



Shaft Generator Solution

Introduction to ZEME's shaftGenerator solution



Group Background



Power Generation



Oil



Coal



Natural Gas



Environmental Protection

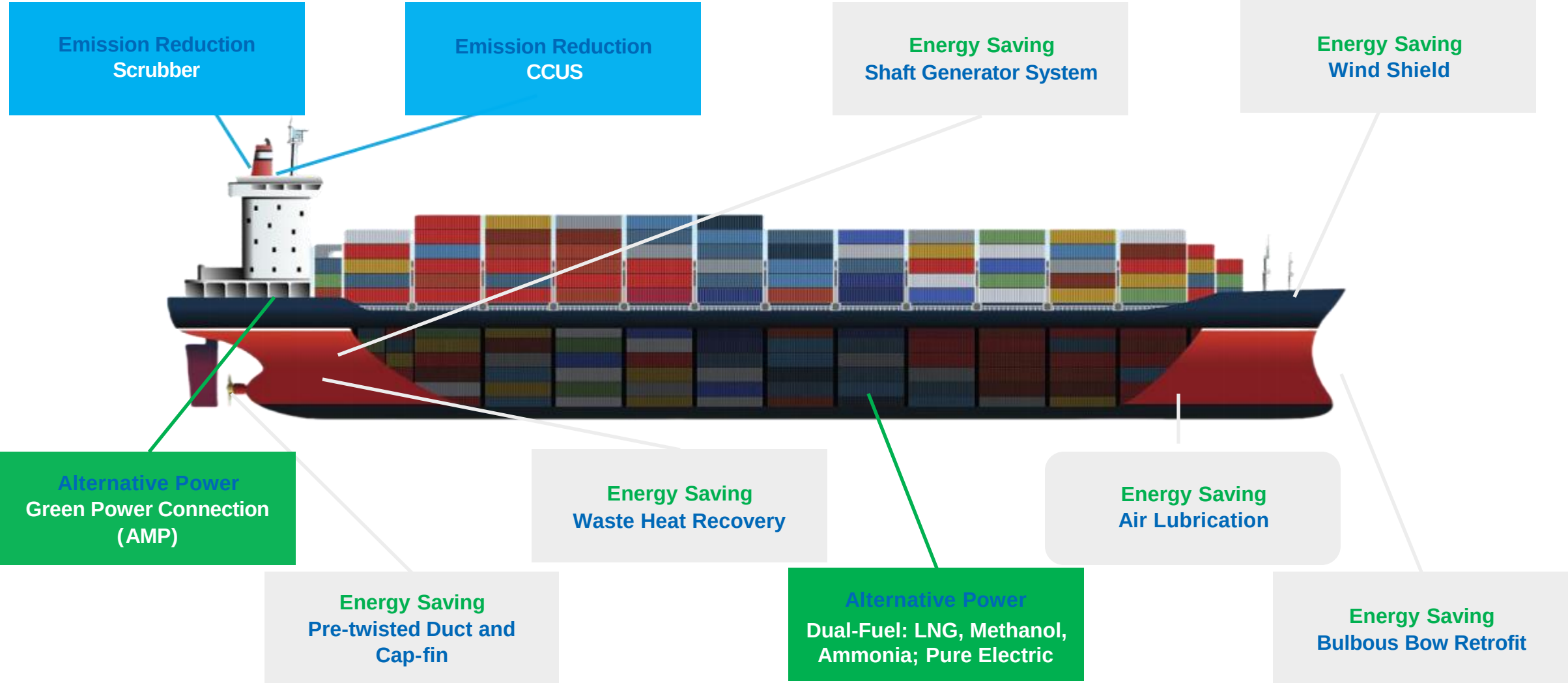


Renewable Energy

ZEME's Green Shipping Solutions



Committed to becoming a leading global provider of comprehensive **green** shipping solutions.



How a Shaft Generator System works

01

A shaft generator is a mechanical device that is integrated into a ship's propulsion system to **convert mechanical energy into electrical energy**.

02

It is connected to the main shaft of a ship and uses **the redundant power of the main engine**. It drives the rotation of the generator rotor through the rotation of the main shaft, thereby generating electrical energy.

03

Shaft generators are firstly introduced to reduce the reliance on auxiliary generators and optimize energy consumption.

Due to that **the AE fuel consumption rate is higher than that of the ME**, fuel saving, and emission reduction can be achieved, and it additionally improves the EEDI of the ship.



Clamp-on Type with original Shaft



8,400 TEU container vessel

Vessel Profile:

- ❖ with annual sailing days of 288
- ❖ ME Power @ MCR: 68520 kW
- ❖ SG Power: 3000 kW (to replace part of AE power)



- Fuel Saving: 1,022.4 t/year (3.6%)
- Fuel Cost Saving: US\$ 511,200
- Reduction of CO2: 3,210.3 t/year
- Maintenance Saving: aboutUS\$ 130,000
- Cost Recovery: 2.5 years

ME + AE Data								
ME RPM	35	40	50	55	60	65	70	75
ME Power at RPM (kW)	3000	4000	8000	11000	13500	15500	22000	25000
% of Sailing Days @ RPM	2%	6%	2%	2%	4%	22%	37%	25%
ME Fuel Oil Consumption Rate (g/kWh)	194	192	190	189	187	185	182	180
ME Fuel Consumption @ RPM (t/year)	80.5	318.5	210.1	287.4	698.0	4360.4	10240.0	7776.0
ME Fuel Consumption (t/year)								23,970.9
AE Power (replaced by SG) (kW)								
AE Fuel Oil Consumption Rate (g/kWh)								
AE Fuel Consumption (t/year)								
ME + AE Fuel Consumption (t/year)								28,414.2

ME + SG Data								
ME RPM	35	40	50	55	60	65	70	75
ME Power at RPM (kW) (SG Power excluded)	3000	4000	8000	11000	13500	15500	22000	25000
SG Power at RPM (kW)	1800	2100	3000	3000	3000	3000	3000	3000
% of Sailing Days @ RPM	2%	6%	2%	2%	4%	22%	37%	25%
Original ME Fuel Oil Consumption Rate (g/kWh)	194	192	190	189	187	185	182	180
ME Fuel Oil Consumption Rate after SG (g/kWh)	191.6	191	189	186.5	184.5	183.8	180	178
ME Fuel Consumption @ RPM (t/year)	127.1	483.2	287.4	360.9	841.7	5170.6	11508.5	8612.4
ME + SG Fuel Consumption (t/year)								27,391.8

Shaft Generator Types

	EESG	PMSG
SG System	Exciter cabinet (1.3m in width) +Frequency Converter	Frequency Converter
Stator	Stator winding made up of cooper wire and iron	
Rotor	A rotor winding supplied by a DC current supplied by a exciter via carbon brush and slip ring	Magenatic steel
Size & Weight	Bigger/Heavier	volume: -6.84%/weight: -22.8%
Efficiency	91%-95%	96-98%
Maintenance	Regular Maintenance	None



Shaft Generator Types

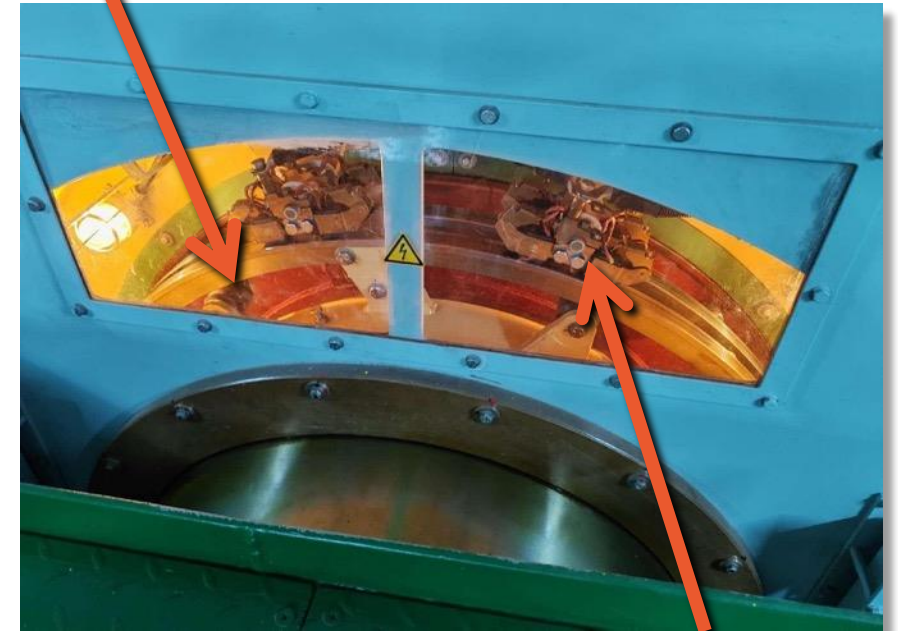
EESG

- ❖ Maintenance of Carbon Brush & Slip Ring (4 pairs, and requires daily visual check, monthly cleaning and annual replacement)
- ❖ An independent generator as Exciter

PMSG

Requires NO maintenance

Slip Ring



Carbon Brush

In summary, the **PMSG's design**, which eliminates the need for additional components, not only makes it a **more maintenance-friendly** option but also contributes to its **superior efficiency**, and its **more compact and lightweight** form factor. These attributes make the **PMSG a preferable choice** in many applications.

Already
150 shaft
 generator
 reference
 projects and
 counting

Vessel Type	PTO (kWe)	Mode	SG Type	Quantity	Delivery Time
53,580DWT Bulk Carrier (690V, Water Cooling, Generator operating speed range: 80-110rpm)	680	Clamp	PMSG	1	2024.10
177,000DWT Bulk Carrier (690V, Water Cooling, Generator operating speed range: 65-90rpm)	1280	Clamp	PMSG	3	2024.11
181,000DWT Bulk Carrier (690V, Water Cooling, Generator operating speed range: 50-80rpm)	1280	Clamp	PMSG	2	2024.12 Combined Test Completed
181,000DWT Bulk Carrier (690V, Water Cooling, Generator operating speed range: 65-87rpm)	1280	Clamp	PMSG	1	2025.2 Combined Test Completed
56,742DWT Bulk Carrier (690V, Water Cooling, Generator operating speed range: 65-87rpm)	680	Clamp	PMSG	1	2025.2 Combined Test Completed
8,400TEU Container Ship (690V, Water Cooling, Generator operating speed range: 50-74.3 rpm)	3000	Shaft-Holding	VEM EESG	2	2024.11 Combined Test Completed
10,766TEU Container Ship (690V, Water Cooling, Generator operating speed range: 45-65rpm)	3000	Shaft-Holding	PMSG	3	2024.11 Combined Test Completed
24,000TEU Container Ship (690V, Water Cooling, Generator operating speed range: 45-64.7rpm)	4300	Shaft-Holding	PMSG	7	2024.11 - 2025.03 Combined Test Completed
3,534TEU Container Ship (690V, Water Cooling, Generator operating speed range: 60-80rpm)	2000	Clamp	PMSG	1	2024.11 Combined Test Completed
181,000DWT Bulk Carrier (690V, Water Cooling, Generator operating speed range: 50-80rpm)	1200	Clamp	PMSG	1	2024.1

The list continues

Vessel Type+B14:G24	PTO (kWe)	Mode	SG Type	Quantity	Delivery Time
3,500-5,000TEU Container Ship (690V, Water Cooling, Generator operating speed range: 60-80rpm)	2000	Clamp	PMSG	27	2025.3 Combined Test Completed
8,000TEU Container Ship (690V, Water Cooling, Generator operating speed range: 45-65rpm)	3000	Shaft-Holding	PMSG	1	2025.2 Combined Test Completed
3,500-5,000TEU Container Ship (690V, Water Cooling, Generator operating speed range: 60-80rpm)	2000	Clamp	PMSG	3	2025.3 Combined Test Completed
13,102TEU Container Ship (690V, Water Cooling, Generator operating speed range: 45-72rpm)	3000	Shaft-Holding	PMSG	2	2025.4 Combined Test Completed
8,000-14,000TEU Container Ship (690V, Water Cooling, Generator operating speed range: 45-65rpm)	3000	Shaft-Holding	PMSG	1	2025.5 Combined Test Completed
9,411TEU Container Ship (690V, Water Cooling, Generator operating speed range: 45-72rpm)	3000	Shaft-Holding	PMSG	10	2024.12 Combined Test Completed
14,336TEU Container Ship (690V, Water Cooling, Generator operating speed range: 45-68rpm)	3000	Shaft-Holding	PMSG	5	2025.1 Combined Test Completed
9,640TEU Container Ship (690V, Water Cooling, Generator operating speed range: 60-80rpm)	3000	Shaft-Holding	PMSG	9	2025.3 Combined Test Completed
8,000-14,000TEU Container Ship (690V, Water Cooling, Generator operating speed range: 45-72rpm)	3000	Shaft-Holding	PMSG	14	2025.4 Combined Test Completed
37,650DWT Bulk Carrier (690V, Water Cooling, Generator operating speed range: 70-93rpm)	700	Shaft-Holding	PMSG	3	2025.4 Combined Test Completed

Multiple power Shaft Generator

PTO

500kW-4300kW

RPM RANGE

45-110rpm

COOLING TYPE

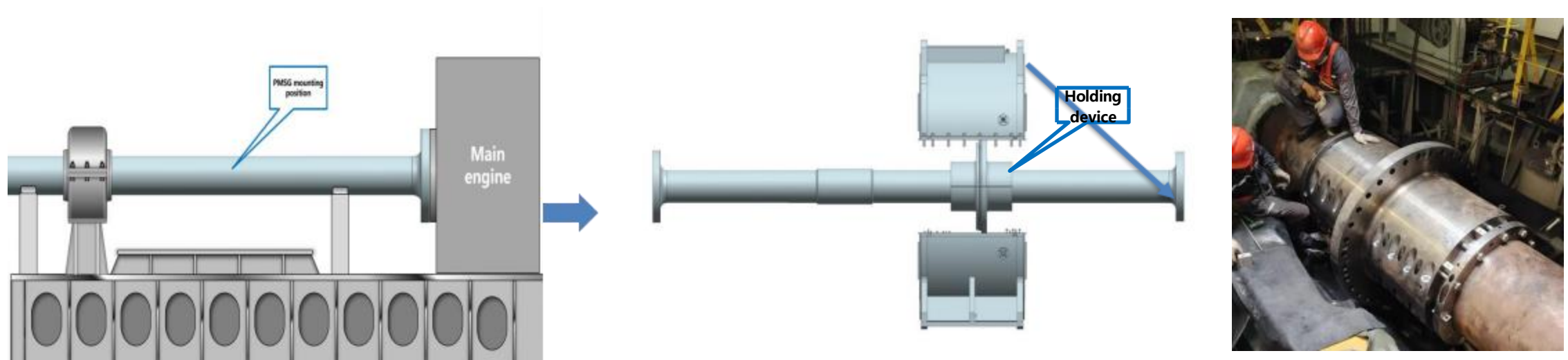
Water Cooling



Combined PMSG Type

Rationale for Holding Device Design

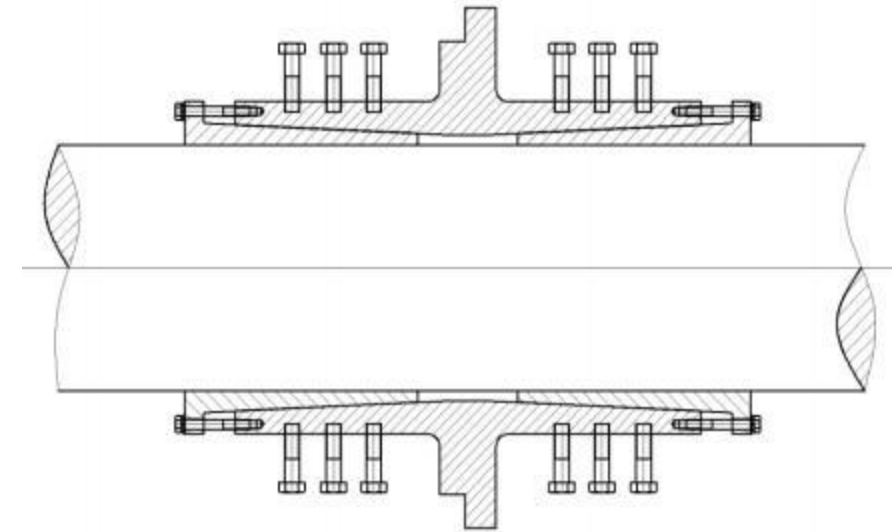
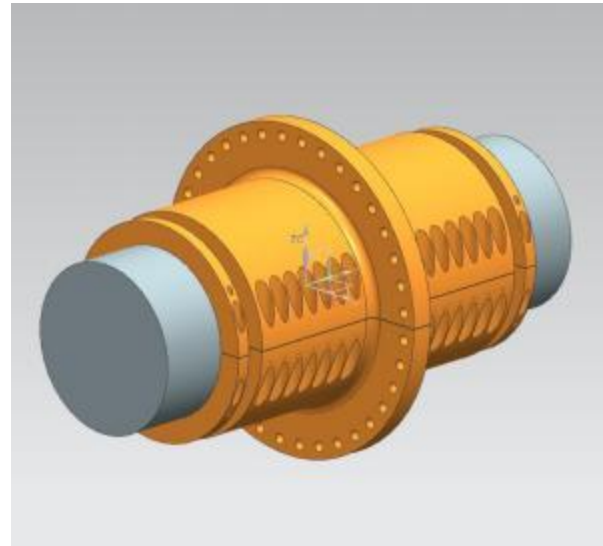
To enable the installation of the shaft generator within a limited retrofit period, the expansion sleeve serves as a key component. Once installed, it eliminates the need to replace the intermediate shaft, significantly reducing both time and cost.



PMSG Expansion Sleeve Coupling

How the holding design device works

The holding device consists of a split flange and a split expansion sleeve, which are taper-matched. Both components are positioned on the rotating shaft using the expansion kit. Their axial placement is determined based on the designed interference fit.



PMSG Expansion Sleeve Coupling

Advantages of the holding device

- (1) Shorten the transformation cycle and reduce costs;
- (2) large torque transmission capacity, 6-8 times the safety margin;
- (3) lightweight design, small moment of inertia;
- (4) Simple and reliable structure, easy installation and maintenance;



SAC & TVC Calculation

shaft Alignment calculation & Torsional vibration calculation in shaft Generator retrofitting

Outer shaft diameter: 790 mm
Effective bearing length: 790 mm
Diametrical clearance: 1.3 mm
Max permissible load: 0.8 MPa / 499 kN

Intermediate shaft bearings (IB3/1): White metal

Outer shaft diameter: 650 mm
Effective bearing length: 352 mm
Diametrical clearance: 0.6 mm
Max permissible load: 1.0 MPa / 235 kN

ORIGINAL
BEARING

Intermediate shaft bearings (IB2): White metal

Outer shaft diameter: 650 mm
Effective bearing length: 580 mm
Diametrical clearance: 0.85 mm
Max permissible load: 1.5 MPa / 565.5 kN

RETROFIT
BEARING



2 INTRODUCTION

DNV Maritime Advisory, section Machinery and Systems was contracted by MSC Shipmanagement to perform a Torsional Vibration Calculation (TVC) for the propulsion shaft line for "MSC MAXINE Class", built by Jiangnan Shipyard Group.

The vessels are a series of container vessel of approximately 131,034 dwt built by Jiangnan Shipyard Group in 2015-2016. The vessels are now to be retrofitted with a new propeller and shaft generator, hence a new TVC is carried out.

Vessel name	Hull No.	IMO No.	Yard	Class Society
MSC MAXINE	H3001	9720287		DNV
MSC SILVIA	H3002	9720457		DNV
MSC JEONGMIN	H3003	9720471		DNV
MSC CHLOE	H3004	9720483	Shanghai Jiangnan Changxing Shipbuilding Co., Ltd	DNV
MSC BRANKA	H3005	9720495		DNV
MSC SASHA	H3006	9720500		DNV
MSC MICHELA	H3007	9720512		DNV
MSC CLEA	H3008	9720524		DNV
MSC GISELLE	H2552	9720196	Jiangnan Shipyard (Group) Co Ltd - Shanghai	DNV
MSC DOMITILLE	H2553	9720201		DNV

The propulsion system for the vessels is a single propulsion system with fixed pitch propeller. The shaft line is driven by a 2-stroke diesel engine.

PMSG Configuration

Model	Generator Structure	Expansion Sleeve Coupling	New Shaft Requirements	Case	Advantage	Installation Time	Cost Comparison
N1-Clamp On (Half-Half) Type	Split	Split	No	680kW, 1,280kW, 2,100kW	Simple Structure, convenient installation, easy maintenance, quick connection and disconnection of equipment can be realized	10 Days	/
N2-Shaft Holding (Integral) Type	Integral	/	Yes	3,000kW, 4,300kW	The transmitted moment of inertia is high, ensuring long service life, strong stability, and enhanced safety.	20 Days	/
	Integral	Split	No	3,000kW, 4,300kW	Easy to install, cost-effective, flexible, short installation time.	12 Days	-10%

PHOTOS

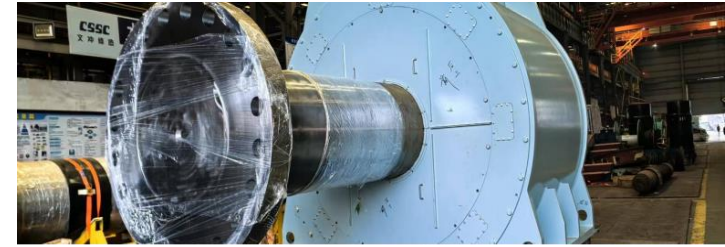
FROM OUR

WORKSHOP



PHOTOS

FROM AN
INSTALLATION
SITE



PHOTOS

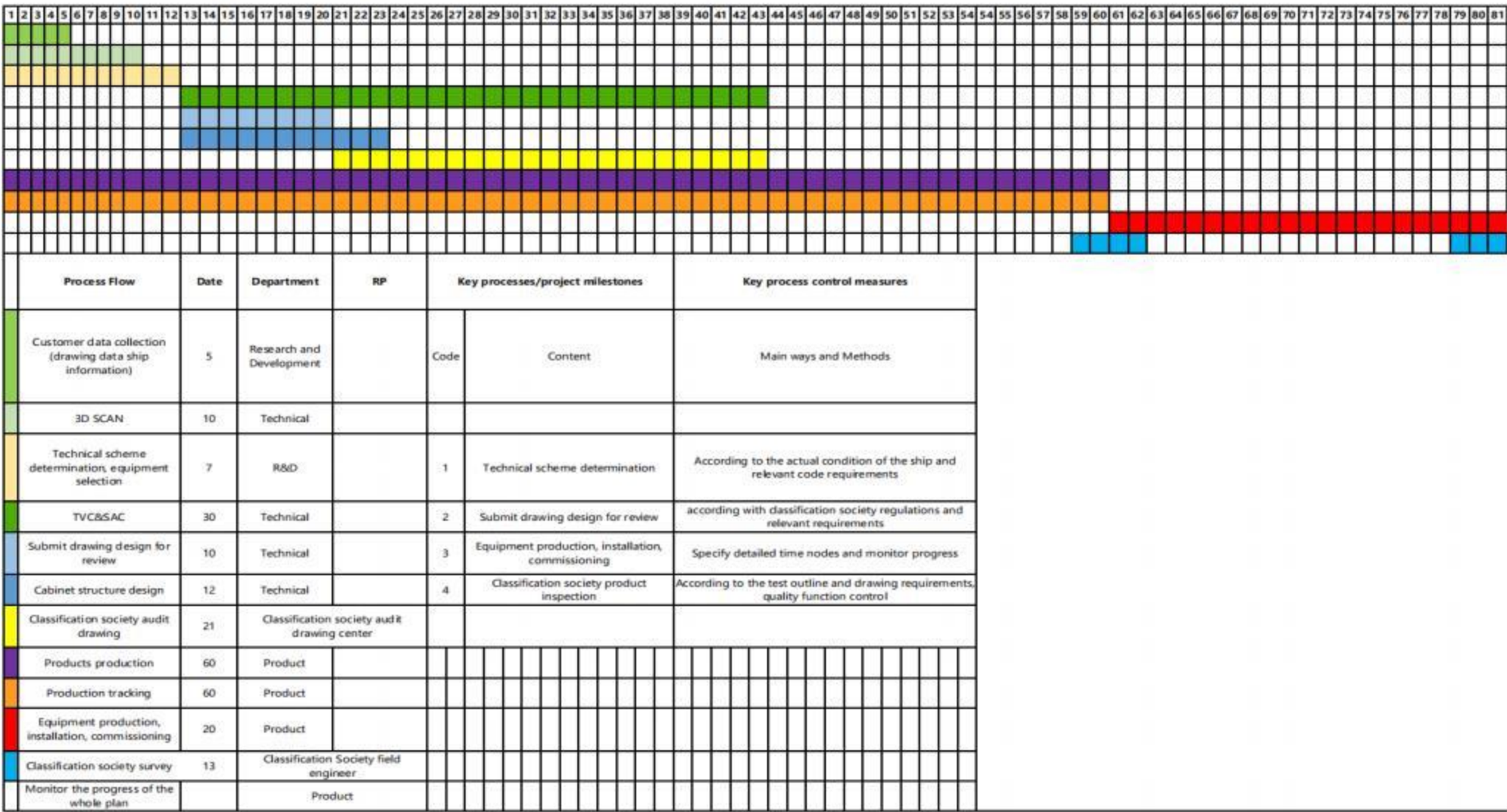
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Period in Shipyard: 20 days



Shaft Generator Project Execution Plan



18/06/2024

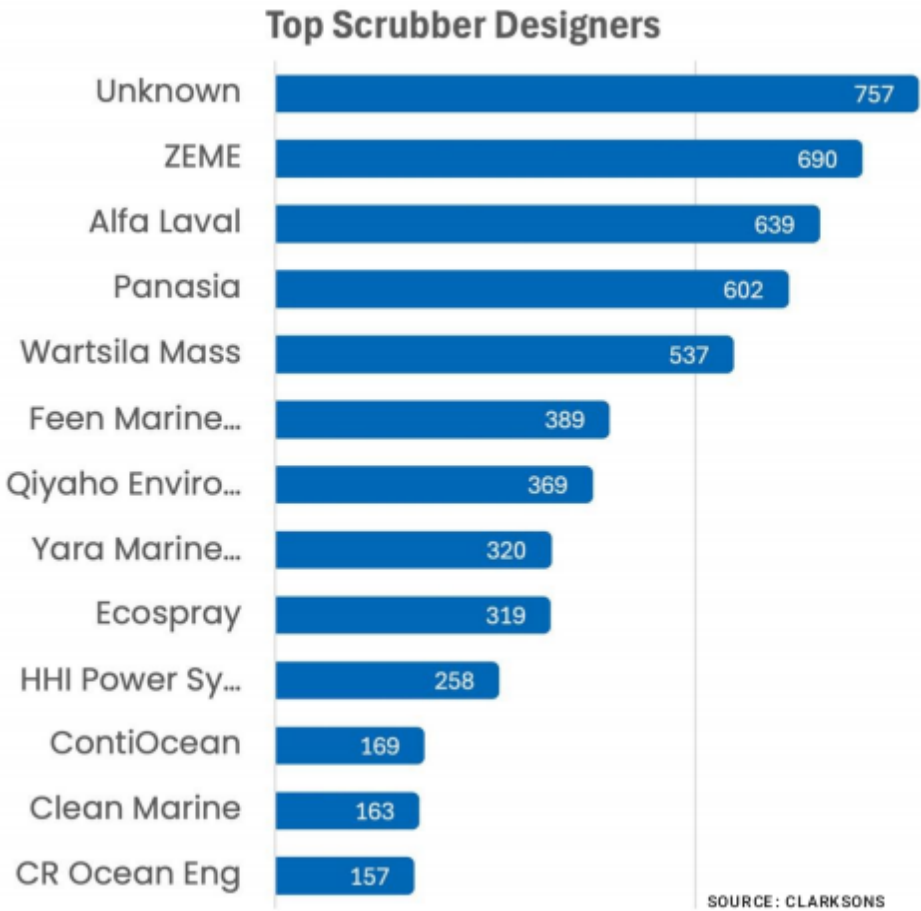
Why choose ZEME?

We are fortunate to count many renowned names in the shipping industry among our clients. Their support, through more than 2,000 orders of our different solutions, has not only enabled us to amass a wealth of experience but also demonstrates that we consistently deliver outstanding quality to our clients' satisfaction.

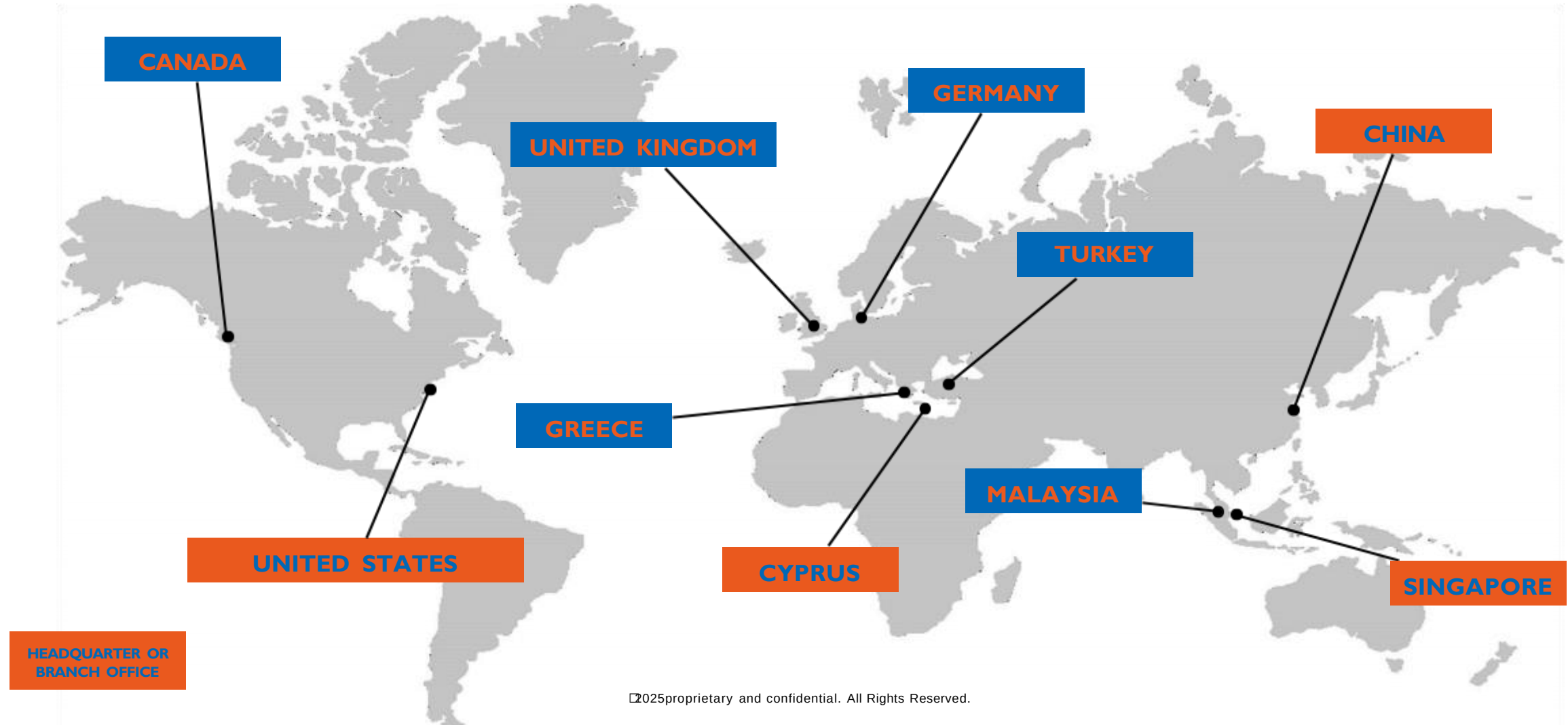
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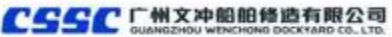
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we are partnering with **464 vetted suppliers**, we manufacture core components in-house, delivering best-in-class products with lead times as short as 2 - 3 months.

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