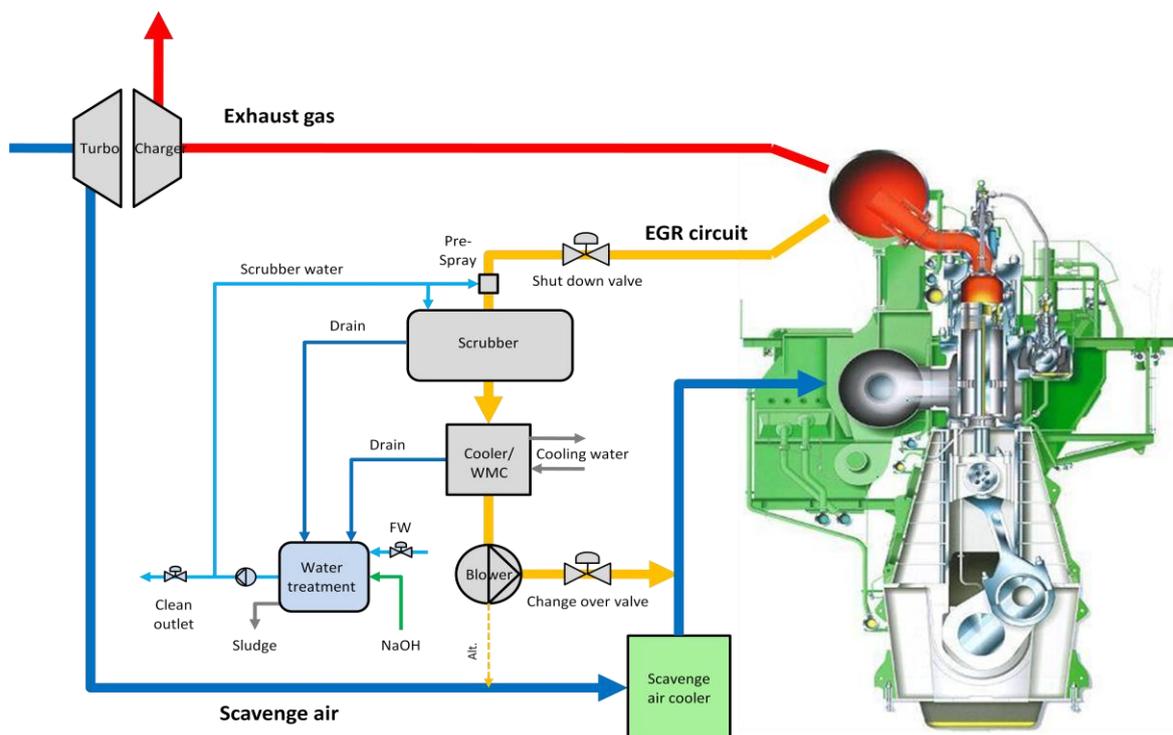
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1. Introduction

Exhaust Gas Recirculation (EGR) is a method to significantly reduce NO_x emissions from marine engines. EGR is proven to be able to meet the Tier III NO_x requirements, which will apply to all new ships entering a NO_x Emission Control Area (ECA) from 2016.

The illustration shows the principle of the EGR system. Part of the exhaust gas is diverted from the exhaust gas receiver through a wet scrubber which cleans the gas and reduces the temperature of the exhaust gas. The EGR gas passes through a cooler and a water mist catcher and finally through the EGR blower which lifts the pressure to the scavenge air pressure. The cleaned exhaust gas is mixed with the scavenging air. A water treatment system supplies the scrubber with cleaned re-circulated fresh water with the addition of NaOH in order to neutralize the Sulphur washed out of the exhaust gas.

The effect of the EGR system is that a part of the oxygen in the scavenge air is replaced by CO_2 from the combustion. The heat capacity of the scavenge air is hereby slightly increased and hence the temperature peak of the combustion is reduced. Accordingly the amount of NO_x generated in the combustion chamber is reduced with a slight penalty on the fuel consumption. The NO_x reduction is almost linear dependent on the ratio of re-circulated exhaust gas.



2. Abbreviation

- EGR: Exhaust Gas Recirculation
- WTS: Water Treatment System, see chapter 6
- WTU: Water Treatment Unit, see chapter 6
- WCU: Water Cleaning Unit, see chapter 6
- Tier II: Refer to IMO Tier II NO_x limit, 14.4 g/kwh
- Tier III: Refer to IMO Tier III NO_x limit, 3.4 g/kwh

3. Engine specification

Engine

Main Engine: 8S40ME-B9.2 (installed with variable exhaust valves)

Nominal MCR: 9,080 kW 146 rpm

Turbo charger: 1 x MDT TCA55 with VTA – or similar from other maker.

EGR amount based on latest experience from test on MDT 4T50ME-X test engine (preliminary values):

Tier II 10% EGR

Tier III 30% EGR

4. Consumables/deliveries

Assumptions

Sailing hours	6000 h/year			
Sailing pattern - SMCR	25%	50%	75%	100%
Sailing pattern - Weight	15	15	50	20
Tier II/Tier III share	85%/15%			
EGR % - Tier II mode	10%			
EGR % - Tier III mode	30%			
S% in HFO	3.0%			
NaOH solution	50%			

NaOH

NaOH consumption 91 m³/year – 7.6 m³/month

NaOH - Tier II mode 1.9 l/MWh

NaOH - Tier III mode 5.7 l/MWh

Fresh water

No consummation besides filling of system – approx. 2.5 m³ pr. filling.

Cooling water - EGR cooler - MCR, Tier III mode

EGR cooler 200 m³/h

Power consumption - MCR, Tier III mode

EGR blower 180 kW

Water Treatment Unit (WTU)

WTU feed pump 3 kW

WTU scrubber pump 8 kW

Water Cleaning Unit (WCU) 21 kW

NaOH dosing pump 0.04 kW

EGR cooling water pump 20 kW

NaOH tank heating to be clarified if necessary /minimum 16 deg C

Sludge tank mixing to be clarified if necessary /only when discharging

Air

Sealing air - EGR blower 50 l/min permanent

Control air - Shut down valve on/off: 60 l, opening time 1 second, 5.5 bar

Control air - Change over valve on/off: 35 l, opening time 1 second, 5.5 bar

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Control air – WCU on/off: to be clarified

Sludge

Sludge accumulation 81 m³/year – 6.8 m³/month

Sludge - Tier II mode 1.7 l/MWh

Sludge - Tier III mode 5.0 l/MWh

5. Engine outline

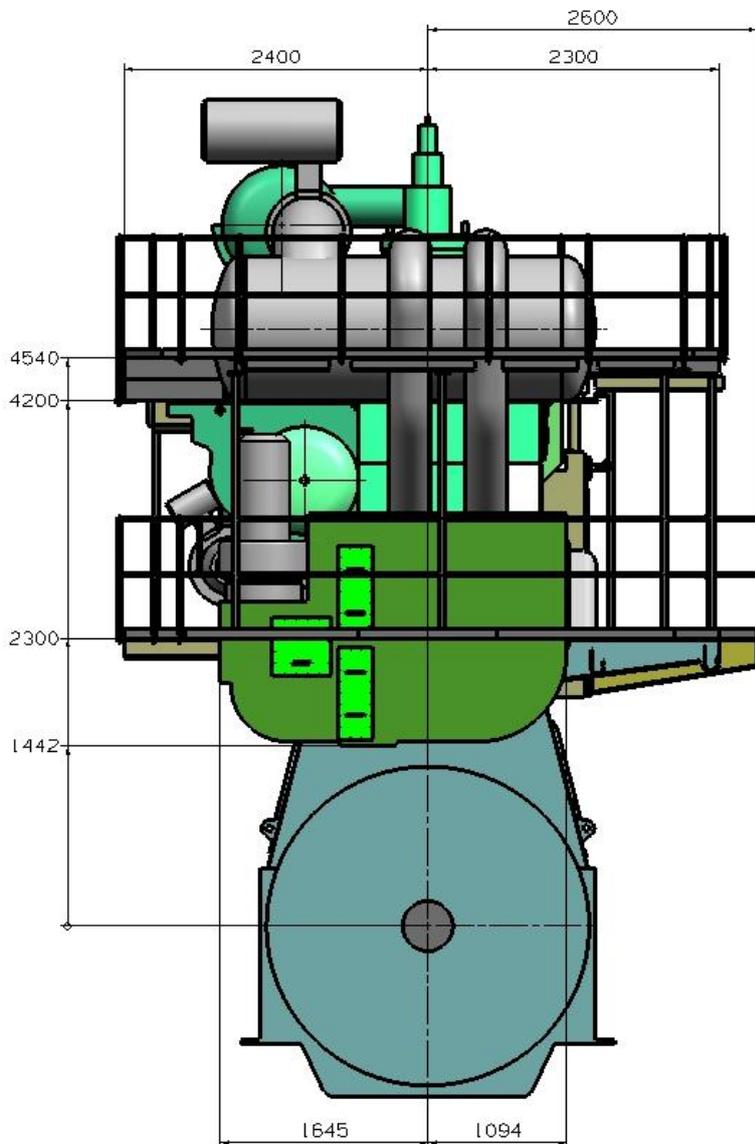
EGR unit

Dimension LxWxH: 2500x1900x3250mm

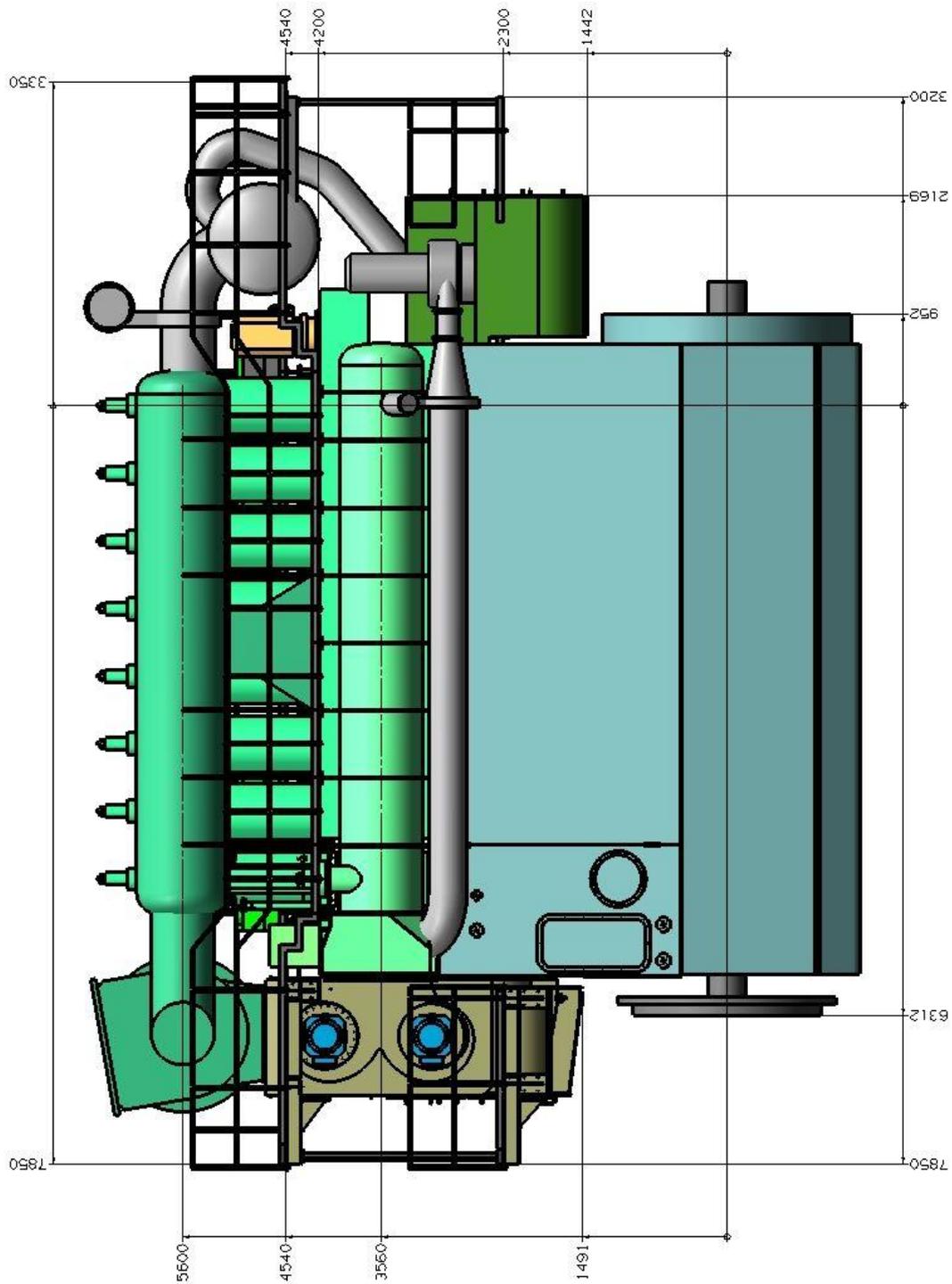
Weight empty approx. 10 ton – to be clarified

Weight operating approx. 11 ton– to be clarified

Weight overflow approx. 17 ton– to be clarified

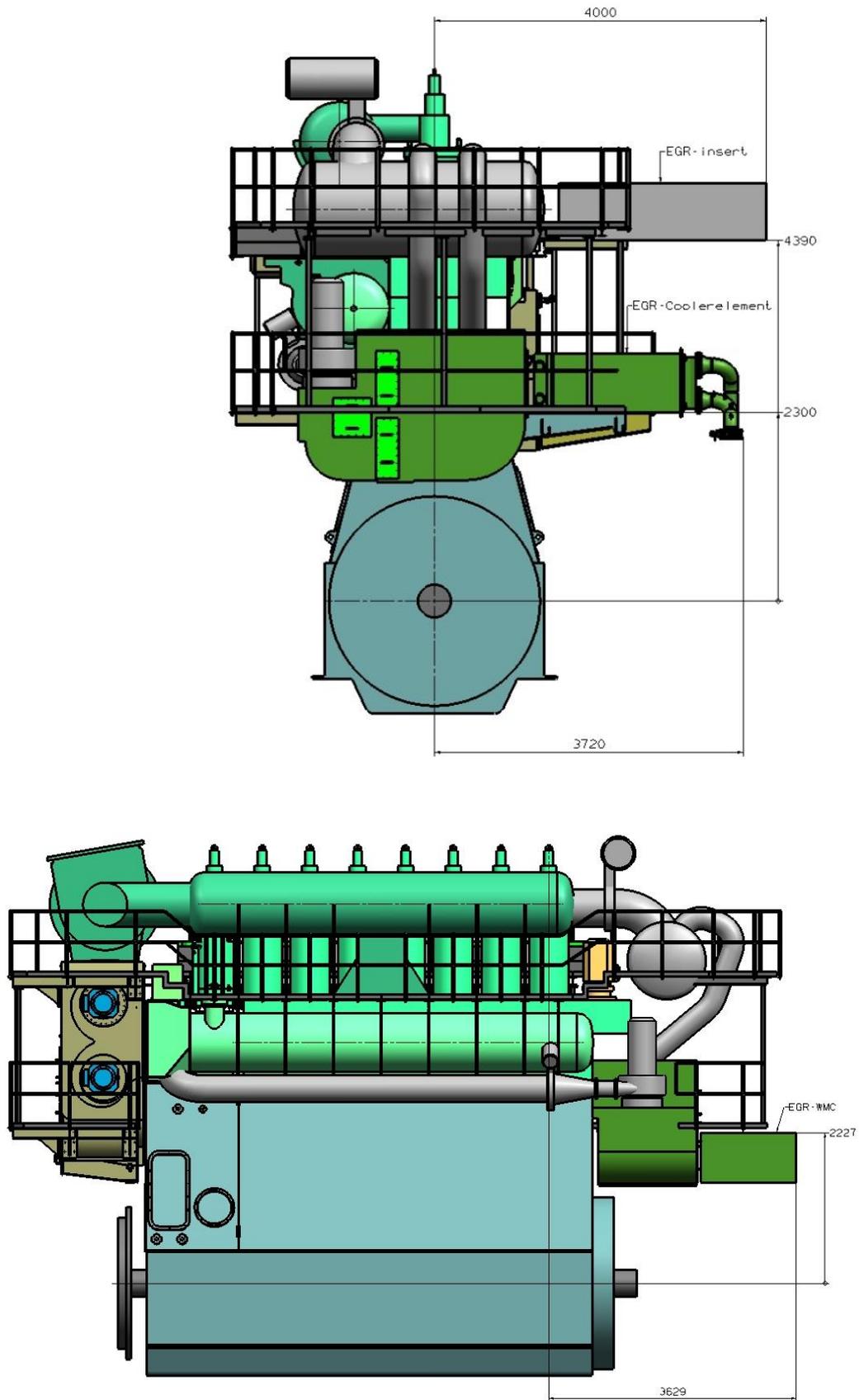


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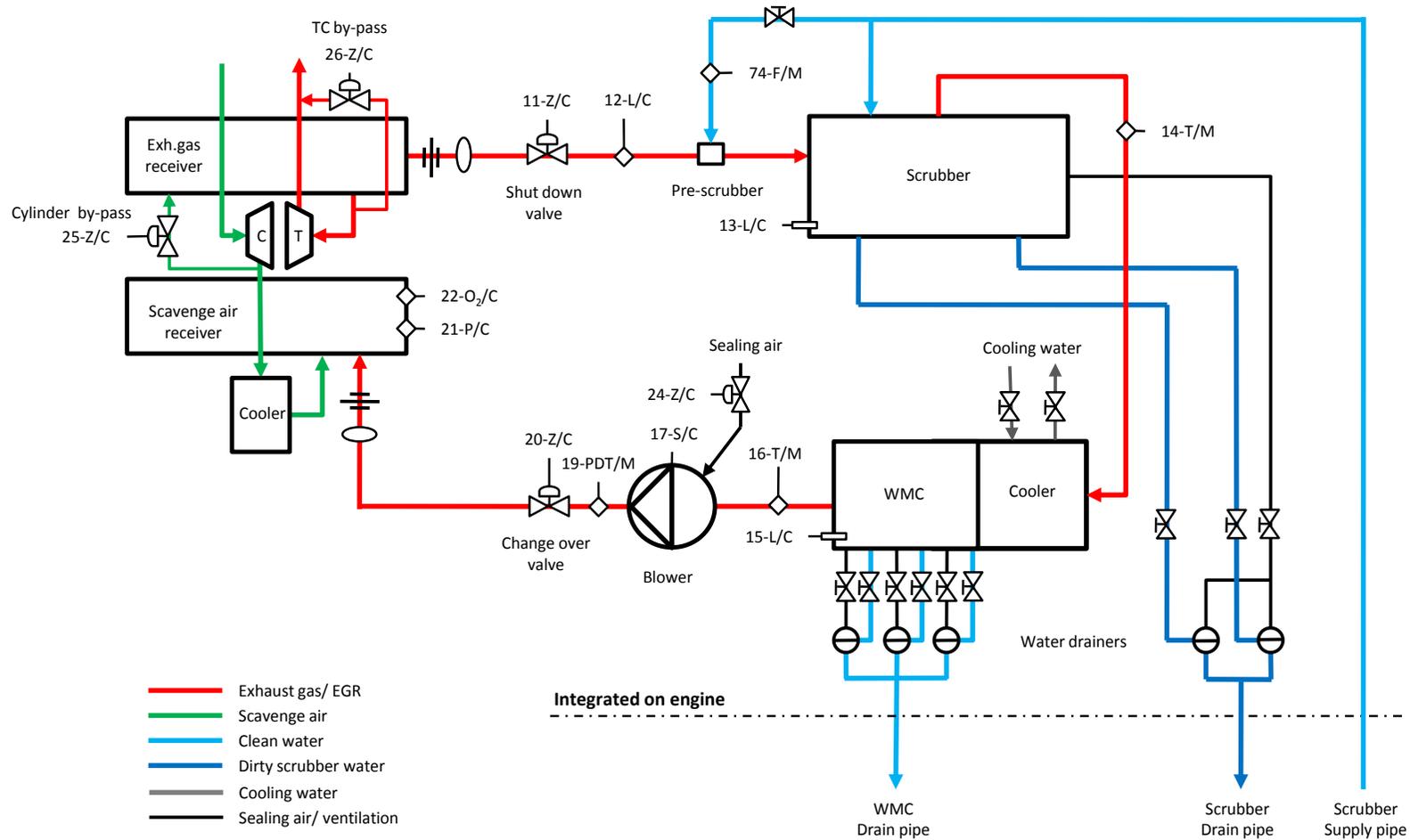


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Overhaul of Scrubber, EGR cooler and EGR Water Mist Catcher

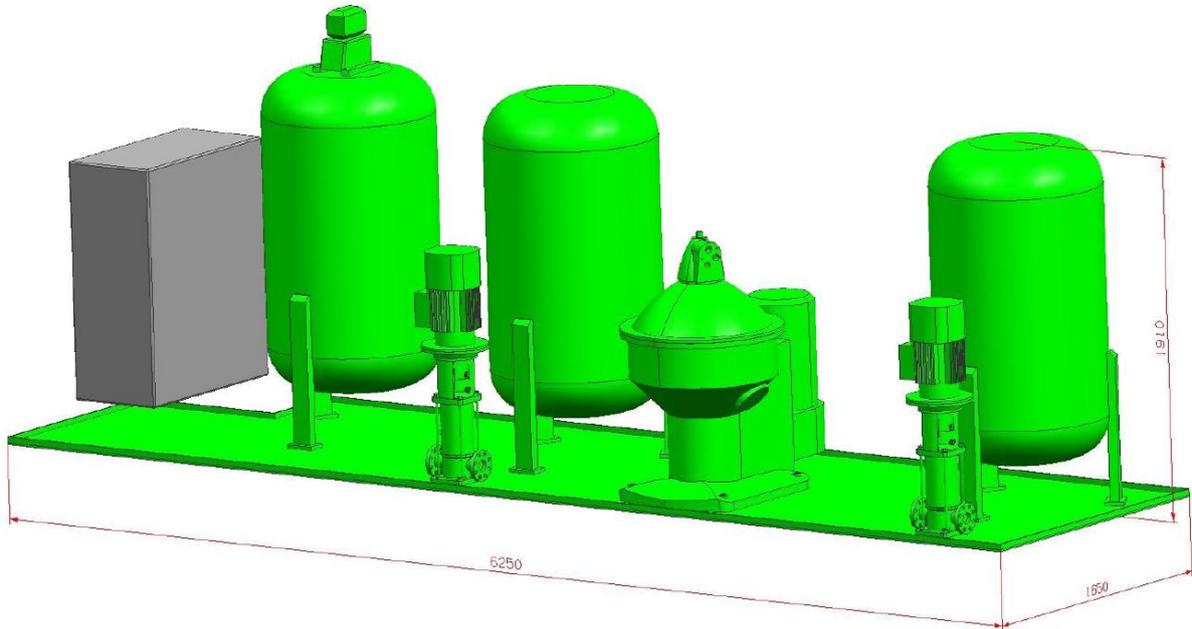


6. EGR - Gas system diagram

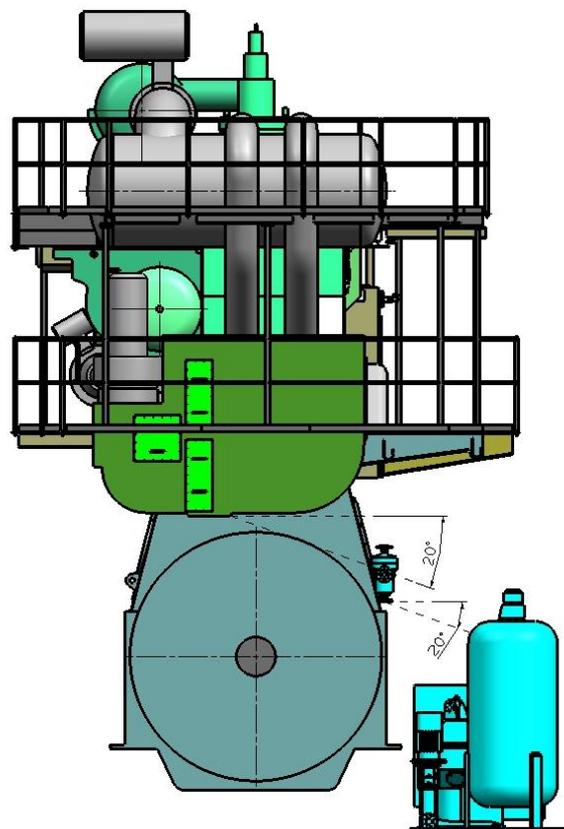


7. Water Treatment Unit – illustrated example

Size approx. LxWxH 6250x1650x1910mm. The WTU can be divided into two or three sections with footprint size according to Shipyard wishes. Weight approx. 4 ton empty and max. 8 ton in filled condition.



Water Treatment Unit



Example of WTU arrangement

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8. EGR system specification - dimensioning

8S40ME-B9.1

Gas system					
EGR Scrubber	1				Integrated on engine
EGR Pre-scrubber	1				Integrated on engine
EGR Cooler	1		4250 kW		Integrated on engine
EGR Water Mist Catcher	1				Integrated on engine
EGR Blower - frequency controlled	1		180 kW		Integrated on engine
Shut down valve	1				Integrated on engine
Change over valve	1				Integrated on engine
Compensators	2				Integrated on engine
Water treatment system					
WMC drainers - placed below WMC	3				Integrated on engine
Scrubber drainers - placed below WMC	2				Integrated on engine
Dirty Buffer tank - placed below drainers	1 m ³	Stainless			Water Treatment Unit
Clean Buffer tank	1 m ³	Stainless			Water Treatment Unit
Sludge tank	10 m ³	Stainless	or coated		Ship system
Water Cleaning unit (WCU)	30 m ³ /h			32 kW	Water Treatment Unit
Clean water outlet valve	1				Ship system
Feed pump- frequency controlled	30 m ³ /h	3 bar		4 kW	Water Treatment Unit
Scrubber pump- frequency controlled	25 m ³ /h	10 bar		12 kW	Water Treatment Unit
NaOH storage tank - 50% NaOH solution	15 m ³	Stainless	or coated		Ship system
NaOH day tank - 50% NaOH solution	1 m ³	Stainless			Water Treatment Unit
NaOH dosing pump	60 l/h	2 bar		0.04 kW	Water Treatment Unit
Cooling water					
Cooling water for EGR Cooler	200 m ³ /h	2 bar		20 kW	Ship system
Electrical system					
Frequency converter - Feed pump	1			4 kW	In WTS cabinet
Frequency converter - Scrubber pump	1			12 kW	In WTS cabinet
Frequency converter - WCU	1			32 kW	In WTS cabinet
Cabinet blower FC	2040 x 1400 x 650				Engine room
Cabinet brake resistance for blower	800 x 1000 x 1000				Engine room
Cabinet – Water Treatment System	2000 x 1600 x 400				Engine room
Control system					
MOP-HMI (existing)	1				Engine control room
WTS – HMI	1				Engine control room
EGRCU – MPC	1				Engine control panel
EGRIU – MPC	1				Engine control panel

9. Tank information

Assumptions

See information for "Consumables"

NaOH storage tank

Tank size	15 m ³	Approximately 2 month consumption
Material	Stainless steel	or mild steel with coating according to shipyard
Required min temp	16°C	NaOH 50% crystallize at 12°C (40%: 16°C)

NaOH day tank

Tank size	1 m ³	26 hours Tier III at 75% MCR
Material	Stainless steel	
Required min temp	16°C	NaOH 50% crystallize at 12°C (40%: 16°C)

Sludge tank

Tank size	10 m ³	Approximately 1½ month accumulation
Material	Stainless steel	or mild steel with coating according to shipyard
Mixer	For discharging	may be needed due to settling risk

Scrubber water: pH 2-13, Natrium content up to 16g/l, Sulphur content up to 12g/l, Chlorides up to 30mg/l, particle solids up to 100g/l and PAH > 200µg/l (to be analysed).

Dirty buffer tank

Tank size ¹	1 m ³	Placed below drainer, free flow at 20 deg inclination
Material	Stainless steel	

Clean buffer tank

Tank size	1 m ³	In level or above dirty buffer tank for free overflow
Material	Stainless steel	

¹ High and slim for optimal water level control

10. EGR cooler

Calculations have been done on EGR-cooler by GEA, which shows that cooling capacity so far can be kept on an acceptable level, without affecting the size of the cooler housing.

Below is output from a cooler calculation for a 9.450 kW engine with slightly more power (370 kW) than the current engine. A more detailed calculation has to be made.

Material: 1.4539 – to be clarified.

8S40ME-B9.2	<i>Unit</i>	<i>EGR-Cooler</i>
Heat rejection*	kW	4275
Gas side		
Cooling surface	m ²	1130
Heat transfer coefficient	W/(m ² K)	145,42
Pressure	bara	3,85
Pressure Drop	mbar	10,5
Mass Flow	kg/s	9,19
Inlet temperature	°C	101,0
Outlet temperature	°C	33,0
Condensat mass flow	kg/s	1,35
Condensat heat quantity	kW	3370
Margin in cooling surface	%	5,0
Water side		
Hydraulic reference diameter	mm	7,4
Mass Flow	m ³ /h	210
Velocity	m/s	2,09
Pressure	bara	4
Pressure Drop	bar	0,88
Inlet temperature	°C	25,0
Outlet temperature	°C	42,6

11. Ship Yard work

Production and installation of tanks

NaOH storage tank	15 m3	Stainless or coated	Incl. bunker/venting pipe, insulation/heating
Sludge tank	10 m3	Stainless or coated	Incl. discharge system

Pipework

Scrubber supply pipe	2 inch	Stainless	PN16	Water Treatment Unit to EGR unit
WMC drain pipe	2½ inch	Stainless	PN10	Water Treatment Unit to EGR unit
Scrubber drain pipe	3 inch	Stainless	PN10	Water Treatment Unit to EGR unit
Fresh Water pipe	1 inch	Galv.	PN10	Ship system to Water Treatment Unit
NaOH pipe	1 inch	Stainless	PN10	NaOH storage tank to NaOH day tank
Vent pipe	2 inch	Stainless	PN10	From dirty buffer tank to Upper Deck
Clean water outlet pipe	1 inch	Stainless	PN10	Water Treatment Unit to Ship Side
WCU sludge pipe	1½ inch	Stainless	PN10	Water Treatment Unit to sludge tank
Dirty buffer drain pipe	2½ inch	Stainless	PN10	Water Treatment Unit to dirty bilge tank
Clean buffer drain pipe	1 inch	Stainless	PN10	Water Treatment Unit to dirty bilge tank
Control air pipe				To Water Cleaning Unit
Control air pipe				To control valves ²
Sealing air pipe				To EGR blower
Cooling water inlet pipe				To EGR cooler
Cooling water outlet pipe				From EGR cooler

Valve installation

Clean water outlet valve	1 inch	Class approval		Water Treatment Unit to Ship Side
NaOH closing valve	1 inch	Stainless	PN10	NaOH storage tank
NaOH control valve	1 inch	Stainless	PN10	NaOH storage tank

Cable work

High voltage supply cable for EGR blower FC	3x440V / 60Hz / 401A
High voltage cable, EGR blower FC to EGR blower	3x440V / 60Hz / 400A
High voltage cable, EGR blower FC to brake resistor	2x35mm ²
High voltage supply cable for WTU	3x440V / 60Hz / 100A
Low voltage cable, ME power supply to WTU	24VDC 10mm ²
Signal cable between EGRIU and WTU	2x4x0.75mm ²
Signal cable between EGRCU and EGR blower FC	2x4x0.75mm ²
Network cable between WTS-HMI and WTU	

Installation of electrical cabinets

Cabinet including blower FC	2040 x 1400 x 650mm
Cabinet including brake resistor	800 x 1000 x 1000mm

² Shut Down valve, Change Over valve, Cylinder By-Pass valve, TC By-Pass valve

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13. Electrical diagram

