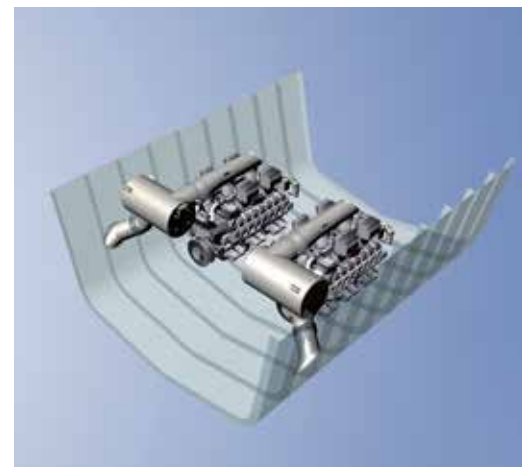
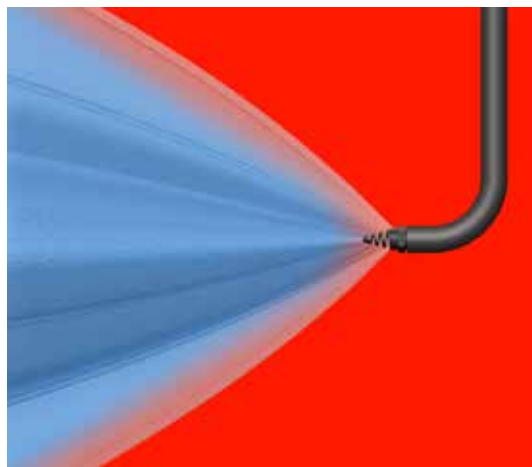
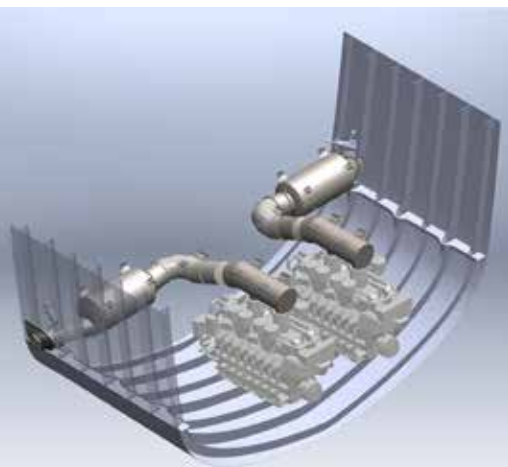


# mecmar

complete exhaust gas systems for marine diesel engines and gas turbines



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## A Pioneer of Engineering

*“Mecmar is a groundbreaking engineering solutions, based on known scientific principles, in the marine diesel engine exhaust gas management field.”*

Mecmar develops and delivers solutions reflecting the combinations of maritime tradition, modern technology, superior workmanship and environmental sensibility.

The company principle to take on the challenge of being first in engineering solution applications in our selected field has placed Mecmar at the forefront of stealth solutions in naval vessels and in pollution reduction in all maritime applications through Exhaust Gas Treatment after combustion.

To retain the winning edge in Marine Exhaust Systems the highly skilled staff of Mecmar typically covers the following disciplines from design to final delivery:

- Mechanical Engineering
- Marine Engineering
- Naval Architecture
- Project Management
- Logistics Engineering and
- Quality Management

## Documentation and Quality Management

*“Mecmar is committed to achieve product delivery through a structured, auditable process. This approach ensures design and production-traceability, complete with well documented installation, commissioning and through life support data.”*

Mecmar conforms to ISO 9001

Depending on customer requirement Mecmar can deliver the following documentation:

- Computational Fluid Dynamics (CFD) analysis
- Back Pressure analysis
- Shock and Vibration analysis
- Weight data
- Attenuation Calculations
- Installation Documentation
- Commissioning Procedures
- Drawings and Parts Lists
- Installation Checkout procedures



## Innovative Technology – Optimal Performance

*“Mecmar is focused on long term performance in the marine market sector through reliable, state of the art yet simple and practical exhaust system designs with maximum benefits to the client.”*

Mecmar’s strategy is to offer the Marine market complete exhaust gas systems based on well known principles proven on smaller vessels and pleasure crafts. Experience has shown that these systems could be scaled, adapted and developed to match the power range and operational conditions applicable to commercial and naval vessels.

Our exhaust system technology growth and increasing demand for new deliveries bears testimony to the success of this approach.

Furthermore, we provide our customers with:

- Quality engineering activities based on cutting edge technology.
- Products and systems displaying quality workmanship to the highest standard.
- Delivery of reliable and cost effective solutions.
- Interactive co-operation to ensure a full understanding of the requirements to shape the solution.
- A full range of support during installation, commissioning and testing where required.
- Complete in-service engineering support to build lasting partnerships in order to maintain our fielded systems.

## Continued Growth – Research and Development

*“Mecmar’s growth is vested in continued investment in product development to track emerging technologies in pace with client and statutory demand.”*

In the quest for pioneering solutions based on proven applied technologies Mecmar invested in a development test installation.

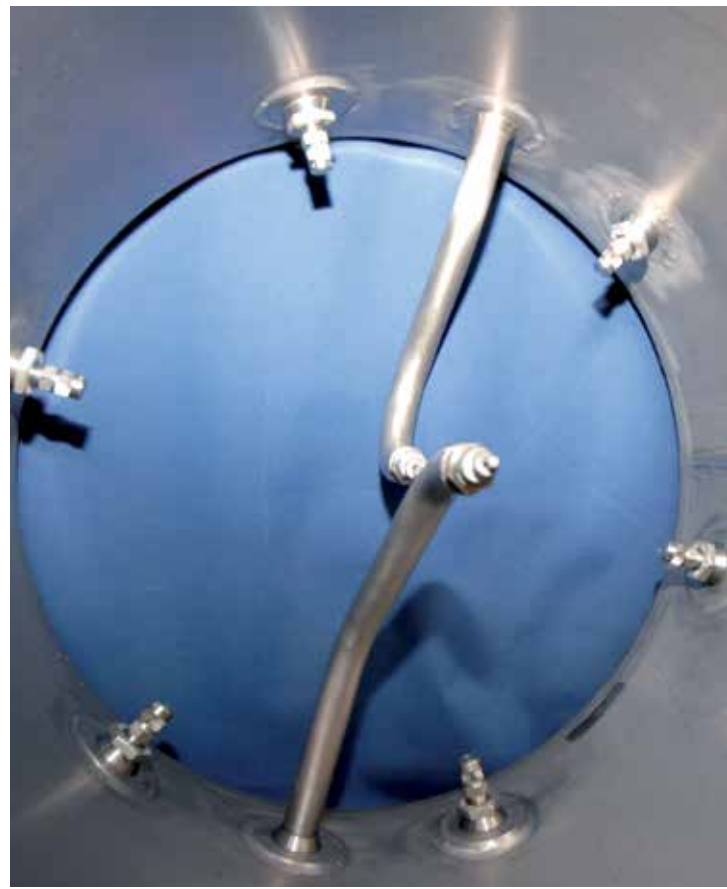
Our test stand is fully calibrated and is used for developing Mecmar exhaust gas system technology. The test stand consists of a 735 kW engine installation. The engine has a hydraulic brake to dissipate the engine power and purpose built exhaust gas systems can be fitted for test and qualification purposes.

The installation is used to verify new product concepts such as Nitrous Oxide (NOx)-, Sulphur Oxide (SOx)-, particle- and noisereduction.

The latest development project involves direct injection of ammonia into the exhaust gas stream to refine the Selective Catalytic Reduction (SCR) application in Marine Diesel Exhaust Systems.



– a pioneer of engineering



# Customised Solutions

*Mecmar supplies complete customized exhaust gas systems optimally designed for specific engine installations in each vessel*

*Since 1994, the Company has delivered more than 500 systems world-wide for various types of vessels such as high speed catamarans, monohull vessels, car ferries and offshore petroleum installations as well as naval vessels.*

## Exhaust Gas Systems for Marine Diesel Engines and Marine Gas Turbines

Mecmar will produce an exhaust system to suit the client's requirements. Initially the systems used a unique solution to inject sea water into the exhaust gas stream. The technology and material selection incorporated in the solution were developed and refined to meet the extremely challenging environment of heat, salt, corrosive exhaust gas products and the limited space onboard most vessels to integrate bulky exhaust systems.

The Marine Industry, with all types of vessels it employs, is a significant contributor to

environmental pollution. Essentially the engine manufacturers have economically optimised the ability to burn fuel more efficiently and cleaner.

Ever increasing limits on exhaust pollutants is driving the Marine Industry in the same direction as it did the road vehicle industry, i.e. the use of post combustion treatment of the exhaust gas to meet the requirements for a cleaner environment.

During the last decade developments in energy conservation, increased sensitivity to, and subsequent legislation in terms of carbon footprints and pollution constraints, provided ever increasing challenges to engineers and industrial developments.

True to the pioneering spirit of Mecmar, new ways of improving the benefits of the proven Sea Water injection Exhaust Systems in Marine Applications are constantly sought.

To this end the Mecmar Exhaust System solutions now incorporate the following options:

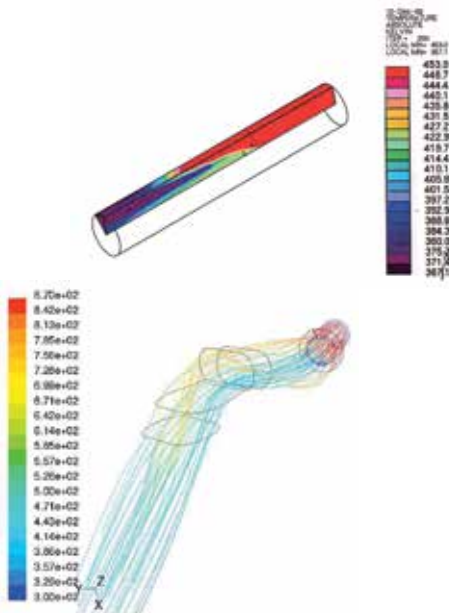
- Standard Sea Water Injection.
- Integrated Selective Catalytic Reduction with the standard system.
- Integrated Exhaust Gas Economisers with either or both the previous two options.



## The Benefits of Sea Water Injection

The basic exhaust gas systems supplied by Mecmar are characterised by injection of sea water into the exhaust gas. Seawater is used to cool the exhaust gas, for reducing emission of harmful components to the atmosphere and to increase safety onboard the vessels. Further, as a consequence of cooling the exhaust gas, the volume of the exhaust gas to be handled is considerably reduced, and hence the systems are more compact and lighter when compared to conventional exhaust gas systems.

In the military application it also enhances the stealth characteristics of the vessel.



## Pollutant Emission Reduction

Although not the only means to do so, introducing sea water into the exhaust stream reduces air pollution to a fractional component of that from conventional dry exhaust gas emissions.

Measurements performed and observations made on in service exhaust gas systems delivered by Mecmar indicate typically the following reduction emission to the atmosphere through water injection alone:

- Sulphur Oxides (Sox) 90-95 %
- Aldehydes 60-70 %
- Aromatic Hydrocarbons 30-50 %
- Nitrous Oxides (NOx) 6-10 %
- Particles considerable



## Safety

Low surface temperature in the exhaust gas system has removed a possible ignition source in case of an oil or fuel leakage, and hence the danger of fire and explosion is reduced. In addition, crew safety is enhanced due to more benign surface temperatures in the engine room area.



## System Integration

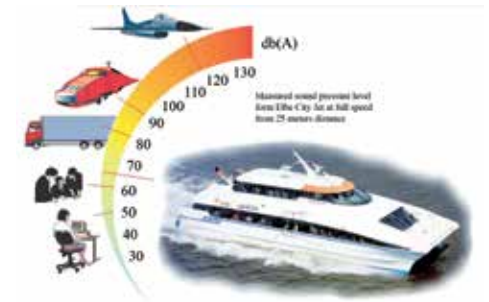
The cooled Exhaust Gas has a significantly lower volume compared to conventional dry systems. The nett effect is that the piping systems and other components downstream from the seawater injection point is more compact and light, with a commensurate space, weight and cost saving to the shipbuilder.

The Mecmar systems are also characterised by the fact that the outlets are above or below the waterline through the ship's side or transom. This feature removes the need for space hungry exhaust trunking through the superstructure, freeing up internal space in the vessel and allowing superior all round visibility from the bridge and command positions.



## Installation

Mecmar supplies the systems complete and ready for installation with all the necessary components. The high degree of completion leads to shorter installation time and better installation economy for the shipbuilder. Furthermore, the low weight of components leads to easier transportation and handling during installation.



## Material Selection

In the hot area of the exhaust system before sea water injection Stainless Steel Alloys are used.

Due to its excellent corrosion resistance, low weight, high elasticity and good fatigue strength a titanium alloy is used in the sea water cooled parts of the exhaust gas system. The use of materials with good fatigue and anticorrosion

properties ensures that the lifetime of a Mecmar system exceeds a conventional full temperature system.



# Exhaust gas system for marine diesel and gas turbines

## Marine Diesel Engine Installations

A typical exhaust gas system delivered by Mecmar for a Diesel Engine Installation comprises the following main assemblies:

- Primary Silencer and Inlet Pipes
- Seawater Supply System and Pump
- Sea Water Injectors, Primary and Secondary
- Main Silencer
- Outlet Pipes
- Drainage System
- Flexible Bulkhead and Hull Penetrators
- Compensators
- Flexible Supporting Elements
- Temperature and Pressure Sensors
- Control and Monitoring System
- Reduction Agent Injection System (optional)
- SCR Unit (optional)
- Integrated SCR Control System (optional)
- Economiser or Waste Heat Boiler (optional)

The exhaust gas is led from each turbo charger through insulated inlet pipes to the primary silencer designed as a single chamber reflection muffler. In this part of the system, the exhaust gas is at high temperature. Where the SCR option is included the SCR Reactor replaces the primary silencer.

Downstream from the primary silencer, in the primary injector, sea water is injected through several nozzles into the exhaust gas, and the exhaust gas is quenched to approximately 60°C.

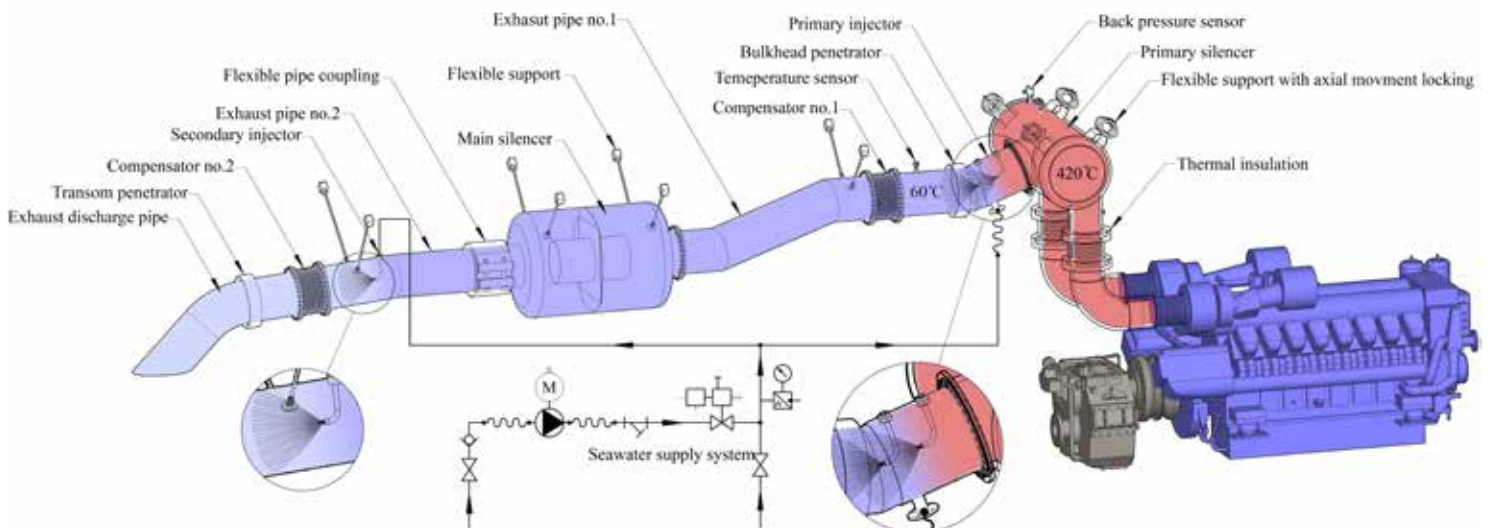
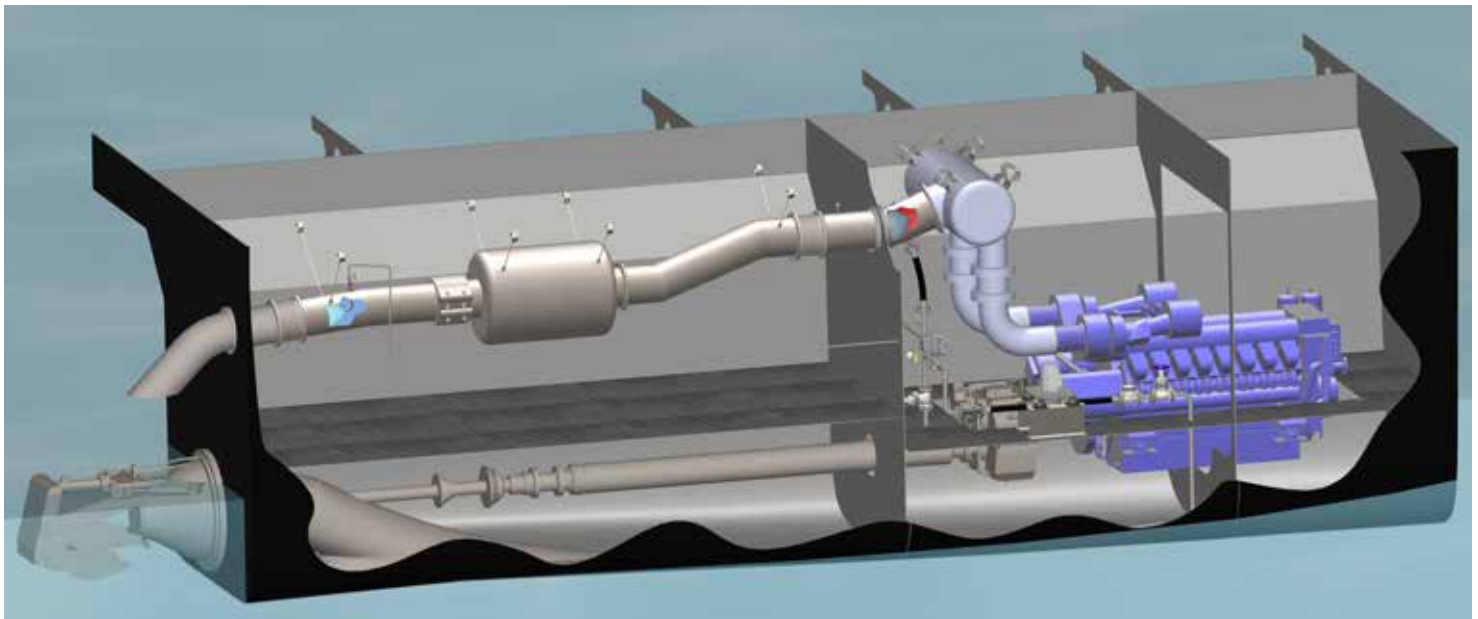
The main silencer attenuates the acoustic noise and leads the cooled exhaust gas from the primary injector to the outlet pipes. A secondary injector is normally installed downstream of the main silencer for the final cooling stage and to scrub particles from the exhaust gas.

Residual water droplets that are not entrained in the exhaust gas through the main silencer are collected and the surplus water is drained and lead overboard by the exhaust piping.

Downstream from the main silencer the exhaust gas is routed overboard through the outlet pipe either to the ships side or through a transom outlet, depending on the engine configuration.

Where the SCR option is selected by the client, the SCR Reactor acts as a primary silencer as well as facilitating the catalytic reaction and is incorporated in the exhaust line before the Main Silencer. With this option there will be a reducing agent injection and mixing device included between the Engine manifold and the SCR Reactor.

Where the Waste Heat Boiler is selected it is integrated into the hot section of the line to maximize the benefit. The boiler has a cooling effect on the gas and therefore reduces the amount of heat to be extracted by the sea water injection process.



## Gas Turbine Installations

As for the Diesel Engines, the sea water injection principle is equally applicable to Gas Turbine installations and Mecmar has successfully delivered exhaust systems for the luxury motor yacht market as well as for the military market.

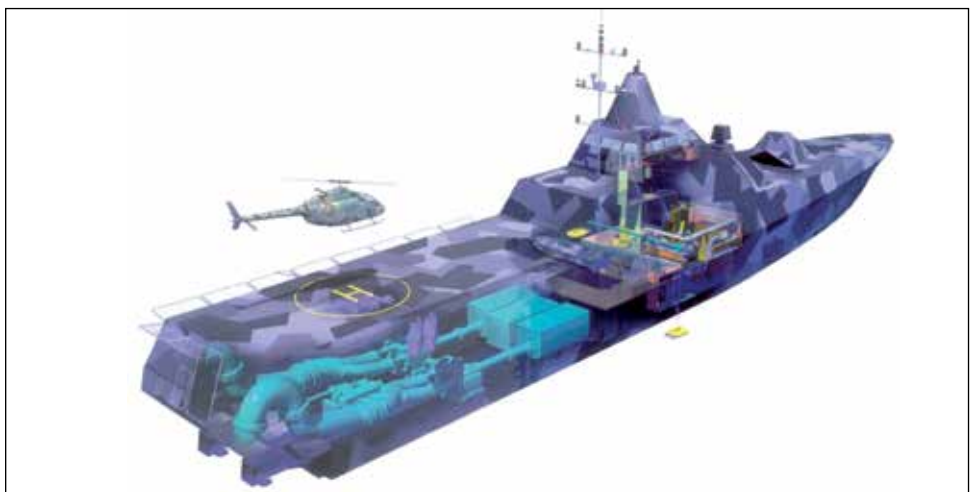
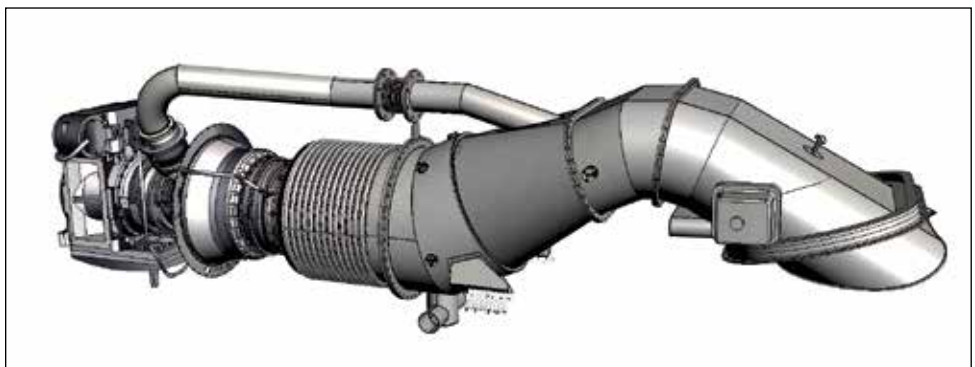
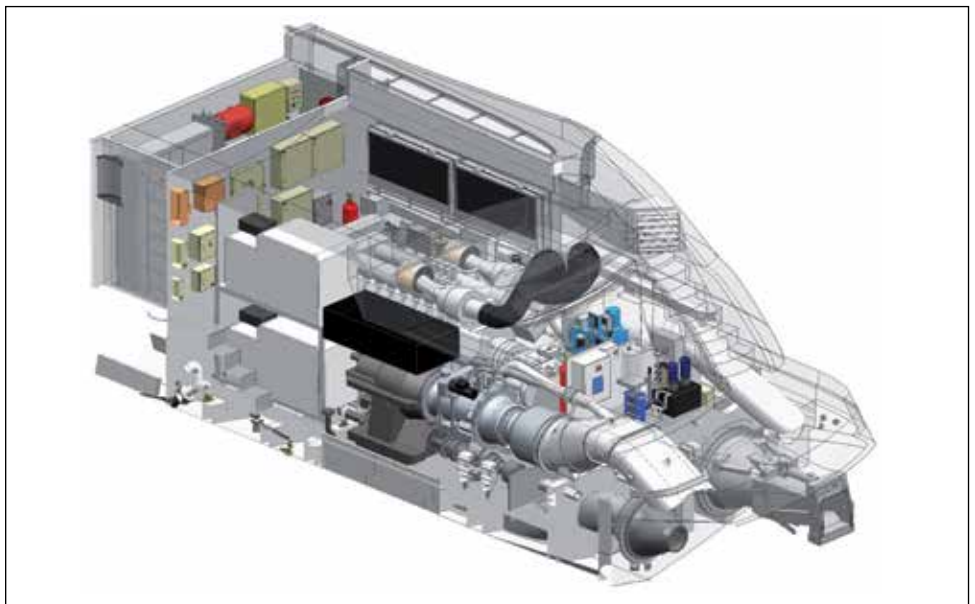
Seawater may be injected immediately downstream from the diffuser/compensator outlet of the Gas Turbine. Performance results achieved to date are similar to that of the Diesel Engine installations.

The control and monitoring principles are similar and the same logic is used in the Gas Turbine applications.

The system also uses two-stage injection. The main difference in the Gas Turbine application is the absence of the silencers, otherwise the mountings, exhaust pipes and ancillary equipment are of the same type.

The functional and system description is therefore the same for the Diesel Engine and Gas Turbine application. Due to the power of the Gas Turbine installation the volume of exhaust gas and therefore the volume of water injected obviously varies and the pumps, piping and size of exhaust piping and ducting is much larger in order to handle the respective volume flows.

The SCR technology and waste heat boiler options have not yet been incorporated into the Gas Turbine exhaust system solutions.



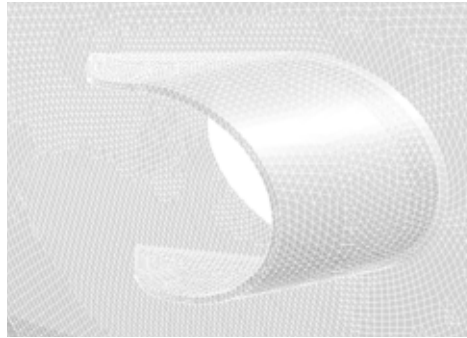
# Computational Fluid Dynamics (CFD) analysis

## Cap

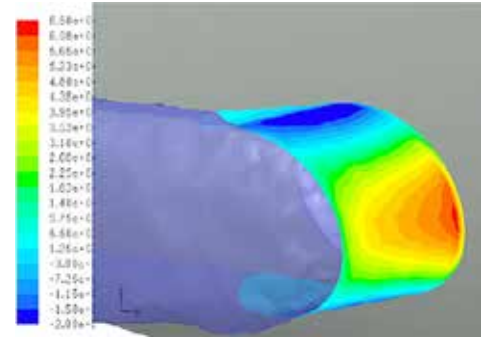
In order to reduce the total back pressure in the exhaust gas system during normal operation, cap is installed on the underwater exhaust gas system outlet.

This component is a fairing device for protecting the exhaust gas discharge outlet to be influenced by sea slamming towards the ship's side during operation. While the vessel is sailing, the sea water flows around the cup which influences on total back pressure reduction.

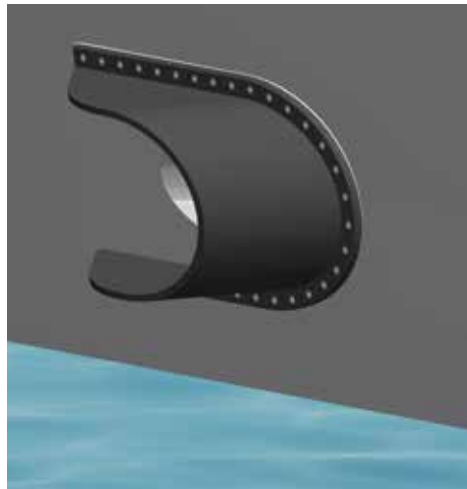
The cap is bolted to the ship's side onto a dedicated flange surface which is an integral part of the lower hull penetration. This component is manufactured in Polyurethane Shore 90 A. The design of the cap is rugged yet flexible and capable of withstanding extreme deflection without being damaged.



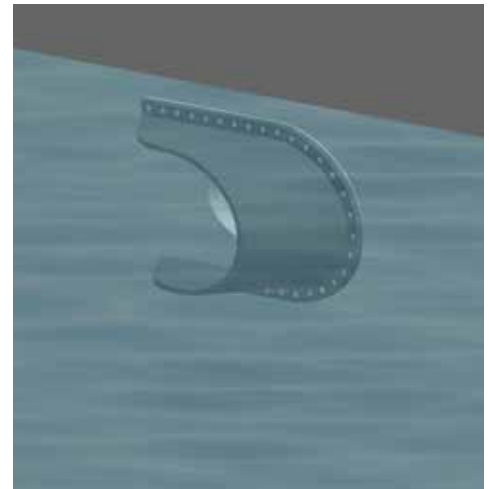
Surface mesh on hull/cap



Pressure contours on cap exterior surfaces



3D model of cap installed above waterline on a ship's side



3D model of cap installed below waterline on a ship's side

## Back Pressure and acoustics

For all exhaust system, a compromise between size and backpressure is necessary. Furthermore, the engine room makes constraints on the exhaust system design. Mecmar uses seawater injection to minimize system size, while at the same time maintaining a low total backpressure for the engines. For engine room requiring no-standard exhaust system layouts; Mecmar employs CFD and acoustics analysis to verify that the design meets requested performance.



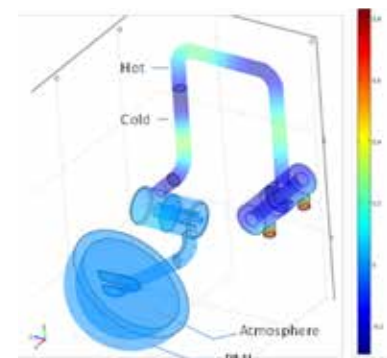
Photo of caps installed on a ship's side



Flow pathlines through the exhaust gas system and colored by temperature



3D Model of complete exhaust gas system



Representation of exhaust gas systems for acoustics analysis. Volumes with different acoustic properties are indicated