


ICER INSTALLATION GUIDELINE

for WinGD dual-fuel engines

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A	2021-03-04	CTU	DST	General clarifications to the exhaust gas piping
B	2021-06-24	MHU	DST	Addition of iCER diesel operation
C	2022-02-18	IAV	DST	Addition of the iCER diesel Tier III mode option and the iCER on-engine system (5- and 6-cylinder X72DF-2.1 and X72DF-2.2)
D	2022-02-23	IAV	DST	The iCER water treatment system updated
E	2022-09-23	IAV	DST	The iCER drainage system updated with a functional description. Addition of the iCER compact arrangement for the off-engine option. The purging and sealing air system section updated.
F	2022-12-14	MHU	DST	List with certified supplier components updated. Guidance for initial iCER system cleaning added. System description for SAC wetting added.
G	2023-03-30	MHU	DST	SAC wetting circulation pump layout criteria defined NO _x sensor installation requirement

Revision	Reference	Description
Revision: G Date: 2023-03-30	4.2	NO _x sensor installation requirement defined
	9.0	Figure SM-0810 updated
	10.1	Figure SM-0923 and SM-0930 updated
	10.4	SAC wetting circulation pump layout criteria defined

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1 Disclaimer

The purpose of this document is to provide advice for the planning of the installation of the Intelligent Control by Exhaust Recycling (iCER) system – a low pressure exhaust gas cooling and recirculation system – into a vessel. It is arranged between the turbine of the turbocharger outlet and the turbocharger compressor inlet.

The detailed information and recommendations enable engine manufacturers, ship designers, and shipyards to design an appropriate project-specific iCER system.

If not agreed otherwise, WinGD is not responsible for the final project-specific design of the iCER system arrangement. Support structures of the exhaust gas piping system, the dimensioning of the piping system and piping components such as valves, are not within WinGD's responsibility.

This guideline has been prepared to the best knowledge and ability of its authors. However, neither Winterthur Gas & Diesel Ltd (WinGD) nor their employees assume any liability – under any legal aspect whatsoever, including possible negligence – in connection with this guideline, its contents, or modifications to it or in connection with its use.

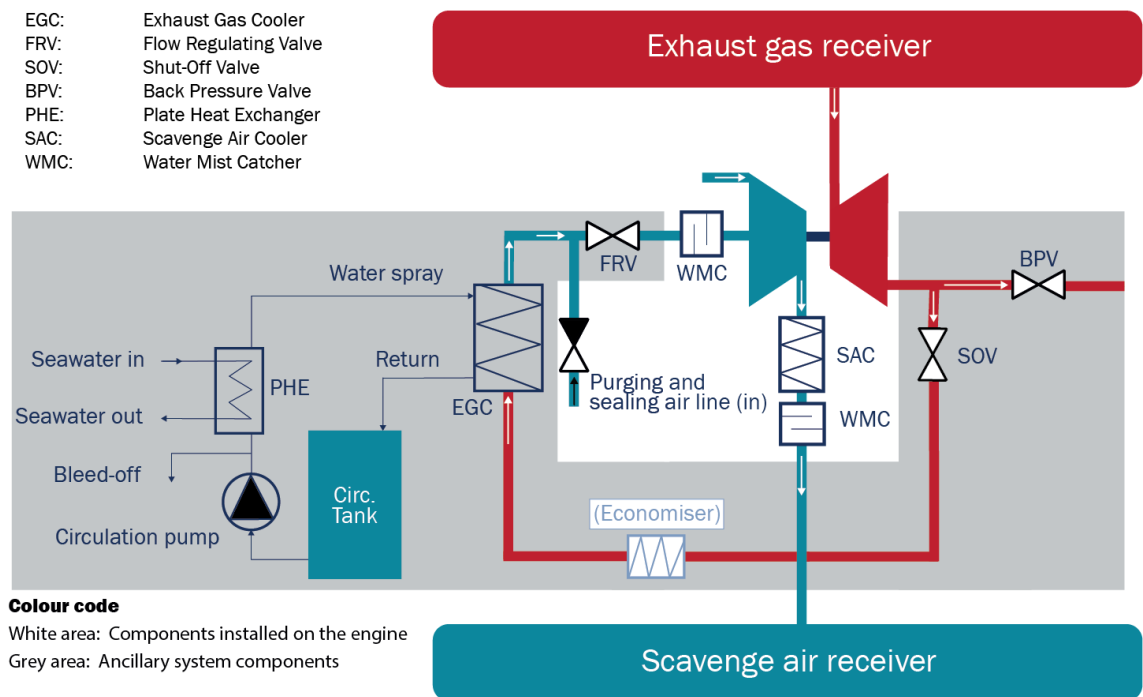
Claims relating to any damage whatsoever or claims of any other nature such as, but not limited to, demands for additional spare supplies, service or others are expressly excluded.

2 System Description

2.1 General system description

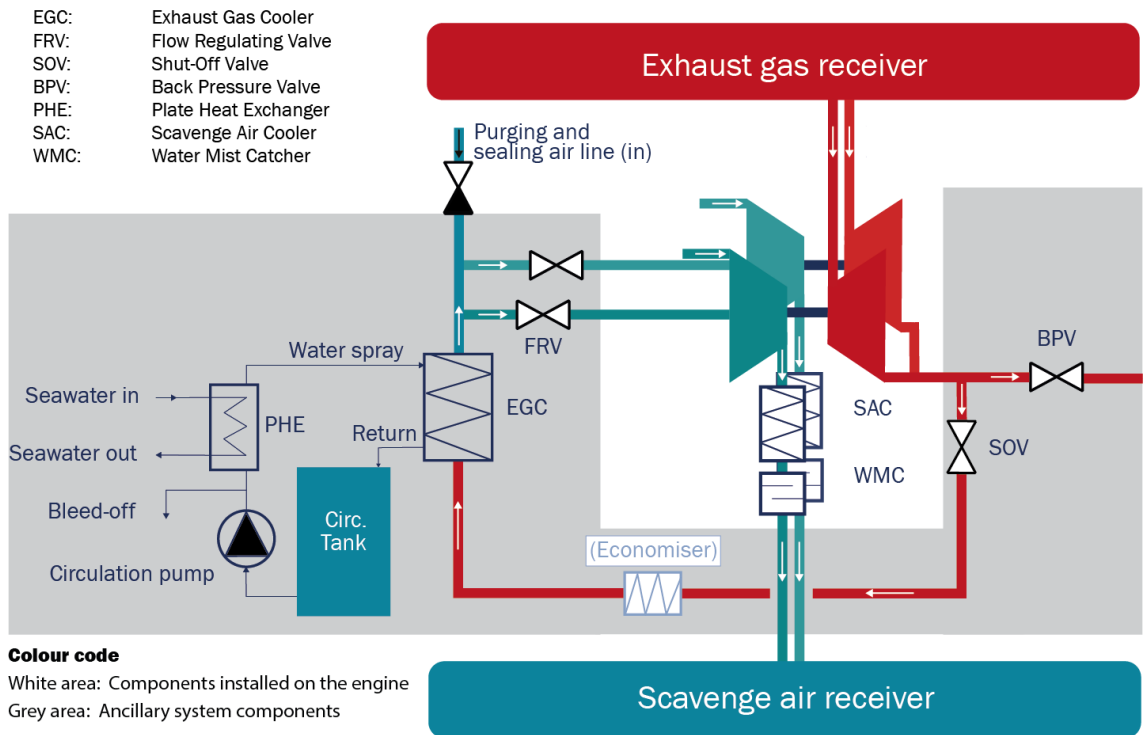
The iCER system improves the X-DF performance by optimising gas and liquid fuel consumption, while reducing the environmental footprint (specifically by a reduction in the emission of unburned methane).

The main component of the iCER system is the Exhaust Gas Cooler (EGC) which enables recirculation of the exhaust gas to the engine. Water spray is used to cool the exhaust gas. The water circulates from the EGC to a circulation tank from which it is pumped through a plate heat exchanger back to the EGC. The circulation water is mainly generated from condensation within the system.



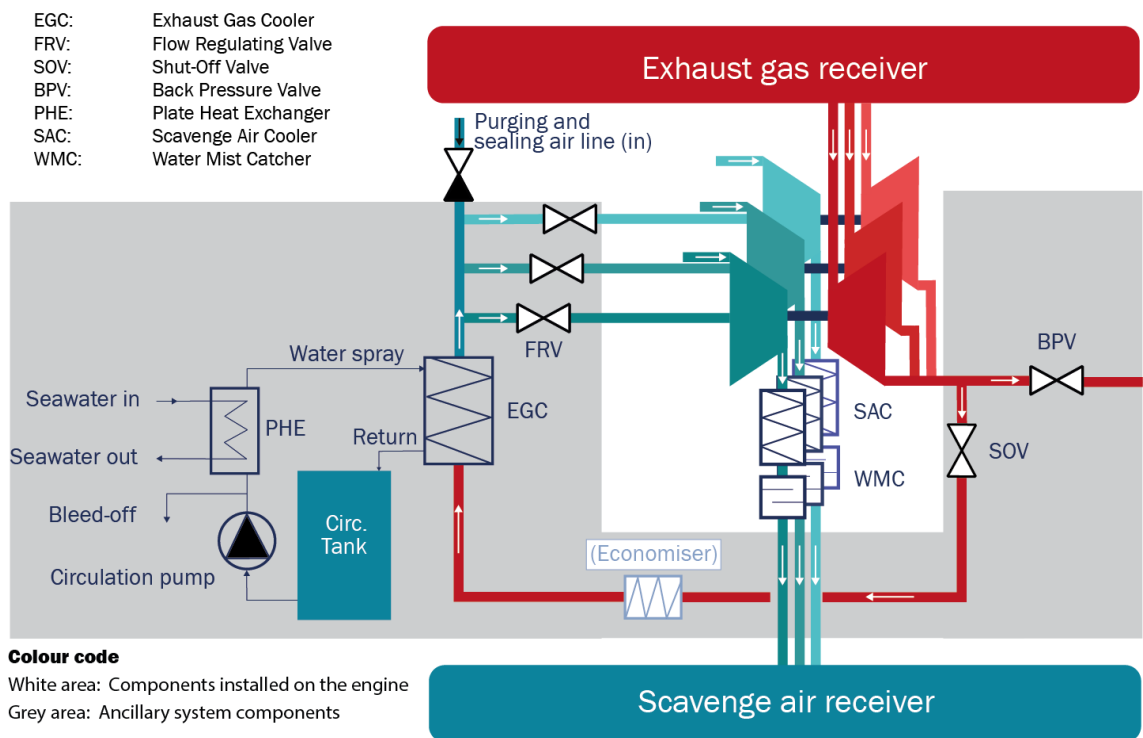
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Figure 2-1: The iCER system (off-engine option) with one turbocharger and the exhaust gas return pipe routed to the turbocharger connection from above



SM-0774

Figure 2-2: The iCER system (off-engine option) with two turbochargers and the exhaust gas return pipe routed to the turbocharger connection from below



SM-0753

Figure 2-3: The iCER system (off-engine option) with three turbochargers and the exhaust gas return pipe routed to the turbocharger connection from below

2.2 Installation options

The iCER system (off-engine option) is normally installed in the engine room. For 5- and 6-cylinder X72DF-2.1 and X72DF-2.2 engines, an iCER on-engine system is available, which provides a compact solution and reduces the installation efforts. Further engines with a single turbocharger configuration will soon be added to the portfolio.

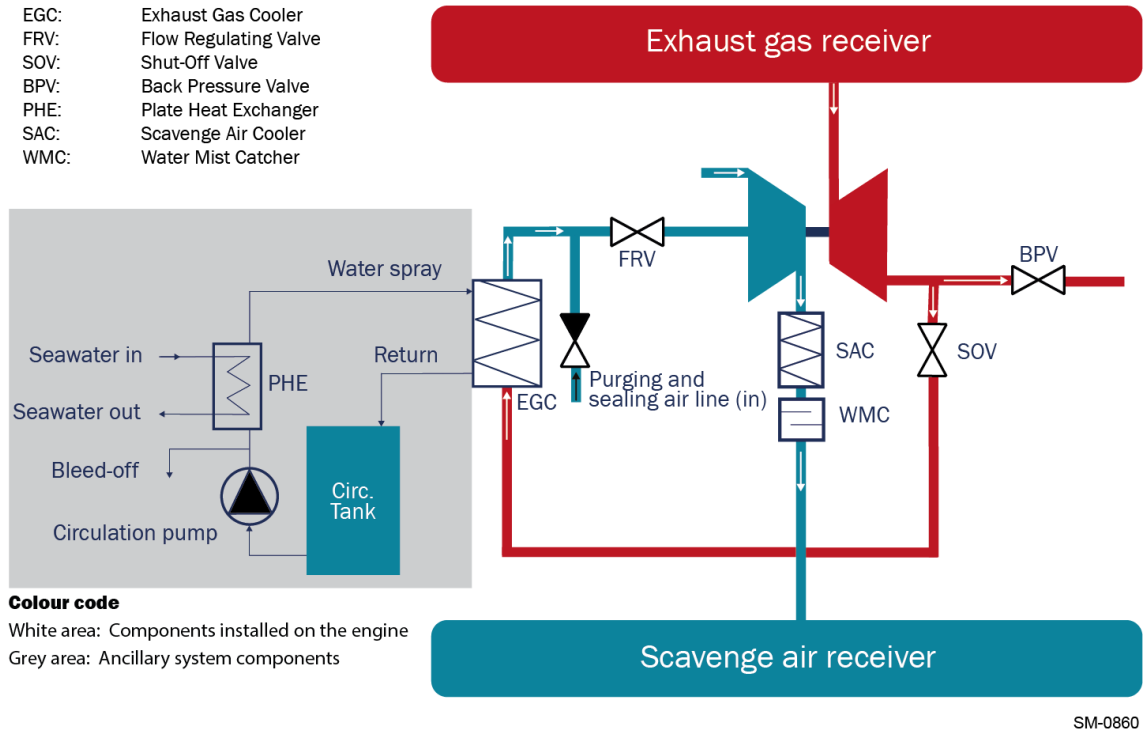


Figure 2-4: The iCER on-engine system

For X72DF-2.1 and X72DF-2.2 engines, a compact arrangement of the iCER system (off-engine option) is possible. With the compact arrangement, the exhaust gas cooler is placed adjacent to the engine, simplifying the arrangement and allowing more space at the free end of the engine. This compact arrangement of the iCER system follows the same installation principles of the configurations with two turbochargers (see Figure 2-2).

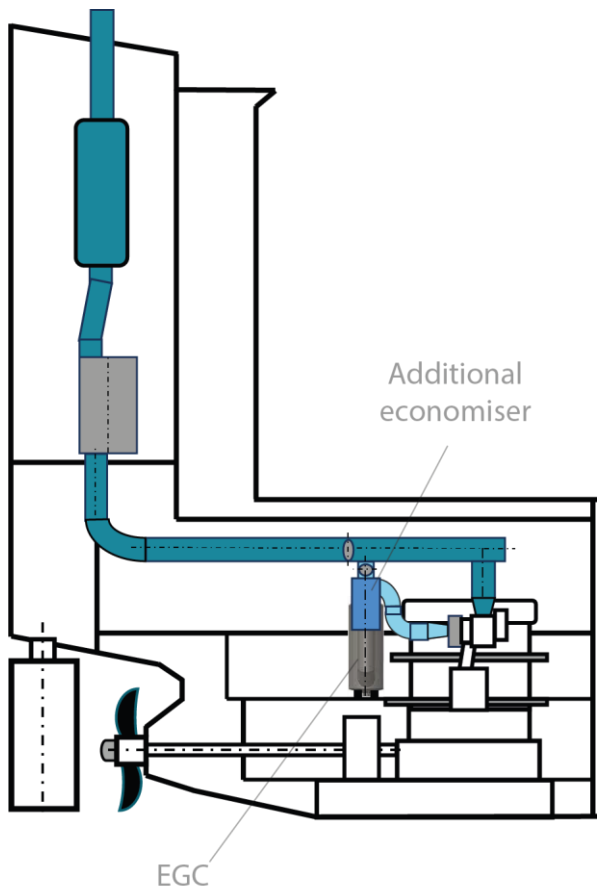
2.3 Different routing concepts

Two different routing concepts are available for the iCER exhaust gas system:

- Short route
- Long route, different variants

2.3.1 Short route arrangement

The branch connection to the iCER system is located directly after the turbocharger outlet. Consequently, the recirculated exhaust gas bypasses the main economiser. To compensate for the resulting lower steam production, an additional economiser can be installed in the exhaust gas recirculation line. Usually, this additional economiser has no steam drum integrated, for compactness and cost purposes, and must therefore be connected to the main economiser.



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Figure 2-5: The short route arrangement

2.3.2 Long route arrangement

The full exhaust gas flow passes through the main economiser. The iCER recirculation branch is connected downstream from the main economiser outlet. The exhaust gas cooler can be placed close to the boiler, close to the turbocharger inlet, or anywhere in between these two positions. The long route arrangement provides the advantage of ensuring that the maximum steam production is available without the requirement of any additional economiser. However, the longer piping provides the challenge of keeping the maximum allowed exhaust gas back pressure in the iCER system within the specified range.

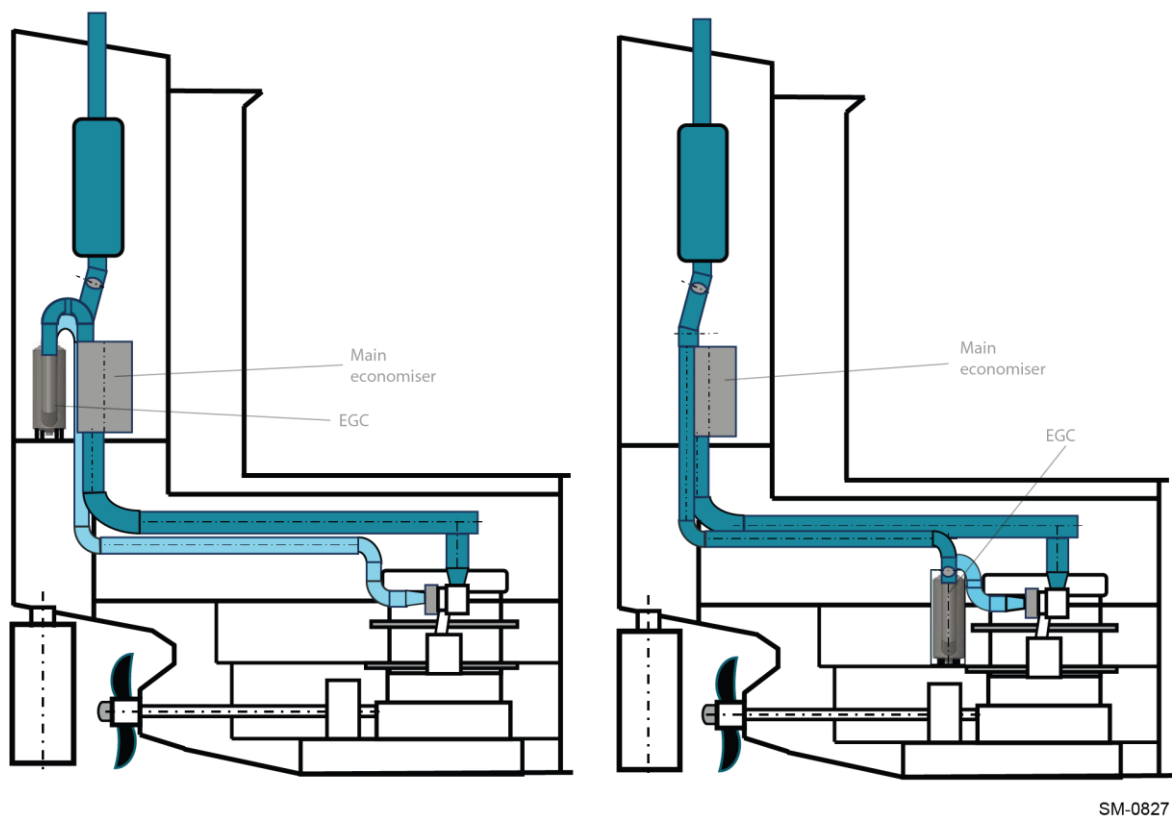


Figure 2-6: The long route arrangement

2.3.3 Special long route arrangement

In cases where it is not possible to fulfil the maximum back pressure limit due to the long route, WinGD should be contacted for project-specific support. Project-specific solutions, including project-specific performance data, can be made available.

3 General Installation Aspects

The Exhaust Gas Cooler (EGC) can be installed either on any platform in the engine room, close to the engine, or as a compact arrangement adjacent to the engine, by partly integrating it in the engine's platforms. For project-specific support and modification requests, please contact the engine builder and/or WinGD.

3.1 Component suppliers

The main components of the iCER system must be purchased from a certified supplier, which must deliver the following components:

- Exhaust gas cooler, see section 4.4
- Water treatment system, see section 9

NOTE

As the components are provided by different parties, the shipyard must take care to coordinate and to align its orders with the engine builder.

The different parties are namely the following:

- Engine builder
- Certified supplier
- Different component suppliers, e.g. valve suppliers
- Shipyard workshops

Some components may have to be initially installed in the engine builder's testbed facility to test run the engine.

3.2 Initial system cleaning before start-up

Before starting the iCER system, it must be ensured that the system is free from any foreign material, like rags, pieces of wood, debris from welding and grinding. Finally, it must be ensured that the system is pressure tight before its initial start-up.

Initially, the system must be visually inspected for any obstructing objects such as wood pieces, rags, leftover tools, etc.

The piping cleanliness must be ensured by manual cleaning to ensure that debris from welding and grinding are thoroughly removed.

4 Components

The following sections describe the required components for the iCER system installation. This document distinguishes between WinGD's recommendations and specifications. The recommendations help to install a trouble-free, long-life system. The specifications must be followed, as otherwise the system might not work properly. Furthermore, some additional information is provided. For some dedicated components, specific product examples are mentioned as according to WinGD's experience. These components provide superior performance which supports a trouble-free introduction of the new iCER technology.

Colour code

- Grey: Delivered with the engine
- Green/Blue: Piping system according to shipyard's supply, including supports, explosion relief devices where necessary, etc.
- Purple: To be ordered from certified supplier
- Yellow: Valves

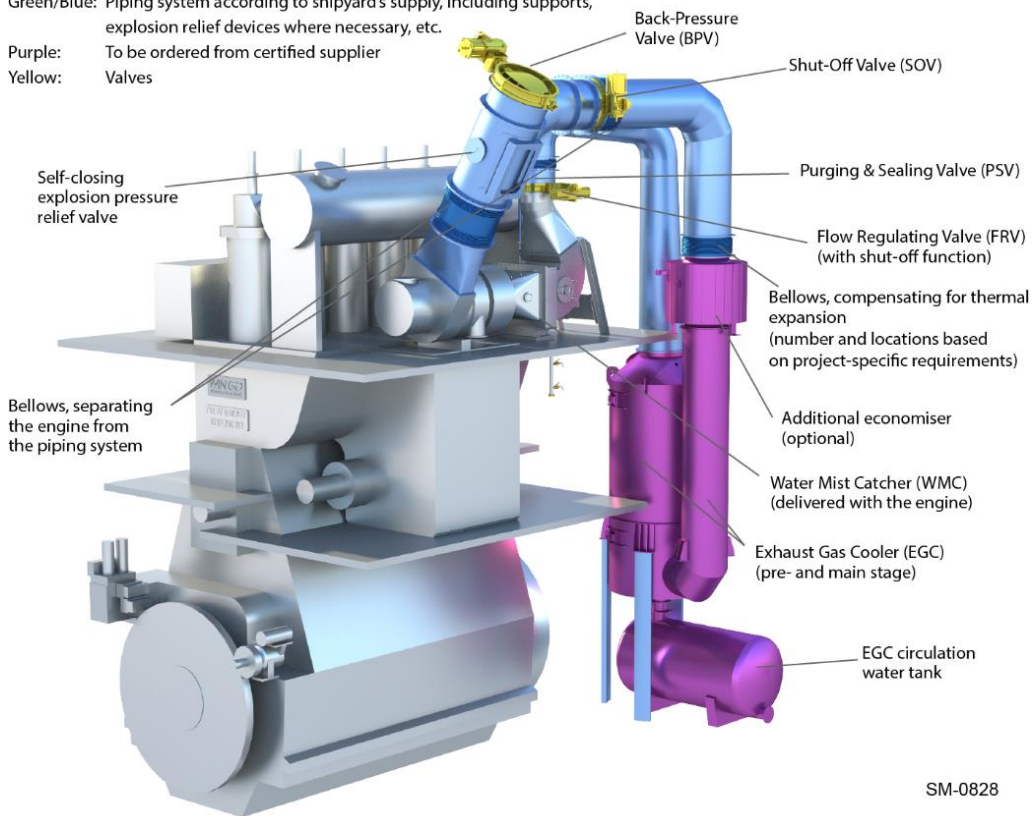
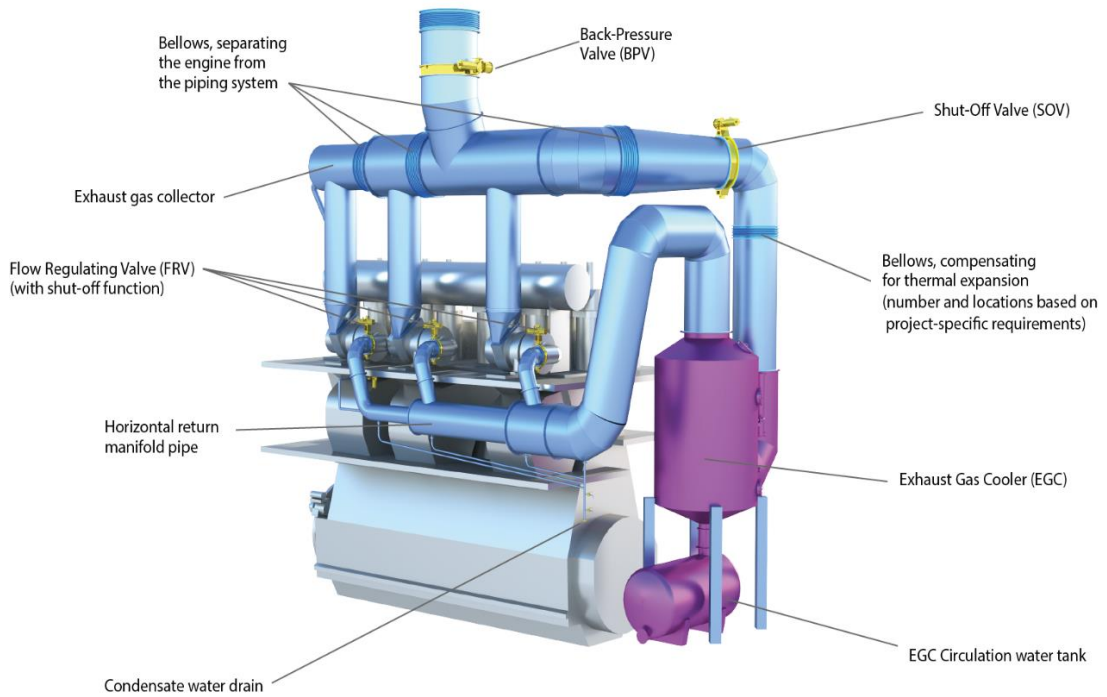
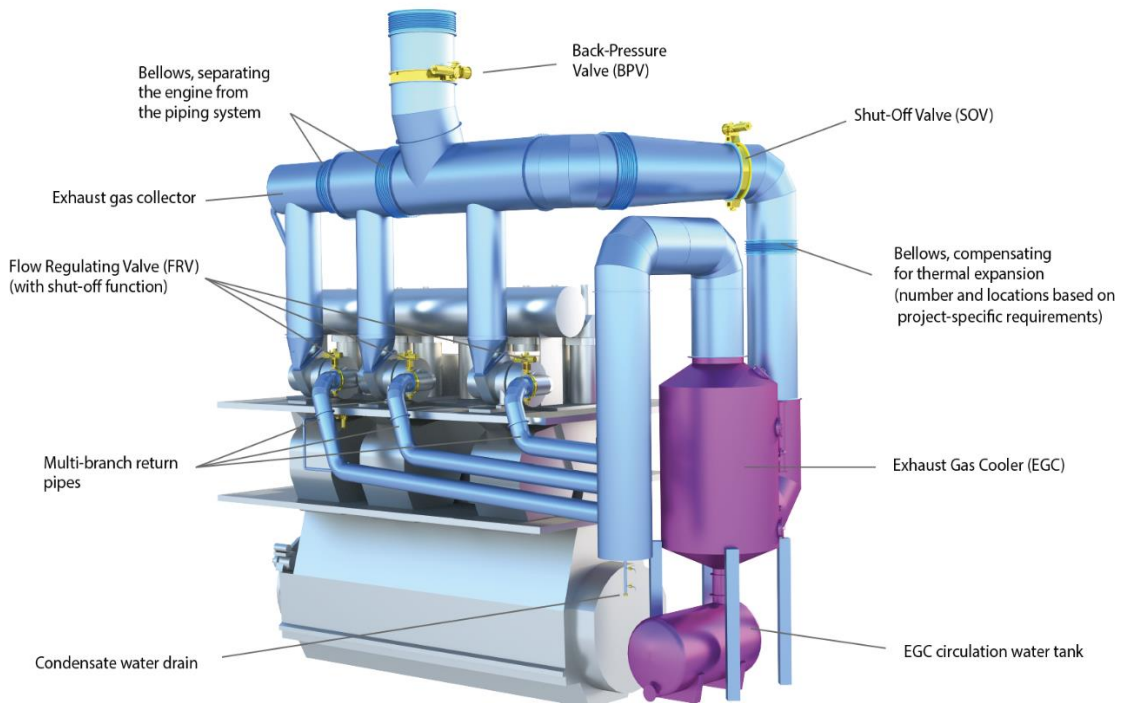


Figure 4-1: Overview of the iCER system with a single turbocharger and its components



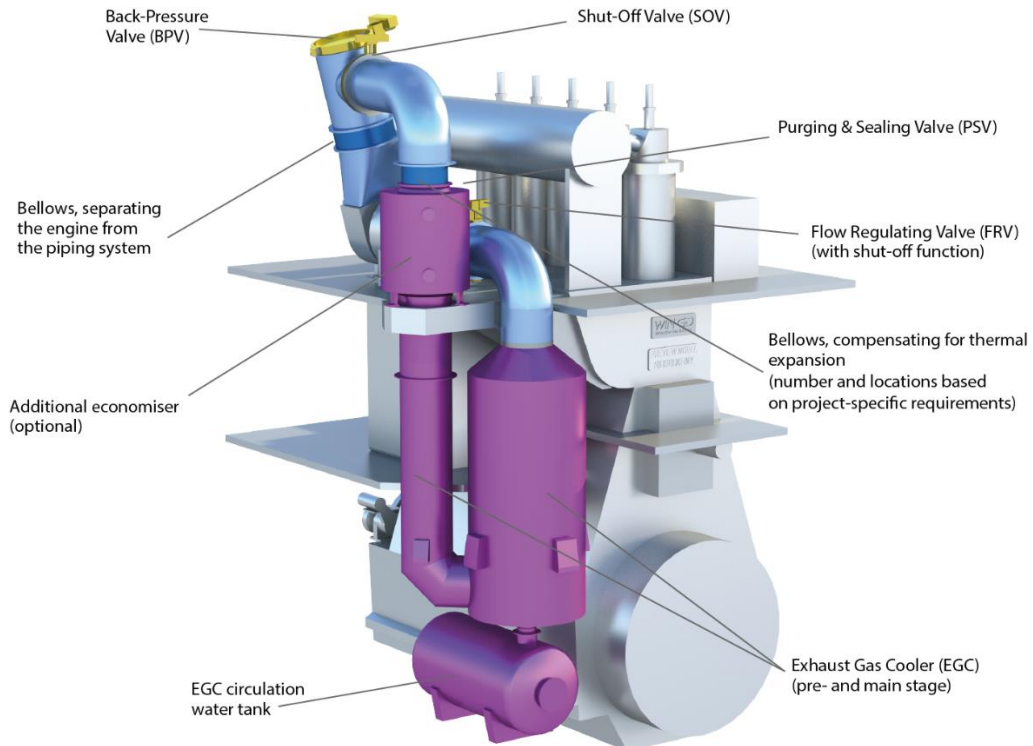
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Figure 4-2: Overview of the iCER system for multi-turbocharger installations with a horizontal return manifold and its components



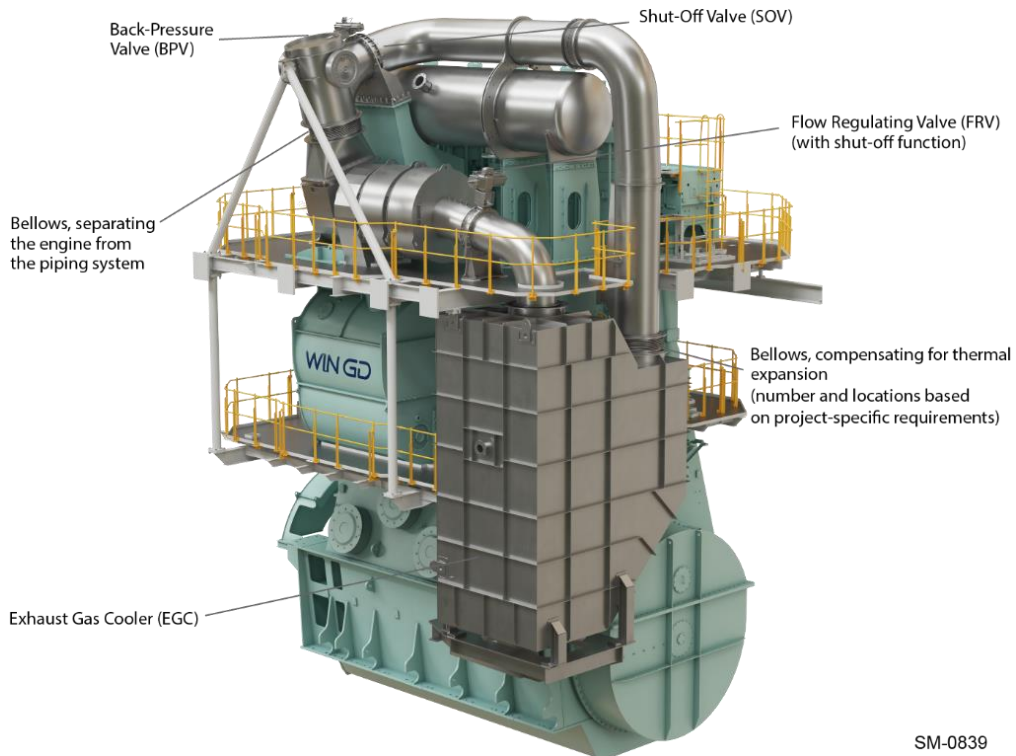
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Figure 4-3: Overview of the iCER system for multi-turbocharger installations with a multi-branch return option and its components



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Figure 4-4: Overview of the components for the compact design of the iCER system



SM-0839

Figure 4-5: Overview of the components for the iCER on-engine system

4.1 Component and piping supports, and expansion compensation

The iCER system operates at the same low exhaust gas pressure as the exhaust gas piping system to the funnel. For this reason, the standard installation practice used for the exhaust gas system can be followed for the iCER system. Proper pipe and component support are required to carry the component weights and to limit vibrations according to common practice. Thermal expansions must be considered by the installation geometry or the application of the expansion bellows.

4.2 Exhaust gas piping

The following description provides WinGD's **specifications**:

- Pipe diameters and bends are designed to fulfil the maximum pressure drop requirements as defined in the Marine Installation Drawing Set (MIDS), considering in addition all other components such as valves, heat exchangers, etc.
- Pipe material:
 - If an additional economiser is installed, then:
 - The branch from the main exhaust gas pipe to the additional economiser must be the same pipe and component material as for any other two-stroke engine exhaust gas pipe installation; and
 - The branch from the additional economiser to the EGC must consist of stainless steel
 - If no additional economiser is installed, then:
 - The branch from the main exhaust gas pipe to the EGC must be the same pipe and component material as for any other two-stroke engine installations; and
 - The branch from the EGC to the turbocharger inlet pipe connection must consist of stainless steel or alternative solutions with coating and must be reviewed on a project-specific basis

For project-specific questions, please contact WinGD.

- The exhaust gas pipes must be insulated:
 - Upstream of the EGC, according to the general rules for exhaust gas pipe insulation (e.g., SOLAS rules)
 - Downstream of the EGC, to prevent condensation of the humid recirculating exhaust gas on the pipe wall. The same standard must be applied as on the hot side before the cooler.
- Explosion pressure relief devices:
 - In general, no dedicated relief devices are required in the iCER exhaust gas recirculation line (between SOV and FRV). The iCER system design pressure must not be exceeded under any circumstances.
 - Relief device installation is required in the main exhaust gas piping system (the piping from the turbocharger to the funnel). The position and number of explosion relief devices must be determined by the system designer or the shipyard through calculation. Relief devices must be examined and certified by the maker. Within the engine room area, only self-closing relief devices are allowed. Normally, a relief device is required to be located opposite to the iCER connection.

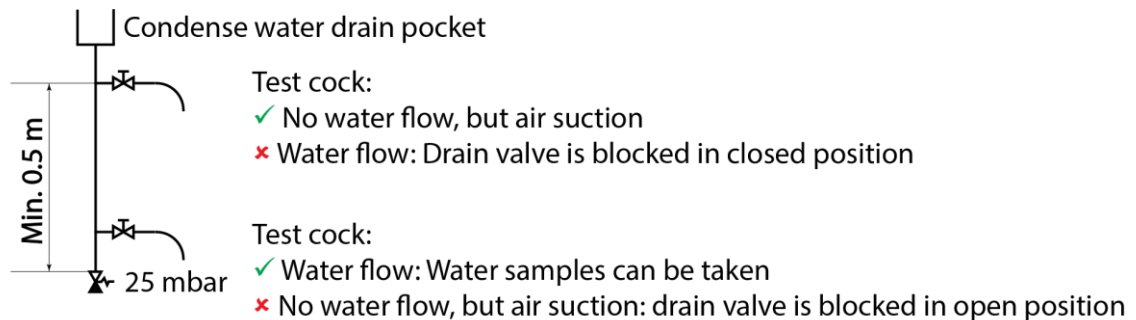
- If the iCER diesel option is selected, a NO_x sensor must be installed in the exhaust gas pipe between Back Pressure Valve (BPV) and turbocharger.
 - The NO_x sensor for the off-engine iCER option is delivered by the engine builder and must be installed by the shipyard. For the on-engine iCER option it is installed by the engine builder and delivered with the engine.
 - For sensor cleaning, clean working air, which fulfils the air quality level of ISO 8573-1: 2010 [1:7:2], must be supplied.

4.3 Water mist catcher

For **iCER system installations with a single turbocharger** (see Figure 4-1), the following description is only provided for information purposes:

- A water mist catcher is integrated on the engine before the turbocharger suction connection. This ensures the removal of water droplets which may have formed in the piping system.
- A drain arrangement as indicated in Figure 4-1 is integrated on the engine.

For **iCER system installations with multi-turbochargers** (see Figure 4-2 and Figure 4-3), no water mist catcher is required, as long as the iCER exhaust gas return pipe is connected from the bottom side to the turbochargers. This return pipe must be equipped with drain pockets. The number and arrangement of the drain pockets must ensure drainage under trim and pitching conditions. The drain pocket must be connected with a drainpipe, which is equipped with a non-return plate valve. These valves must be installed one metre below each drain pocket and be designed for an opening pressure of 25 mbar (see Figure 4-6).



SM-0798

Figure 4-6: Water drain arrangement for iCER system installations with multi-turbochargers

For iCER on-engine and for compact arrangement installations, the same principle follows as for iCER system installations with multi-turbochargers. However, for the iCER on-engine, the drain arrangement is already integrated into the engine.

4.4 Exhaust gas cooler

This **specified** component and the specifications below must be delivered by a certified supplier.

The following specifications are therefore only for **information**:

- The required cooling capacity as defined by the GTD
- Providing the Failure Mode and Effect Analysis (FMEA) of the gas cooling system
- Integrated automation and control system according to WinGD's interface specification
- Material: Stainless steel, quality according to class rules and specified maximum sulphur content of fuel (maximum 0.10% m/m sulphur)
- Demister selection and installation, to ensure a water mist droplet size of maximum 30 microns in diameter

4.5 EGC circulation water tank

This **specified** component and the specifications below must be delivered by the EGC circulation water tank supplier.

The following tank layout data are only provided for **information purposes**:

- Design pressure: 0.5 bar(g)
- A refilling connection. No refilling is usually required during normal operation.

Specifications:

- The shipyard must provide the pipe connection to the hydrophore system, including the system separation valves
- A temperature transmitter must be installed in the outlet piping of the circulation tank
- A pressure transmitter must be installed in the outlet piping of the circulation tank

4.6 Plate heat exchanger

This **specified** component and the specification below must be delivered by the plate heat exchanger supplier.

The following specification is only provided for **information purposes**:

- A titanium seawater-resistant heat exchanger. The maximum design pressure drop must be the same as that of the central cooler.

4.7 EGC circulation water pump arrangement

This **specified** component and the specifications below must be delivered by the EGC circulation water pump supplier.

The following details are only provided for **information purposes**:

- The flow rate is selected according to the EGC size
- All valves and control functionalities are included in the arrangement

The following **specifications** must be considered:

- The maximum permissible pump suction and delivery heights must be acquired from the supplier's specifications. In cases where alternative pump specifications are required, the new selection must be agreed upon with the supplier.

4.8 Water treatment system for iCER

For all information concerning the iCER water treatment system, please refer to the "*The iCER drainage system*" section in the Marine Installation Manual (MIM).

4.9 Additional economiser

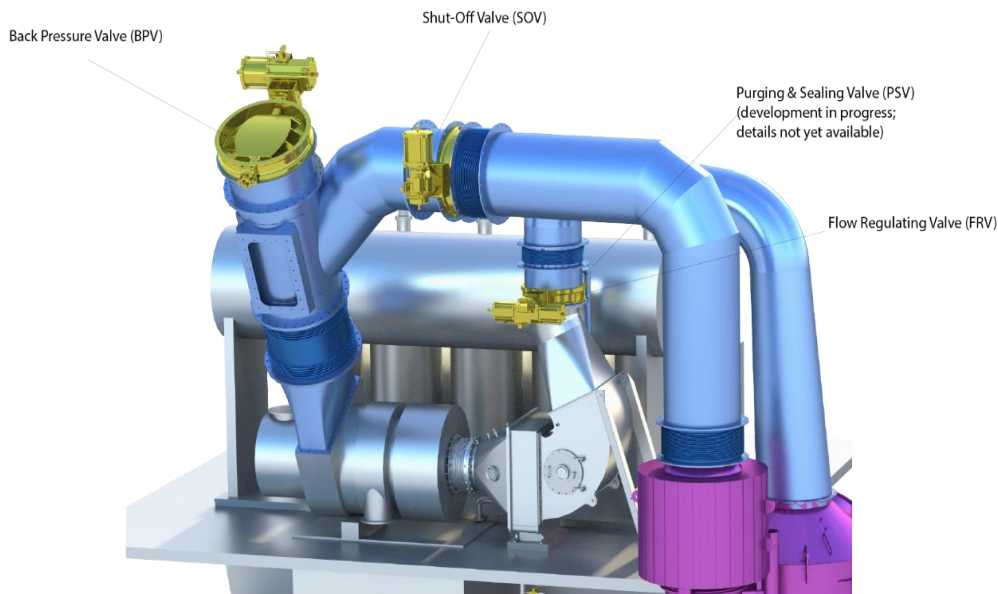
This is an optional component to ensure sufficient waste heat recovery, while the engine operates in gas mode or in iCER diesel Tier III mode.

The waste heat recovery demand must be checked carefully, as in general, less steam production power is required during gas operation. To keep this additional economiser compact, no water drum is usually included and direct connection to the main economiser is required. This additional economiser is only available for the off-engine option.

Specifications, if installed:

- The shipyard provides the component support and the thermal expansion compensation
- The shipyard provides the pipe connection between the main economiser and the additional economiser

4.10 Valves



SM-0829

Figure 4-7: Arrangement of the valves in the iCER system

Description of the valves and accompanying equipment, along with the settings, are available in Table 4-1.

The following general installation requirements must be considered:

- Lifting lugs must be available to lift the components during installation and maintenance
- Accessibility to the valve actuators must be provided for commissioning, maintenance, and manual operation
- Air supply to the actuators must be ensured and preferably supplied by the control air. If required, a pressure control device must be added. The air cleanliness specifications of the actuator supplier must be followed.
- The piping and equipment must be selected, and the selection must be based on a flow optimised design (especially as the pressure drop in the iCER system must be kept low)
- As shown in Figure 4-6, a drain arrangement must be connected:
 - To the water mist catcher (valid for engines with a single turbocharger)
 - At the lowest point of the inclined exhaust gas distributor pipe (valid for engines with multi-turbocharger installations)
 - Valves can be supplied either by the engine builder or by the shipyard. Valves supply must be agreed and coordinated between the parties (see note General Installation Aspects in Chapter 3).

Table 4-1: Description of the valves which must be installed in the iCER system

	Row #	Code	Properties	Back pressure valve	Shut-off valve	Flow regulating valve
Medium	1	-	Valve function	Back pressure control	iCER shut off	Shut off/control
	2	I	Fluid	Exhaust gas (max. 0.5% m/m sulphur in fuel)	Exhaust gas (max. 0.5% m/m sulphur in fuel)	Exhaust gas (max. 0.1% m/m sulphur in fuel)
	3	S	Minimum design temperature [°C]	380		max. 160 continuously 380 for up to 10 minutes in case of failure
	4	I	Operating differential pressure [bar(g)]	0.08	0.12	0.12
	5	S	Maximum differential pressure which the valve must withstand [bar(g)]	1.0	1.0	0.5
Valve specifications	6	R	Valve type	Butterfly valve, single or double disc		
	7	S	Valve body size	Engine power-related / iCER specific, considering the total system back pressure The WinGD iCER layout tool supports the correct selection		
	8	R	End connections	Wafer or flange		
	9	R	Body material	Stainless steel: Fulfilling class rules applicable to pressure class and leakage class criteria		
	10	R	Disc material			
	11	R	Shaft material			
	12	S	Minimum leakage class according to EN 60534-4/ANSI-FCI 70-2	Not applicable. The valve is always open.	Class II (see 4.11.2)	Class II (see 4.11.2)
	13	S	Local position indication	Yes		
	14	R	Actuator	Double acting (alternatively, single acting)		
	15	S	Fail safe	Yes		
	16	S	Manual override option	Yes: Hand wheel (After selecting manual override)		
	17	S	Travel	The minimum position must be fixed during commissioning: Full closing is not allowed maximum 90° opening	0 – 90 degrees	0 – 90 degrees
	18	S	Minimum valve body pressure	1.0 bar(g)	1.0 bar(g)	1.0 bar(g)
	19	S	Minimum counter flange pressure class	PN 2.5	PN 2.5	PN 2.5
	20	E	Bore pattern of flanges according to EN 1092-1 based on minimum PN class			

Codes:	Description
I	= Information
E	= Example
R	= Recommendation
S	= Specifications which must be followed

	Row #	Code	Properties	Back pressure valve	Shut-off valve	Flow regulating valve
Actuator	21	R	Type	Pneumatic (The air consumption is marginal and does not need to be added to the compressor sizing)		
	22	R	Minimum / maximum supply pressure [bar(g)]	5.5 – 6.9		
	23	S	Maximum stroking time	20 s	20 s	20 s (open) / 10 s (close)
	24	S	Fail position	Open	Close	Close
	25	R	Air filter regulator with automatic drain	Yes		
Fail safe description and accessories	26	S	Fail system description	If electric and/or pneumatic supply is missing, valve must move to fail safe position (see electro-pneumactical drawings as provided by WinGD)		
	27	S	Fail system (only for double-acting actuators). Drawings available upon request.	PTAA015284	PTAA015284 or as alternative PTAA015335	PTAA015334
Air tank (only for double-acting actuators)	28	R	Air tank size	Designed for minimum two full strokes		
	29	R	Air tank minimum / maximum supply pressure [bar(g)]	5.5 – 6.9		
	30	R	Mounting strap	Yes		
	31	R	Safety valve G1/4"			
	32	R	Non-return valve on inlet			
	33	R	Ball valve for water drain			
	34	R	Pressure gauge 1/4" 0-10 bar			
	35	R	Manual override pressure release valve (shortcut valve)			
Positioner electrical connection and equipment	36	R	Positioner location	Directly mounted on actuator (alternatively, remote location)		
	37	S	Control signal	4 – 20 mA Direct	0/24 V on/off	4 – 20 mA Direct and 0/24 V on/off (fast closing/fast opening)
	38	S	Feedback signal	4 – 20 mA		
	39	E	Manufacturer	ABB		
	40	E	Positioner model	EDP300		
	41	S	Limit switch	Yes (inductive recommended)		
	42	S	Positioning accuracy	≤ 0.45 degrees	Not applicable	≤ 0.45 degrees
	43	S	Angle detection	Yes (contact free – inductive recommended)		
	44	R	Marine approved	Yes		
	45	I	Explosion-proof design	No		
	46	R	Valve components completely assembled, commissioned and ready to install	Yes (position switch for closed condition must be set during sea trial)		

Codes:	Description
I	= Information
E	= Example
R	= Recommendation
S	= Specifications which must be followed

Special class requirements regarding design temperature, position indicator arrangement, manual override, and emergency operation options must be followed.

4.11 Purging and sealing air system arrangement

4.11.1 Purpose of the purging and sealing air system

- Removal of hot exhaust gas from the recirculation line after stopping the exhaust gas recirculation operation
- Preventing exhaust gas ingress to the recirculation circuit while not in operation
- Reducing the condensation on the pipe surface when the iCER system is deactivated

4.11.2 Purging and sealing of the iCER exhaust gas system

The purging and sealing air system is controlled by the engine control system. Two possible variants are available for the system:

- Engine-mounted purging and sealing air blower. This variant is valid for all projects contracted before April 2022 and for any iCER on-engine installations.
- Ship side purging and sealing air blower. This variant is valid for any other iCER system installations.

For iCER on-engine systems, the following design calculation criteria are not relevant for the ship designer and shipyard since the purging and sealing air system is integrated onto the engine.

For iCER systems with the off-engine option, the purging and sealing air blower must be designed with a 0.15 bar(g) pressure head at a testing temperature within the range of 25 - 45 °C. The flow rate of the blower is defined by either the purging air demand or the sealing air demand, depending on which is higher.

The purging air demand is defined as 4.5 times the volume of the iCER exhaust gas system (V_{iCER}) per hour:

$$Q_{purging} = \frac{4.5 \cdot V_{iCER}}{[h]}$$

Equation 4-1: Blower flow rate calculation defined by the purging air demand

Where:

- $Q_{purging} [\frac{m^3}{h}]$ represents the blower flow rate defined by the purging air demand
- $V_{iCER} [m^3]$ represents the volume of the iCER exhaust gas system between the SOV and the FRV

The sealing air demand is defined by the leakage rate of the FRV and the SOV at a differential pressure of 0.15 bar(g) and at a testing temperature within the range of 25 - 45 °C. These values are provided by the selected FRV and SOV suppliers.

$$Q_{sealing} = n_{FRV} \cdot Q_{FRV} + Q_{SOV}$$

Equation 4-2: Blower flow rate calculation defined by the sealing air demand

Where:

- n_{FRV} represents the number of FRVs installed in the iCER exhaust gas system depending on the number of turbochargers (see Figure 4-10, Figure 4-11, and Figure 4-12)
- $Q_{FRV} [\frac{m^3}{h}]$ represents the leakage rate of the FRV at 0.15 bar(g) and at 25 - 45 °C
- $Q_{SOV} [\frac{m^3}{h}]$ represents the leakage rate of the SOV at 0.15 bar(g) and at 25 - 45 °C

To limit the sealing air amount, a higher leakage class can be selected.

The blower flow rate (Q_{blower}) is defined by the maximum between the $Q_{purging}$ and $Q_{sealing}$:

$$Q_{blower} = \max(Q_{purging}, Q_{sealing})$$

Equation 4-3: Minimum blower flow rate at 0.15 bar(g) and at 25 - 45 °C

An example of the blower flow rate calculation, based on the case study of an iCER short-route installation with a 6X72DF-2.1 (off-engine option):

$$Q_{purging} = 4.5 \cdot 67.7 \frac{m^3}{h} = 305 \frac{m^3}{h}$$

$$Q_{sealing} = 112 \frac{m^3}{h} + 200 \frac{m^3}{h} = 312 \frac{m^3}{h}$$

$$Q_{blower} = \max\left(305 \frac{m^3}{h}, 312 \frac{m^3}{h}\right) = 312 \frac{m^3}{h}$$

An example of the blower flow rate calculation, based on the case study of an iCER long-route installation with a 9X92DF-2.0:

$$Q_{purging} = 4.5 \cdot 440 \frac{m^3}{h} = 1980 \frac{m^3}{h}$$

$$Q_{sealing} = 3 \cdot 112 \frac{m^3}{h} + 354 \frac{m^3}{h} = 690 \frac{m^3}{h}$$

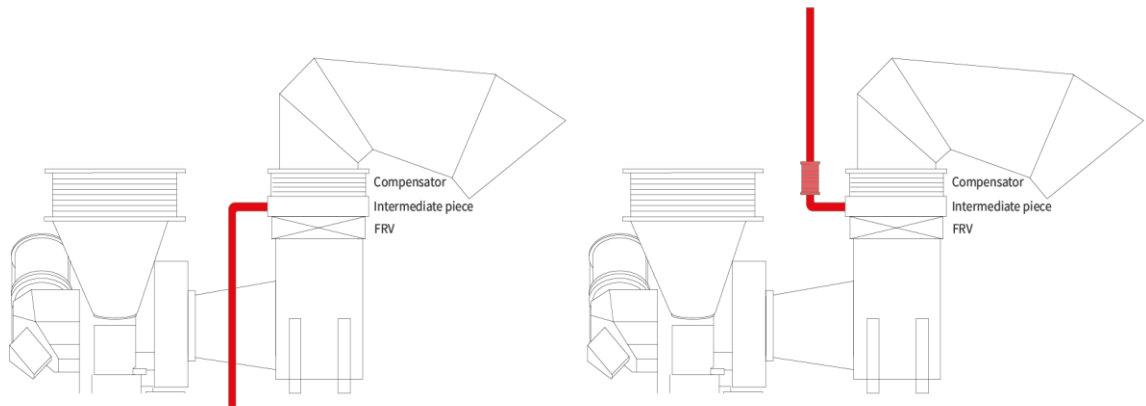
$$Q_{blower} = \max\left(1980 \frac{m^3}{h}, 690 \frac{m^3}{h}\right) = 1980 \frac{m^3}{h}$$

During purging, the purging and sealing air blower provides continuous air. Purging air pushes the residual gas through the open SOV to the funnel. The sealing air pressure must be maintained between 0.10 and 0.15 bar(g).

For iCER on-engine systems, the purging and sealing air system is integrated onto the engine.

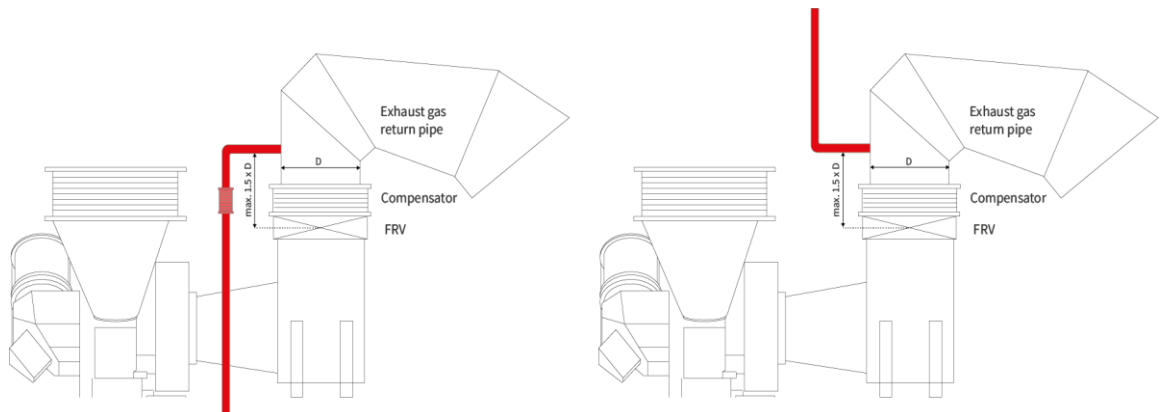
For iCER systems with the off-engine option, two configurations can be implemented for the connection of the purging and sealing air line to the exhaust gas return pipe:

1. Connection to an intermediate piece between the FRV and the exhaust gas return pipe compensator
2. Direct connection to the exhaust gas return pipe



SM-0759

Figure 4-8: Option 1 includes a connection to an intermediate piece for an engine-mounted purging and sealing air blower (left side) and for a ship side purging and sealing air blower (right side)



SM-0760

Figure 4-9: Option 2 includes direct connection to the exhaust gas return pipe for an engine-mounted purging and sealing air blower (left side) and for a ship side purging and sealing air blower (right side)

The design of the purging and sealing air system consists of:

- A purging and sealing air blower unit comprised of one or two blowers, depending on the selected variant and on the owner preference
- One non-return valve
- One purging and sealing air line connected upstream from the FRV. In case of multiple turbochargers this connection is completed by means of a dedicated branch pipe for each FRV.

Important: The distance of the purging and sealing air line connection from the FRV is defined as maximum 1.5 times the exhaust gas return pipe diameter.

NOTE Due to possible acid condensation in the piping downstream from the EGC, it is recommended to use SUS316 material for the non-return valve.

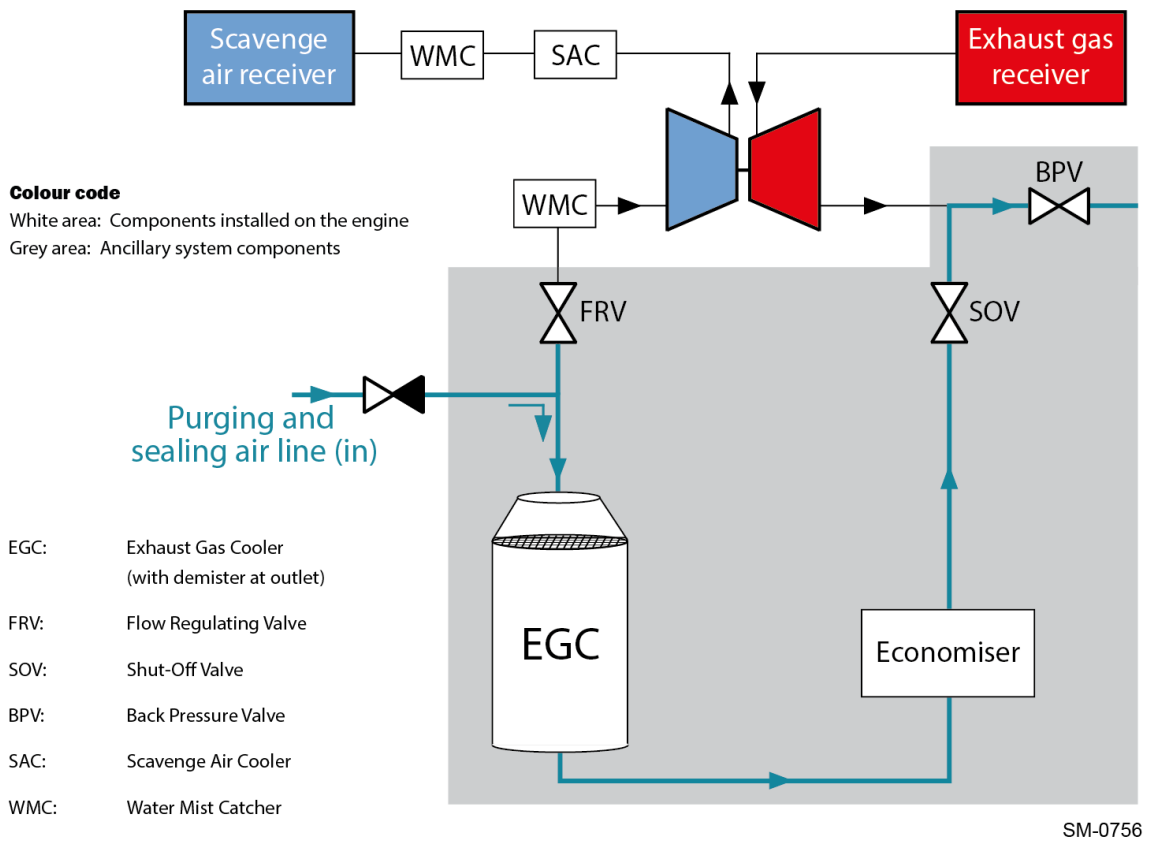


Figure 4-10: The iCER exhaust gas system with a single turbocharger showing the purging and sealing procedure

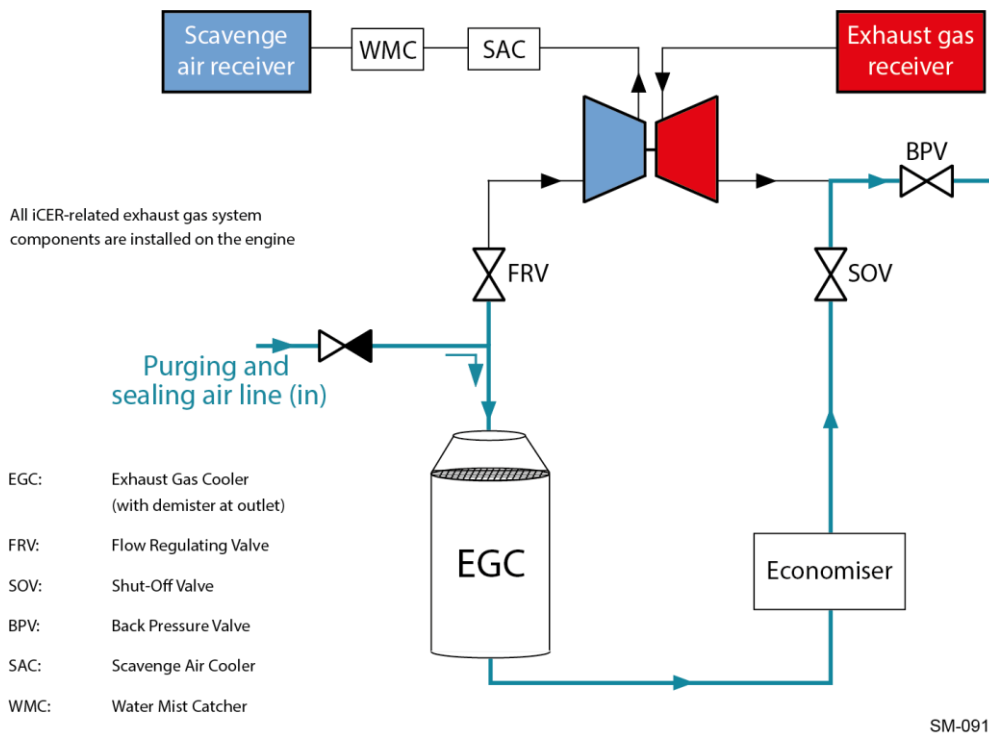


Figure 4-11: The iCER on-engine exhaust gas showing the purging and sealing procedure

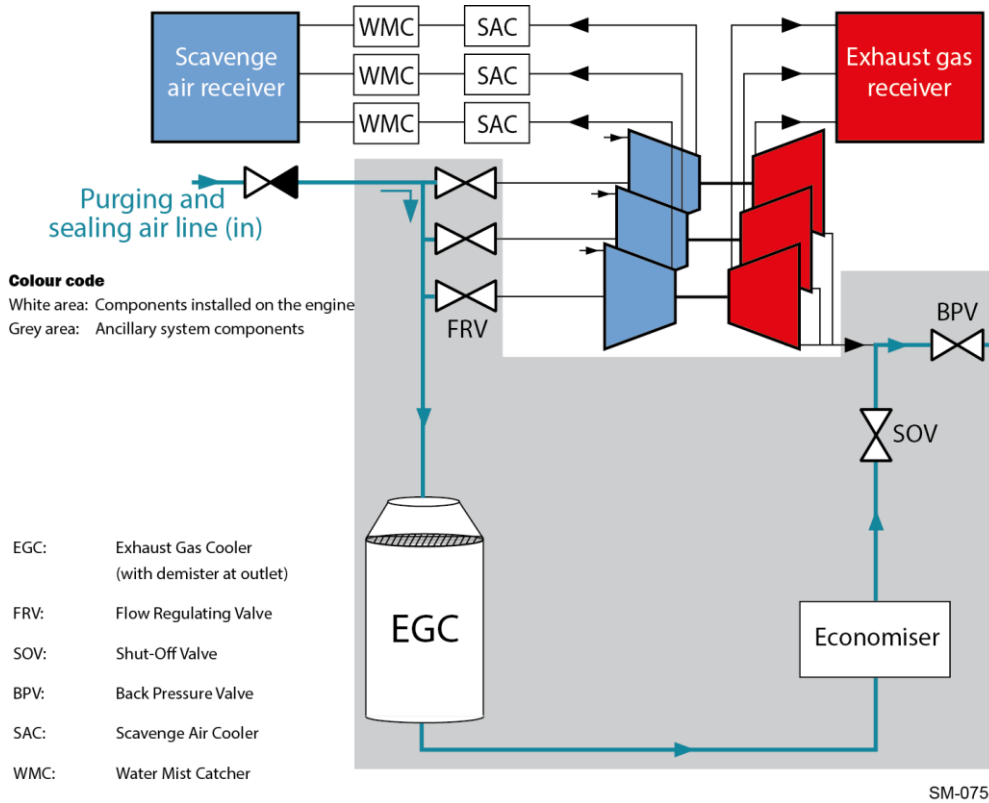


Figure 4-12: The iCER exhaust gas system (with a multi-turbocharger installation) showing the purging and sealing procedure

5 Electrical Interface

The electrical interface specification is provided by the WinGD EGR System Design document (see DG4010).

6 Functional Description of the EGC

The main function of the Exhaust Gas Cooler (EGC) is to cool the exhaust gas to a temperature set-point defined by the iCER control system (e.g. 3 °C below scavenge air temperature) and to guarantee a good engine performance.

6.1 Closed-loop mode of the EGC

The EGC gas outlet temperature is adjusted by the EGC control system. In the Engine Control System (ECS), the temperature set-point is defined. The iCER control system, which is connected and communicating with the EGC control system, then requests this temperature set-point and the EGC control system adjusts the EGC gas outlet temperature. The temperature set-point depends on the fuel type, the Contracted Maximum Continuous Rating (CMCR) power of the engine and the ambient conditions. For example, during gas mode at 100% CMCR power and under tropical conditions, the iCER control system will define a temperature set-point of 32 °C. The EGC uses the seawater control valve, the temperature control valve, and or the optional speed control of the EGC circulation water pump to regulate the exhaust gas temperature.

6.2 Cooling after deactivation of the iCER system

After deactivation of the iCER system, the EGC circulation water system must continue to spray into the EGC for a set period to ensure a proper cooling process of the EGC.

6.3 Cleaning of the EGC demister

The automatic cleaning of the demister is integrated into the EGC. The cleaning automatically starts after a defined period from the last cleaning and once the iCER system has been deactivated.

6.4 Monitoring of the exhaust gas temperature before the EGC outlet valve

The exhaust gas temperature at the EGC outlet valve must be monitored to prevent thermal damage of the turbocharger (compressor side). When the temperature exceeds the high limit of the pre-alarm, an alarm will be triggered. When the temperature exceeds the high limit of the alarm, the iCER system will be deactivated.

6.5 Monitoring of the EGC pressure drop

The exhaust gas pressure drop through the EGC is continually monitored. An excessive pressure drop may be due to an excessive EGC water level, which in turn may be due to a clogged drain or insufficient degassing.

7 Functional Description of the EGC Circulation Water System

7.1 Seawater pump

There are two solutions available:

- The main seawater capacity is adapted to cover the EGC circulation water cooling
- A separate seawater pump set is installed for circulation water cooling

7.2 EGC circulation water temperature control

The EGC cooling water temperature must follow the ECS temperature set-point. This can be achieved by two possible set-up solutions:

- Controlling the EGC circulation water temperature at the EGC circulation water cooler by means of a temperature control valve (see arrangement on left side of Figure 7-1)
- Controlling the seawater flow to the EGC circulation water cooler by means of a seawater flow control valve (see arrangement on right side of Figure 7-1)

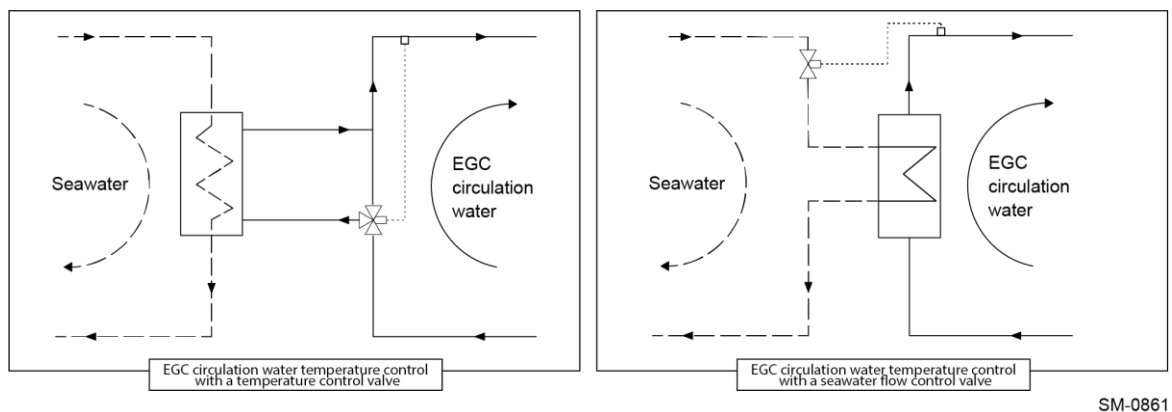


Figure 7-1: EGC circulation water temperature control with a temperature control valve (left side) or a seawater flow control valve (right side)

7.3 EGC circulation water pumps (with optional speed control)

The EGC water system includes redundant EGC circulation water pumps. These pumps supply the required amount of EGC circulation water to the EGC. The EGC circulation water pump capacity must be sufficient to achieve the ECS temperature set-point at all CMCR powers and ambient conditions, as defined by the GTD.

The EGC circulation water pumps are recommended to be equipped with a Variable Frequency Drive (VFD), enabling reduction of the energy consumption. The pump speed is adjusted according to the engine power output.

7.4 Monitoring of water inlet pressure of the EGC circulation water pumps

It is recommended to monitor the water inlet pressure of the EGC circulation water pump to prevent dry running of the pumps, and any resulting damages.

7.5 The EGC circulation water tank

The function of the EGC circulation water tank is to collect the condensate water from the EGC and to recirculate the clean water (refresh water) from the Water Treatment Unit (WTU).

The size of the EGC circulation water tank is provided by the EGC circulation water system supplier. The tank's size depends on this supplier and on the main engine size.

8 Functional Description of the Wastewater Holding Tank

During iCER operation different effluents are collected in the wastewater holding tank in preparation for the WTU(s). The wastewater holding tank collects the following:

- The SAC drain water
- The EGC circulation water overflowing from the EGC circulation water tank
- The drain water of the EGC cooling water circuit, when the iCER system is deactivated
- The return water from the WTU(s), when malfunctioning of the WTU(s) occurs (e.g. oil-in-water content exceeds the limit for the overboard discharge)

The description below refers to the latest unified design of the iCER drainage system introduced in April 2022. For further information, please see the iCER drainage system section of the MIM.

8.1 Volume calculation

To ensure a proper buffer capacity in case of malfunctioning of the Water Treatment System (WTS), a target filling level must be defined. The wastewater holding tank volume (V) can be calculated using the following formula:

$$V = \frac{\text{Max discharge rate}}{(100\% - \% \text{ target filling level})} \cdot 2 \text{ h} \cdot 110\%$$

Equation 8-1: Wastewater holding tank volume calculation

Equation 8-2 provides an example of a wastewater holding tank volume calculation which includes a target filling level of 30%:

$$= \frac{\text{Max discharge rate}}{(100\% - 30\%)} \cdot 2 \text{ h} \cdot 110\%$$

Equation 8-2: An example of the wastewater holding tank volume calculation

Where:

- *Max discharge rate* represents the maximum amount of effluents in the wastewater holding tank (SAC drain water and bleed-off water)
- *% target filling level* represents the maximum filling level of the wastewater holding tank. A target filling level of 30% is recommended for the volume calculation.
- *2 h* is a recommended time interval, the value may vary depending on the downtime of the WTS as specified by the certified supplier

In Equation 8-1, the 110% accounts for the return flow to the wastewater holding tank when the circulation pumps are stopped.

8.2 pH neutralisation

The effluents collected in the wastewater holding tank can have a low pH value. To adjust the pH of the effluents to a proper level (e.g. above pH 6), pH-monitoring and neutralisation are required (preferably using NaOH). To have an efficient pH-neutralisation process and to avoid alkaline overdosing, the direct alkaline dosing in the wastewater holding tank is not recommended.

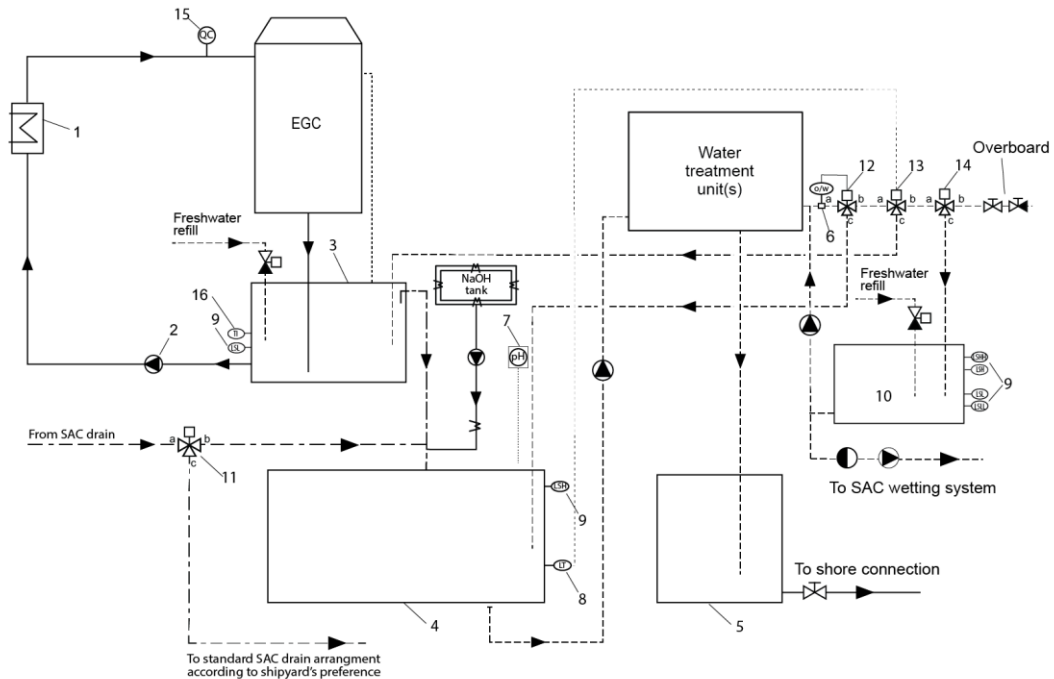
8.3 Water level measurement

The water level in the wastewater holding tank must always be kept at the target filling level of 30% to ensure sufficient buffer capacity (see Equation 8-1). The wastewater holding tank must be equipped with an analogue level transmitter. This controls the clean water refresh rate (see Figure 9-1 with the three-way valve, No. 13), which is recirculated from the WTU back to the EGC circulation water tank.

9 Functional Description of the Water Treatment System

The Water Treatment System (WTS) handles the effluents of the iCER drainage system. It includes the following parts:

- Pump unit
- The water treatment unit(s)
- The monitor and control unit



- | | | | | | | | | | | | | | |
|---|--|---|------------------------------|-------|------------------|-------|------------------------|-----------|---------------------------------|-------|---------------|-----------|-----------|
| <ol style="list-style-type: none"> 1 EGC circulation water cooler 2 EGC circulation water pumps (frequency controlled) 3 EGC circulation water tank 4 Wastewater holding tank 5 iCER sludge tank 6 Oil-in-water (o/w) monitoring sensor, standard type 7 Water analyser (pH) 8 Level transmitter 9 Low/High-level switch 10 Combined clean water holding tank and SAC wetting buffer tank 11 Engine-mounted and controlled three-way valve 12,13,14 Three-way valves 15 Water analyser (quality, not required if the WTS is continuously in operation) 16 Temperature Indicator | <table border="0"> <tr> <td>—</td> <td>EGC circulation water system</td> </tr> <tr> <td>- - -</td> <td>Bleed-off system</td> </tr> <tr> <td>.....</td> <td>Water treatment system</td> </tr> <tr> <td>- · - · -</td> <td>pH-neutralisation dosing system</td> </tr> <tr> <td>.....</td> <td>Venting pipes</td> </tr> <tr> <td>- - - - -</td> <td>SAC drain</td> </tr> </table> | — | EGC circulation water system | - - - | Bleed-off system | | Water treatment system | - · - · - | pH-neutralisation dosing system | | Venting pipes | - - - - - | SAC drain |
| — | EGC circulation water system | | | | | | | | | | | | |
| - - - | Bleed-off system | | | | | | | | | | | | |
| | Water treatment system | | | | | | | | | | | | |
| - · - · - | pH-neutralisation dosing system | | | | | | | | | | | | |
| | Venting pipes | | | | | | | | | | | | |
| - - - - - | SAC drain | | | | | | | | | | | | |

SM-0810

Figure 9-1: The unified iCER drainage system (on- and off-engine option)

The description below refers to the latest unified design introduced in April 2022. For further information, please see the iCER drainage system section of the MIM. The final layout may vary depending on the selected WTS supplier.

9.1 WTS capacity calculation

The theoretical estimation of the WTS capacity can be calculated using the following formula:

$$WTS_{capacity} = (SAC_{drain\ max}) + (m_{bleedoff}) + (m_{wetting}) + CWR$$

Equation 9-1: WTS capacity calculation

Where:

- $SAC_{drain\ max}$ represents the maximum amount of SAC drain water at 100% CMCR power and in tropical conditions. The values are available in the GTD.
- $m_{bleedoff}$ represents the maximum amount of bleed-off water at 100% CMCR power and in tropical conditions. The values are available in the GTD.
- $m_{wetting}$ represents the maximum amount of water used for wetting the SAC at 100% CMCR power
- Clean Water Recirculation (CWR) represents the recirculation rate of clean water from the WTU to the EGC circulation water tank. This is required to maintain a maximum solids content of 150 mg/l in the EGC circulation water. The minimum volume of the EGC circulation water tank must be considered for the calculation of the recirculation rate, and this volume must take into consideration the vessel trim and pitch.

9.2 Pump unit

The WTS includes redundant pumps to continuously supply the wastewater to the WTU.

9.3 The water treatment unit(s)

In the water treatment unit(s), the effluents from the wastewater holding tank are treated. The sludge is drained into the iCER sludge tank and clean water is directed to the outlet of the WTU. Below is a list of the available WTU types:

- Centrifugal
- Air floating
- SiC membrane

9.4 Monitor and control unit

The WTS includes the monitor and control unit. This unit provides information about the system status, errors, as well as parameters to the iCER control unit.

9.4.1 Oil-in-water monitoring sensor and valve unit

The oil-in-water (o/w) monitoring sensor and valve unit consists of multiple devices which must be installed in a specific order. These include the o/w monitoring sensor and changeover valve, the CWR valve, and the overboard changeover valve.

The o/w monitoring sensor must be MEPC 307(73) compliant and is used to continuously monitor the o/w content of the clean water downstream from the WTU (see Figure 9-1 with the o/w monitoring sensor, No. 6). This sensor is normally part of the WTS and is connected to the WTS monitoring and control unit. In case of malfunctioning of the WTS, where the o/w content exceeds 15 ppm, then the changeover valve must return the water to the wastewater holding tank (see Figure 9-1 with the three-way valve, No. 12). The buffer capacity of the wastewater holding tank is designed to store such water in the event of a WTS malfunction.

The CWR valve is an analogue controlled three-way valve which regulates the clean water refresh rate, based on the water Level Transmitter (LT) in the wastewater holding tank (see Figure 9-1 with the with the three-way valve, No. 12 and LT, No. 8). In case of failure, the manual operation function of the CWR valve must be available.

The following control logic must be implemented by the WTS supplier and/or shipyard:

- If the wastewater holding tank level decreases, then the CWR valve is activated. The flow rate to the EGC circulation water tank will increase and the overboard discharge rate will decrease.
- If the wastewater holding tank level increases, then the CWR valve is activated. The flow rate to the EGC circulation water tank will decrease and the overboard discharge rate will increase.

Depending on the vessel's position, the clean water can either be directly discharged overboard

(e.g. when the vessel is operating outside an area of restricted discharge) or stored in the clean water holding tank (e.g. when the vessel is operating inside an area of restricted discharge). This is achieved by means of an overboard changeover valve (see Figure 9-1 with the three-way valve, No. 14). If connected to a positioning tracking system, this valve can be automatically operated. Otherwise, this valve can be manually operated.

9.4.2 Freshwater refill valve

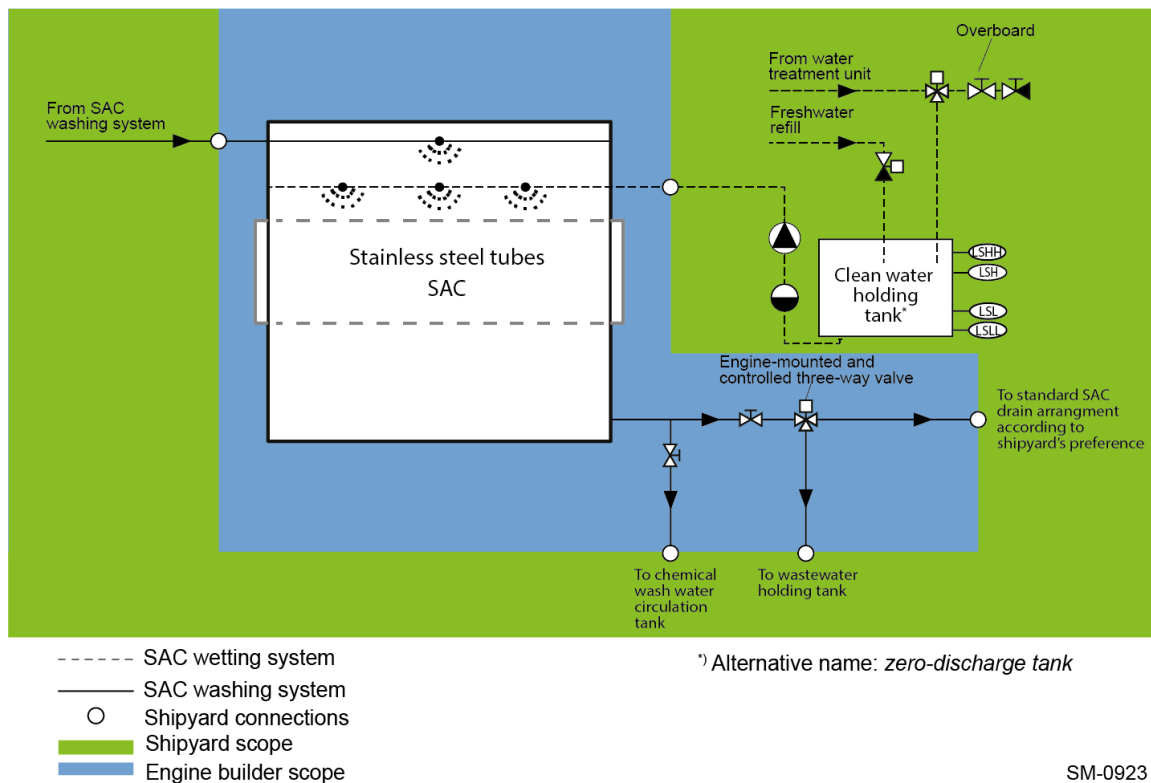
A freshwater refill valve must be connected to the EGC circulation water tank. This valve is used for the initial EGC circulation water tank filling, as well as for refilling after maintenance.

10 SAC Wetting System

Since particulate matter and oil cannot be fully removed from exhaust gas as it passes from the EGC through the SAC, part of it tends to accumulate on the SAC, leading to fouling over time. Deposits reduce the SAC thermal efficiency and increase the pressure drop over the SAC, potentially affecting engine operation. In principle, a cleaner SAC leads to lower engine fuel consumption. To help prevent fouling, a wetting system is implemented.

10.1 System arrangement

As shown in Figure 10-1, treated water from the clean water holding tank is directed to the upper part of the SAC and sprayed to keep the active cooling surfaces wet. This significantly reduces accumulation of particulate matter, ash, and oil on the active cooling surfaces of the SAC. For projects without a clean water holding tank, a dedicated SAC wetting buffer tank is required as shown in Figure 10-2.



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Figure 10-1: The SAC wetting system with the clean water holding tank arrangement

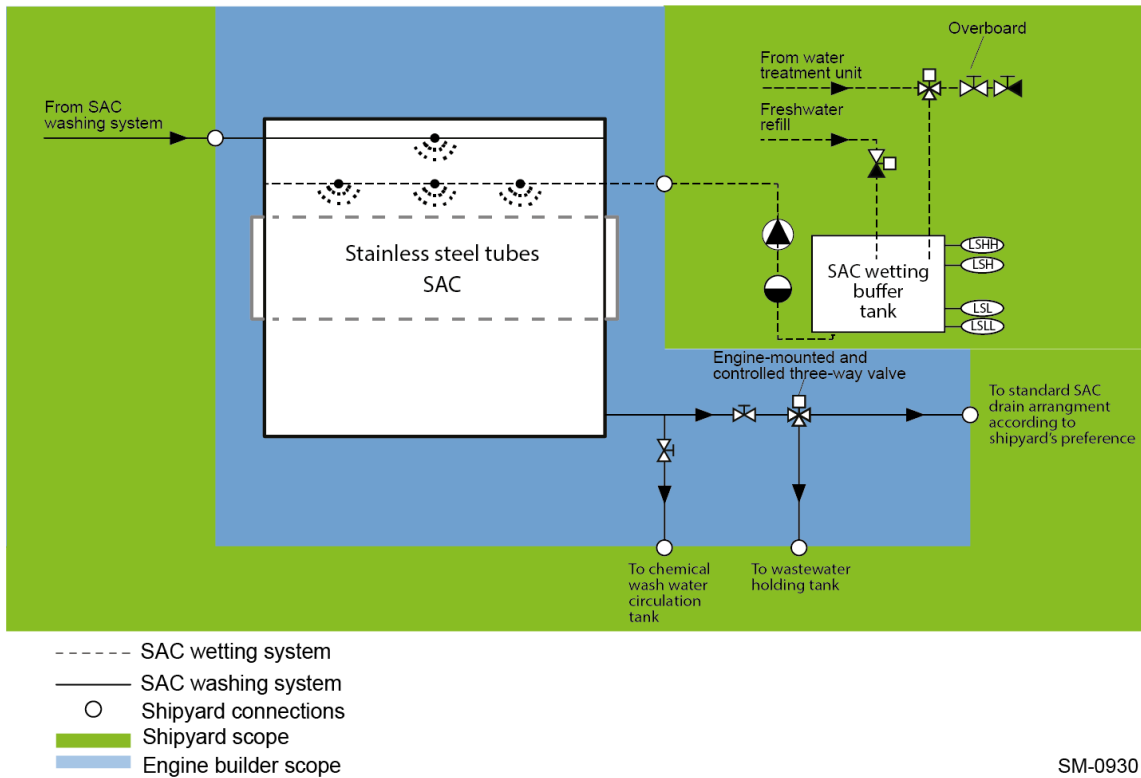


Figure 10-2: The SAC wetting system with the SAC wetting buffer tank arrangement

10.2 Functional description

The SAC wetting system is controlled by an SAC wetting control unit. The ECS communicates with this control unit, commanding when wetting starts and stops.

For systems with the clean water holding tank arrangement, the water from the WTS is directed to the clean water holding tank by means of a three-way valve. In case the minimum tank level is reached, the three-way valve directs the water to the clean water holding tank. Otherwise, overboard discharge depends on the ship's operating area.

For systems with an SAC wetting buffer tank, an additional Level Switch High-High (LSHH) sensor is installed on the buffer tank (see Figure 10-2). This sensor is required to control the three-way valve to keep the tank full while the WTS is running.

From the clean water holding tank or the SAC wetting buffer tank, the water is sprayed onto the active cooling surfaces of the SAC by means of a wetting water pump. In case of a Level Switch Low-Low (LSLL) detection, an emergency stop is initiated to prevent the pump from running dry.

In addition to the SAC wetting system, an optional SAC washing system can be applied to ensure thorough cleaning during engine standstill.

10.3 SAC wetting buffer tank capacity calculation

10.3.1 For iCER installation design with continuous WTU operation

The downtime of the WTU (i.e. time, including the offline time for backflushing and sludge discharge) must be considered. In general, the following downtimes of different WTU types can be applied:

- Dissolved Air Floating (DAF) type: 5 to 15 minutes approximately every 8 hours
- Silicon Carbide (SiC) membrane type: 5 to 15 minutes approximately every 3 hours
- Centrifugal type: 1 hour approximately every 5 hours

Calculation example for the minimum wetting water capacity $[V_{min}]$ required for continuous SAC wetting, example data from main engine design with DAF type WTU:

- Maximum technically required WTU downtime $[T_{stop}]$: 20 minutes (including 5 minutes margin)
- Total wetting system water flowrate $[Q_{wetting}]$: 1.0 m³/h (16.67 ℓ/min)

Calculation:

$$V_{min} = T_{stop} * Q_{wetting} = 20 \text{ min} * 16.67 \text{ ℓ/min} = 333 \text{ ℓ}$$

For installations with an SAC wetting buffer tank, the buffer tank volume $[V_{bufferTK}]$ must be a minimum of three times the size of the required water capacity. This is because the target filling range of the SAC wetting buffer tank is one-third to two-thirds of the total tank capacity.

$$V_{bufferTK} = V_{min} * 3 = 1,000 \text{ ℓ}$$

10.3.2 For iCER installation design with discontinuous WTU operation

For discontinuous WTU operation, an operational pause is used in the calculation instead of the WTU-related downtime $[T_{stop}]$ presented in section 10.3.1. This pause can be selected if the WTU capacity has sufficient margin to maintain the required water quality without operating continuously.

Calculation example for the minimum wetting water capacity $[V_{min}]$ required for continuous SAC wetting with discontinuous WTU operation:

- Maximum selected pause time of the WTU $[T_{stop}]$: 60 minutes
- Total wetting system water flowrate $[Q_{wetting}]$: 1.0 m³/h (16.67 ℓ/min)

Calculation:

$$V_{min} = T_{stop} * Q_{wetting} = 60 \text{ min} * 16.67 \text{ ℓ/min} = 1,000 \text{ ℓ}$$

As in section 10.3.1, the buffer tank volume $[V_{bufferTK}]$ must be a minimum of three times the size of the required water capacity.

$$V_{bufferTK} = V_{min} * 3 = 3,000 \text{ ℓ}$$

10.4 SAC wetting pump layout calculation

The SAC wetting pump layout must consider at least 20% flow margin to allow flow control, i.e. the value, as provided in the MIDS system drawing as engine inlet value, must be increased by at least 20%. The pump delivery head must cover the static height difference between the tank and the engine inlet as well as the pressure losses in the piping system. An additional fouling margin of 2.0 bar must be added.