TURBOMED

PROTOPOROS MARINE TURBO INC.

Type Approval Certificate No 15/00096 Lloyd's Register

TM 180 & TM87

MADE IN HELLAS

Add value to your vessel now!

T/C Retrofit for high speed and low fuel consumption

TURBO-GENIUS™ SOFTWARE TOOL

NEW TURBOCHARGER RETROFIT SOLUTIONS

for Propulsion and Generator Engines

Daihatsu, Yanmar, Mitsubishi, Wartsila, MAN-B&W

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Turbocharger Solutions for Propulsion and Generator Engines

The reason of turbocharging an engine is the increase of output power. Despite the differences between propulsion and generator systems, the purpose is similar: reaching the desired output power in such a manner that covers the application needs in a safe and optimum way.

Generally, the efficiency of a diesel engine decreases over time. This fact forces the engine to waste more fuel in order to reach the desired operating point. Moreover, an old turbocharger model makes the efficiency of the engine – turbocharger (T/C) system even worse, leading to harmful consequences such as high temperature levels, heavy smoke emissions and increased soot formation on engine components. The aforementioned reduce the life time of critical engine's components (ex. exhaust valves, piston rings, piston head) leading to very frequent replacements of engine or T/C components. Furthermore, over the years, there is a limited availability of spare parts for old T/C models. Thus, the overall maintenance cost is higher. Eventually, the long term poor performance of the diesel engine increases the possibility of a fatal T/C breakdown which is apparently not cost efficient due to vessel's frozen operating state and idle time for retrofit. Consequently, it is clear that leaving your engine with an old T/C model increases the overall maintenance and operating costs, while the root of the problem (old T/C with low efficiency) is not solved.

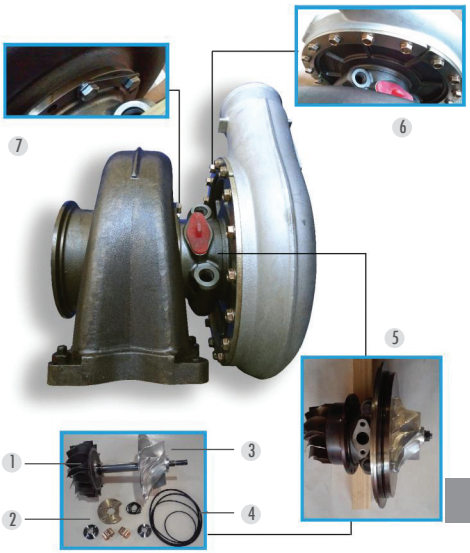
Retrofit offer benefits like:

- Extension of time between T/C overhauls
- Extension of time between replacement of main engine components
- Reduction of SFOC due to higher efficiency of the new T/C leading to significant savings on operating costs
- Higher efficiency of the new matched T/C leads to more charge air to the engine and combustion becomes more efficient with reduced particulate emissions
- Lower exhaust gas temperatures

TURBOMED S.A. invests in specialized scientific personnel and develops in house simulation tools continuing the superior Hellenic naval tradition.

TM87-X New Retrofit Solution

for Daihatsu, Yanmar, Mitsubishi, Wartsila, MAN-B&W D/G



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TM87-X
Features and Advantages

Overall cost efficiency

Water cooled casing

High strength compressor manufactured

Lower maintenance cost due to demand of less spare parts

Effortless installation and maintenance even by non-specialized crew members

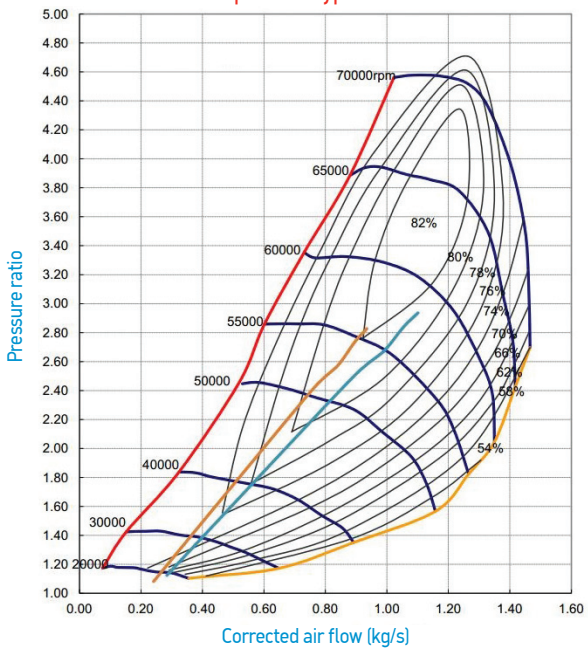
Lower exhaust gas temperatures due to the absence of nozzle ring

2 years warranty/10.000 hours of operation

1. TURBINE SHAFT
2. FLOATING JOURNAL BEARINGS
   - THRUST BEARING
   - THRUST PLATES
3. COMPRESSOR WHEEL
4. O-RINGS
5. CATRIDGE COMPLETE
6. COMPRESSOR HOUSING
7. TURBINE HOUSING

Compressor map and estimated pressures

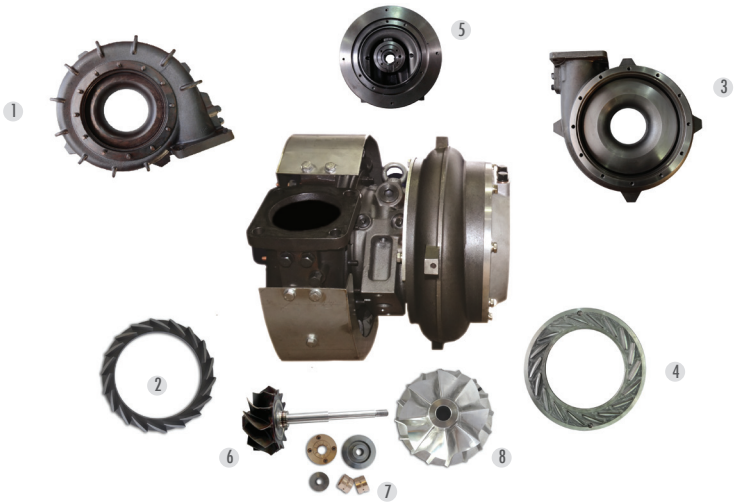
Compressor type TM87-X



MODEL	Air flow rate (Kg/S)		Matching Power (kW)	Maximum Pressure Ratio	Maximum Efficiency factor n[%]
TM87-X	Π=1.2	Π=4.5	350 - 600	4.5	82
	0.1 - 0.35	1.0 - 1.35			

TM180 New Retrofit Solution

for Daihatsu, Yanmar, Mitsubishi, Wartsila, MAN-B&W D/G



TM180 Features and Advantages

Type Approval Certificate
No 15/00096

Lloyd's Register

Overall cost efficiency

Lower maintenance cost
due to demand of less spare parts

High strength compressor manufactured

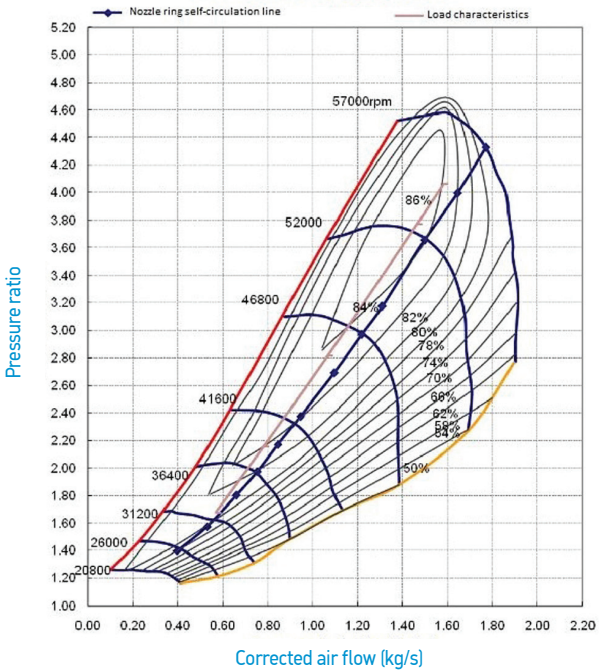
Effortless installation and maintenance
even by non-specialized crew members

2 years warranty/10.000 hours of operation

1. TURBINE HOUSING
2. NOZZLE RING
3. COMPRESSOR HOUSING
4. DIFFUSER
5. CATRIDGE
6. TURBINE SHAFT
7. FLOATING JOURNAL BEARINGS
   - THRUST BEARING
   - THRUST PLATES
8. COMPRESSOR WHEEL

Compressor map and estimated pressures

Compressor type TM180



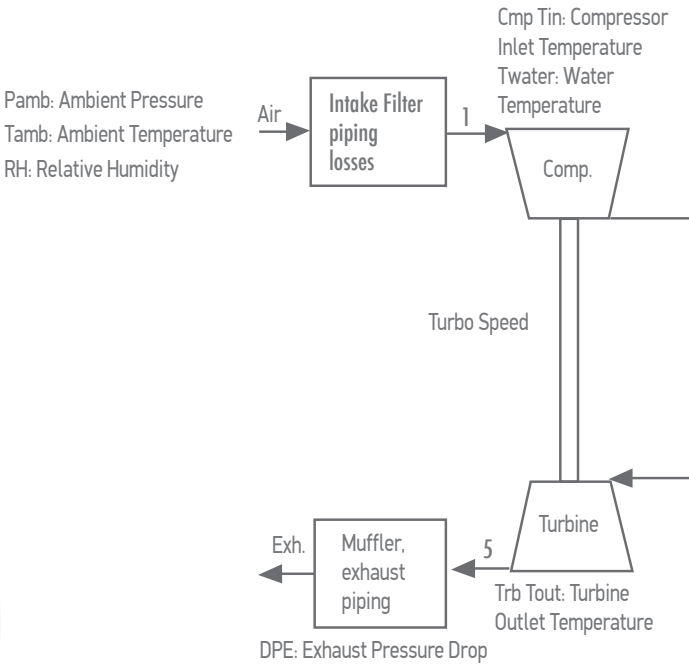
MODEL	Air flow rate (Kg/S)		Matching Power (kW)	Maximum Pressure Ratio	Maximum Efficiency factor n[%]
TM180	Π=1.2	Π=4.5	600 -1100	4.5	86
	0.1 - 0.35	1.3 - 1.7			

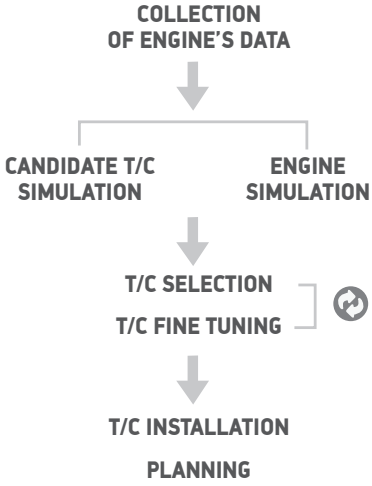
Retrofit Process

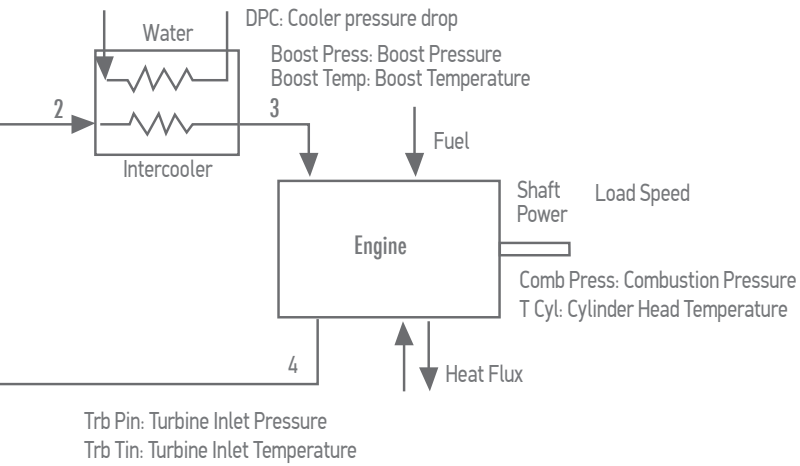
When a client requires a retrofit solution, a series of steps are necessary before a suggestion can be recommended. The main parameters of the engine and the operating conditions drive the T/C selection. Therefore, for the specific engine a list of candidate T/C solutions is considered. The next step of methodology is the simulation of the engine with these possible T/C solutions. The inappropriate turbochargers are excluded and a fine tuning on the selected T/C is performed. Finally, the modification work that may be needed is carefully planned, based on the engine layout restrictions and optimum aerodynamic performance.

Turbo-genius™ Simulation Tool

A complex simulation is required, when conducting a study regarding the variation of engine's performance after T/C replacement. For this reason, the company has developed a Hellenic in-house simulation tool in cooperation with NTUA (National Technical University of Athens). The components of this system are as follows:




COLLECTION
OF ENGINE'S DATA
CANDIDATE T/C
SIMULATION
ENGINE
SIMULATION
T/C SELECTION
T/C FINE TUNING
T/C INSTALLATION
PLANNING

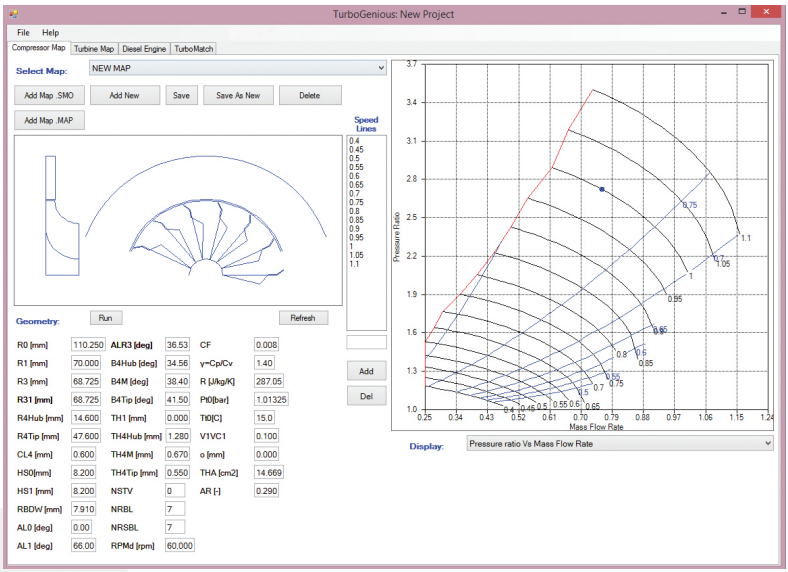

Water
DPC: Cooler pressure drop
Boost Press: Boost Pressure
Boost Temp: Boost Temperature
2
3
Intercooler
Fuel
Engine
Shaft
Power
Load Speed
Comb Press: Combustion Pressure
T Cyl: Cylinder Head Temperature
4
Heat Flux
Trb Pin: Turbine Inlet Pressure
Trb Tin: Turbine Inlet Temperature

Engine:

The main parameters of the engine such as bore, stroke, rotational speed etc. are the inputs of this component. These are defined from the manuals of the manufacturer and sea (or) shop trials.

Compressor:

The geometrical characteristics of the compressor are used for estimation of performance maps, or digitizing the existing ones from the manufacturer (if available).

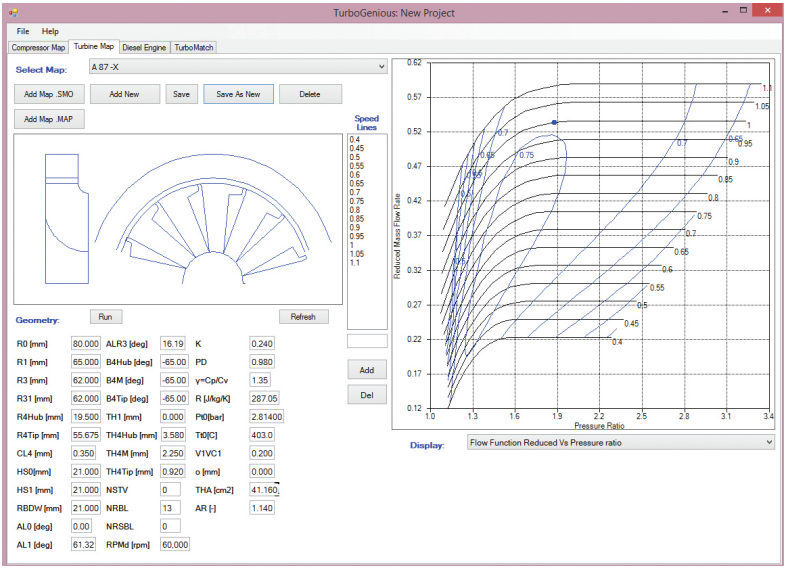


Turbine:

The geometrical characteristics of the turbine wheel are used for estimation of its performance maps in order to complete the turbocharger's model.

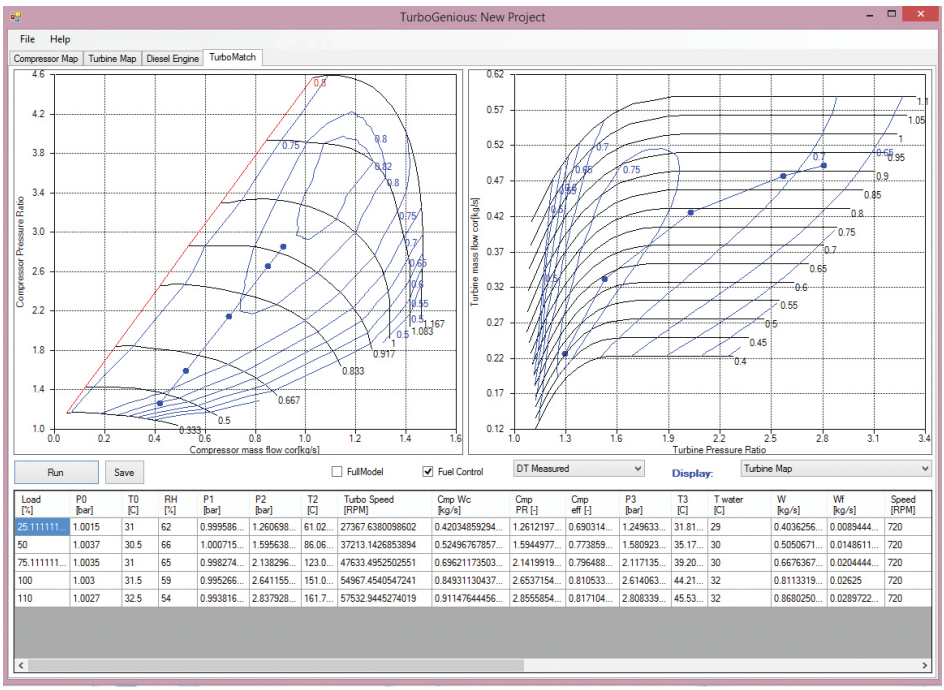
Intercooler:

This component simulates the pressure and temperature after the air-cooler.



Turbo matching

All these components are simulated together as a system in order to estimate the performance of the engine and turbocharger after the retrofit. Furthermore, a fine tuning sensitivity analysis is carried out if the turbocharger has more than one specification.



Load [%]	P0 [bar]	T0 [C]	RH [%]	P1 [bar]	P2 [bar]	T2 [C]	Turbo Speed [RPM]	Cmp Wc [kg/s]	Cmp PR [-]	Cmp eff [-]	P3 [bar]	T3 [C]	T water [C]	W [kg/s]	Wf [kg/s]	Speed [RPM]
25.111111...	1.0015	31	62	0.999586...	1.260698...	61.02...	27367.6380098602	0.42034859294...	1.2612197...	0.690314...	1.249633...	31.81...	29	0.4036256...	0.0089444...	720
50	1.0037	30.5	66	1.000715...	1.595638...	86.06...	37213.1426853894	0.52496767857...	1.5944977...	0.773859...	1.580923...	35.17...	30	0.5050671...	0.0148611...	720
75.111111...	1.0035	31	65	0.998274...	2.138296...	123.0...	47633.4952502551	0.69621173503...	2.1419919...	0.796488...	2.117135...	39.20...	30	0.6676367...	0.0204444...	720
100	1.003	31.5	59	0.995266...	2.641155...	151.0...	54967.4540547241	0.84931130437...	2.6537154...	0.810533...	2.614063...	44.21...	32	0.8113319...	0.02625	720
110	1.0027	32.5	54	0.993816...	2.837928...	161.7...	57532.9445274019	0.91147644456...	2.8555854...	0.817104...	2.808339...	45.53...	32	0.8680250...	0.0289722...	720

Warranty - Maintenance Program

- **Warranty period of 10.000 Hours is valid within the terms of the provided maintenance program and on exchange basis**

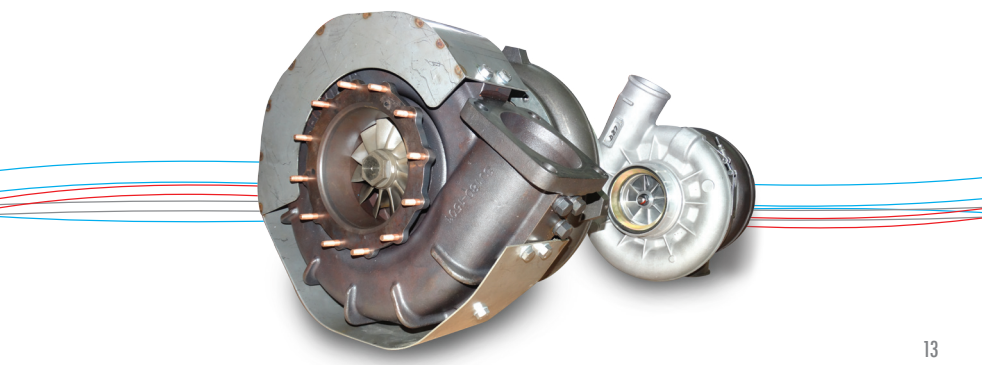
After 10.000 hours of operation, the turbocharger should be sent to TURBOMED's workshop for overhauling. In the meanwhile, the company will replace it with another overhauling cartridge for installation. The maintenance process is free of charge only for the first 10.000 hours.

- **Part Replacement Warranty**

In the case that any turbocharger problem occurs during the warranty period, TURBOMED S.A. undertakes to repair or replacement of the defective part within a reasonable period of time and with no additional charge. This warranty does not cover damages resulting from turbocharger's external reasons like broken valves, high temperatures from engine etc.

Training

The experienced technical staff-service engineers of TURBOMED S.A. can train the members of the crew so as to be able of installing and maintaining the new T/C models that are available for retrofit.



Our work, your advantage!

If there is an interest in retrofit for diesel engines, the technical department of TURBOMED S.A. can study the main parameters of the diesel engine and suggest you the most appropriate retrofit solution for T/C replacement. Moreover, the specialized technical staff will undertake the modification work that may be needed during the installation procedure of turbocharger on the diesel engine.

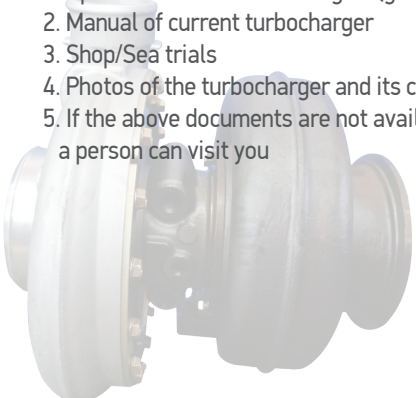
For any inquiries, please contact our technical department at

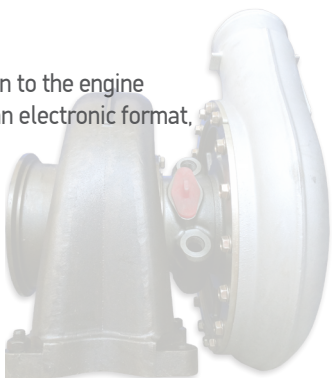
turbomed@otenet.gr or at **(+30) 210 40 00 111.**

24hours help line: (+30) 6932 210060

Please provide us the following documentation:

1. Operation Manual of the engine (genset)
2. Manual of current turbocharger
3. Shop/Sea trials
4. Photos of the turbocharger and its connection to the engine
5. If the above documents are not available in an electronic format, a person can visit you





24 Hours Worldwide Turbocharger Services

TURBOMED S.A. provides a wide range of turbocharger services to the marine industry. The Company has:

- **Forty years of experience**
- **Expertise**
- **Advanced machinery**
- **Equipment of latest technology**
- **Well-trained and certified technical staff**
- **A project portfolio of great accomplishments in turbocharger sector**

With a state of the art machine shop in Piraeus, TURBOMED S.A. is capable of satisfying its customers' needs in the marine industry worldwide, in workshop or even on board.

ISO 9001:2008 and ISO 14001:2005

ENERGY LINE P5456

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