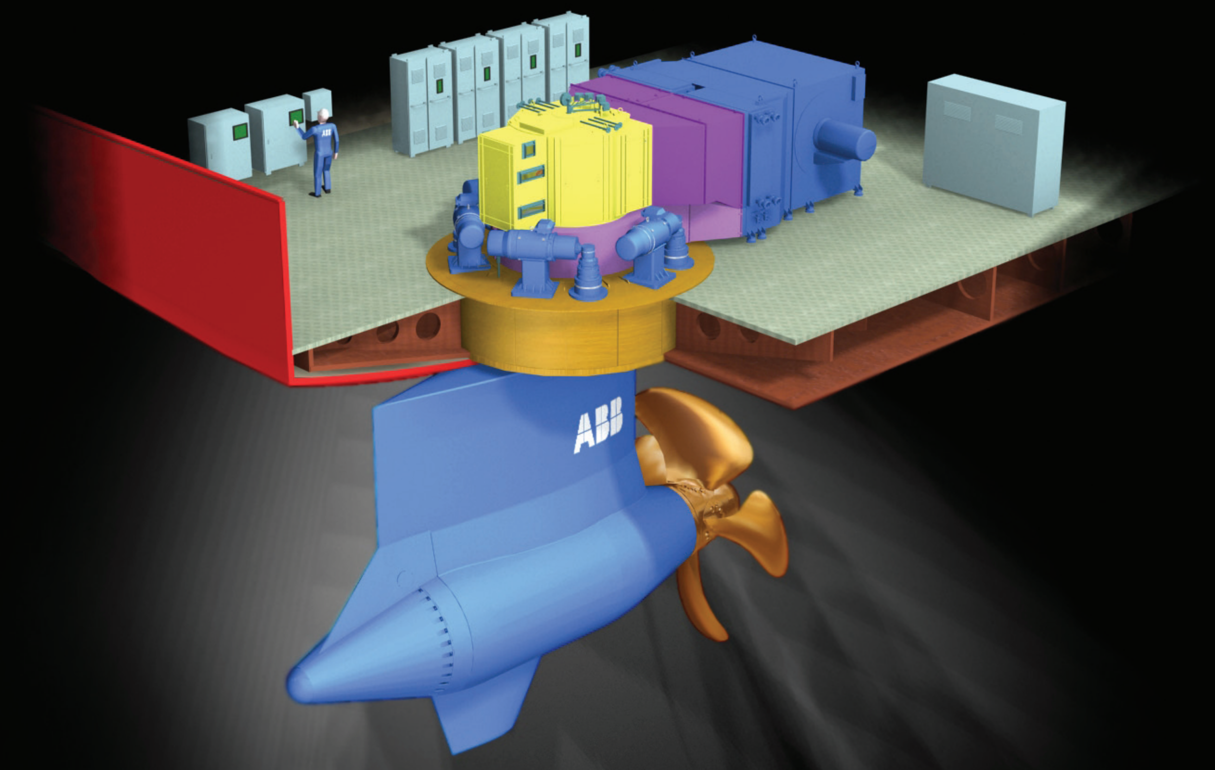
Product Introduction

Azipod® XO2100 and XO2300



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Preface

This Product Introduction provides system data and information for preliminary project planning of an Azipod® podded propulsion and steering system outfit. Furthermore, our project and sales departments are available to advise on more specific questions concerning our products and regarding the installation of the system components.

Our product is constantly reviewed and developed according to the technology progression and the needs of our customers. Therefore, we reserve the right to make changes to any data and information herein without notice.

All information provided by this publication is meant to be informative only. All project-specific issues shall be agreed separately and therefore any information given in this publication shall not be used as part of agreement or contract.

Helsinki, July 2012

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1 General

Azipod is an electric azimuthing propulsion system. The electric motor is inside a submerged pod. Propulsion module with speed controlled fixed pitch propeller can be rotated 360 degrees around its vertical axis. The system offers high efficiency with excellent maneuverability.

1.1 Azipod Propulsion and Steering

The Azipod XO2100 and XO2300 are the successors to the classic “V21” and “V23” series Azipod products.
Azipod propulsion is designed for the preferential use of the (directly driven) pulling propeller when driving in the ahead direction. The type XO2100 and XO2300 Azipod propulsion units are available generally for power ratings of between 13 - 18 MW and 18 – 23 MW respectively. The power rating is depending on the propeller design.

The full ship system consists of the required number of Azipod steering propulsors, plus the delivery of an PWM type marine Propulsion Power Drive per each Azipod. Additionally, propulsion supply transformers (if needed), a remote control system, and the power plant (generators, switchboards and transformers) are usually included in the scope of the delivery.

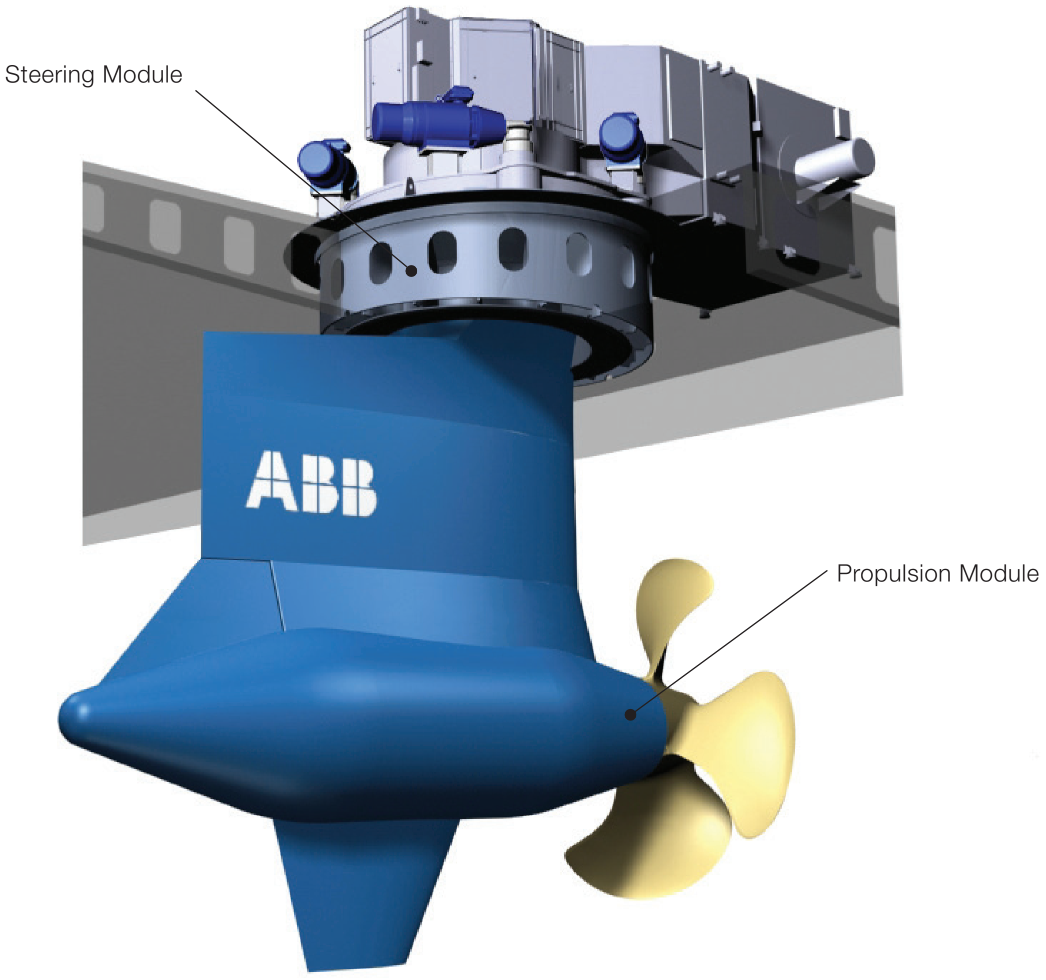

Figure 1-1 Basic arrangement of the Azipod XO

1.2 Improvements in the Azipod XO series

	Subject	Benefit
A.	Easy access and work arrangements inside the Propulsion Module	Safer work with extended possibilities for inspections and preventive maintenance
B.	Streamlined design of the Propulsion Module, and the propeller blades and hub	Better hydrodynamic efficiency. Improved versatility for propeller installation procedures
C.	Design of the propeller shaft bearings and seals to improve the life cycle cost prognosis	Possibility to change shaft seals while in port. Thrust bearing assembly with traditional white metal slide pad elements for the axial forces, pads exchangeable while in port.
D.	Fully electro-mechanical steering gear	Contemporary solution with steering speed regulation versatility and no need for pressure hydraulics
E.	In-house designed remote controls for the Bridge and for the Engine Control Room	Readily adaptable modularity for improved ergonomics, efficient ship handling and project-specific Bridge design integration.
F.	Advanced “Propulsion Condition Monitoring System”, as a variety of options	Improved tool allowing continuous monitoring of the Azipod system

1.3 Type designation for the Azipod product

In the ship concept design stage, the following main designation is used. (A more specific type code will be allocated for the product during the advanced design stage).

C = “Compact” Azipod
V = “Classic” Azipod
X = Next Generation Azipod

O = Designed for operation in open water
I = Designed for icebreaking or operation in ice conditions
C = “Contra-Rotation Propeller” use with traditional propulsion
Z = Product with Kaplan propeller and nozzle for utility vessels

Diameter of the propulsion motor (mm.)

“S”, “M” or “L” = Length of the (synchronous) propulsion motor
“A” = Asynchronous propulsion motor

Azipod® □□ xxxx y

Example: Azipod® XO 2100 S

1.4 Electric propulsion and power plant

In order to drive the Azipod propulsion system, the ship needs an electric power plant (not specifically discussed in this document). Generator sets supply power to the 50 or 60 Hz installation of electric switchboards for distribution to all consumers onboard, including Azipod propulsion.

Generally, ABB aims to deliver the power plant as well as the Azipod system. Our mechanical interface to the engine maker is basically standard, although dependent on the delivery of engines or e.g. gas turbines from the contractors.

During the whole project, the basic tool for power plant design is the so-called single-line diagram. The actual onboard configuration can be efficiently discussed already in the early stages of work by using this clear visual representation.

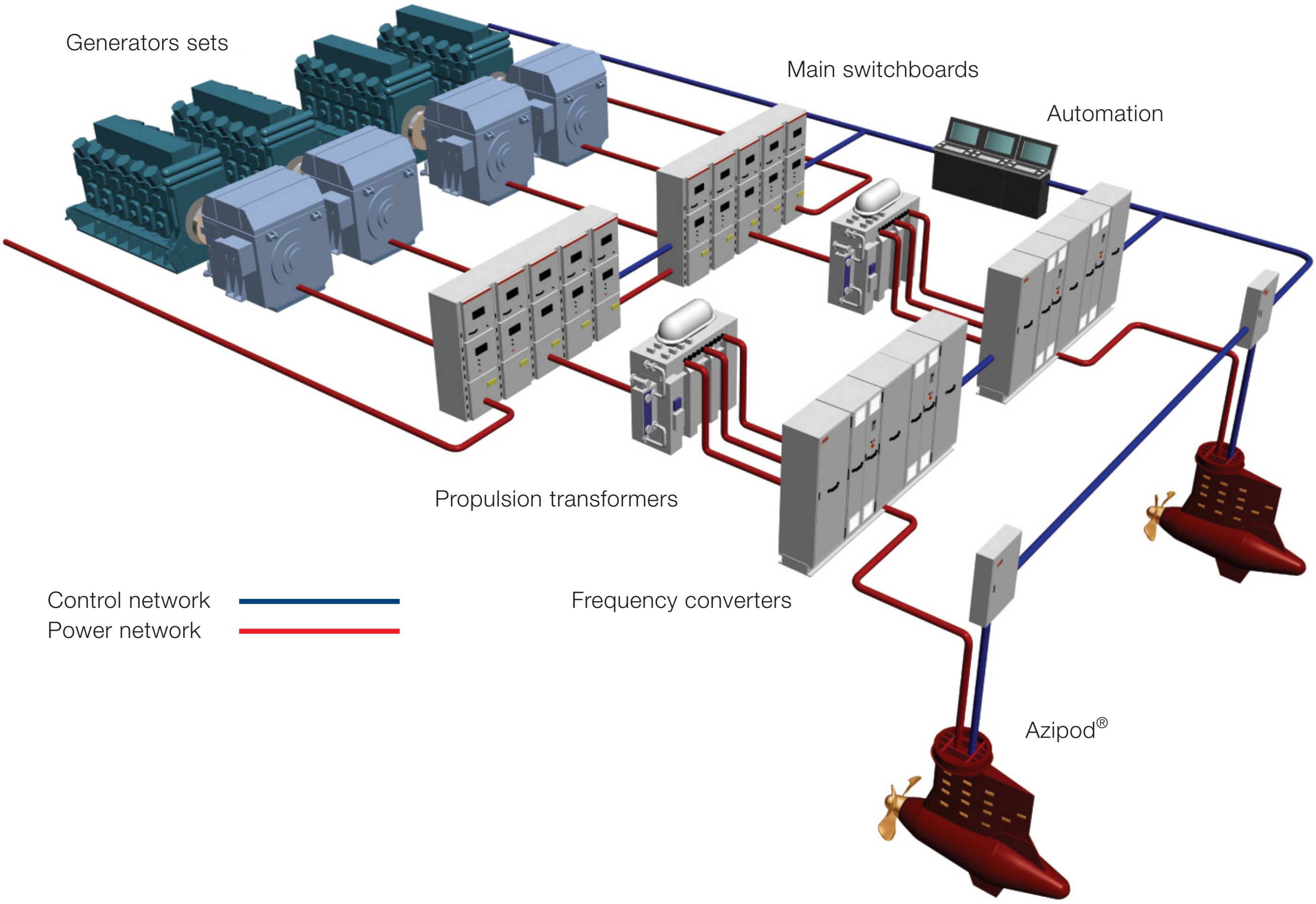

Figure 1-2 Simplified single line diagram of the power plant with a propulsion system

2 Technical features on the scope of supply

2.1 General

The Azipod Propulsion Module and the associated Steering Module are of fabricated steel construction. The Steering Module will be welded to the ship's hull as a structural member. The submerged Propulsion Module incorporates a three-phase electric propeller motor in a dry environment, directly driving a fixed-pitch propeller.

The propeller is custom-designed by ABB to fit with the ship particulars confirmed by the shipyard.

The Propulsion Module is to be bolted to the azimuthing part of the Steering Module.
Each Azipod delivery usually consists of the following fourteen items: two (2) modules and twelve (12) auxiliaries. They are built internally ready for separate deliveries, for shipyard installation, as follows:

2.2 Azipod-specific delivered items

- Propulsion Module
- Steering Module
- Four (4) Steering Drives (SD-1…4)
- One (1) Electric Steering Control Unit (ESCU)
- One (1) Cooling Air Unit (CAU)
- Two (2) adapting Air Ducts (AD-In), (AD-Out)
- One (1) Slip Ring Unit (SRU)
- One (1) Shaft line Support Unit (SSU)
- One (1) Azipod Interface Unit (AIU)
- One (1) Local Backup Unit (LBU)

A layout example of Azipod modules and units is shown in the figure 2-1.

The mounting, inter-unit connection, and external connection work of the above mentioned separate items is to be done by the shipyard, except for the ABB site installation work for the piping and cabling that interconnect the Propulsion Module and the Steering Module.

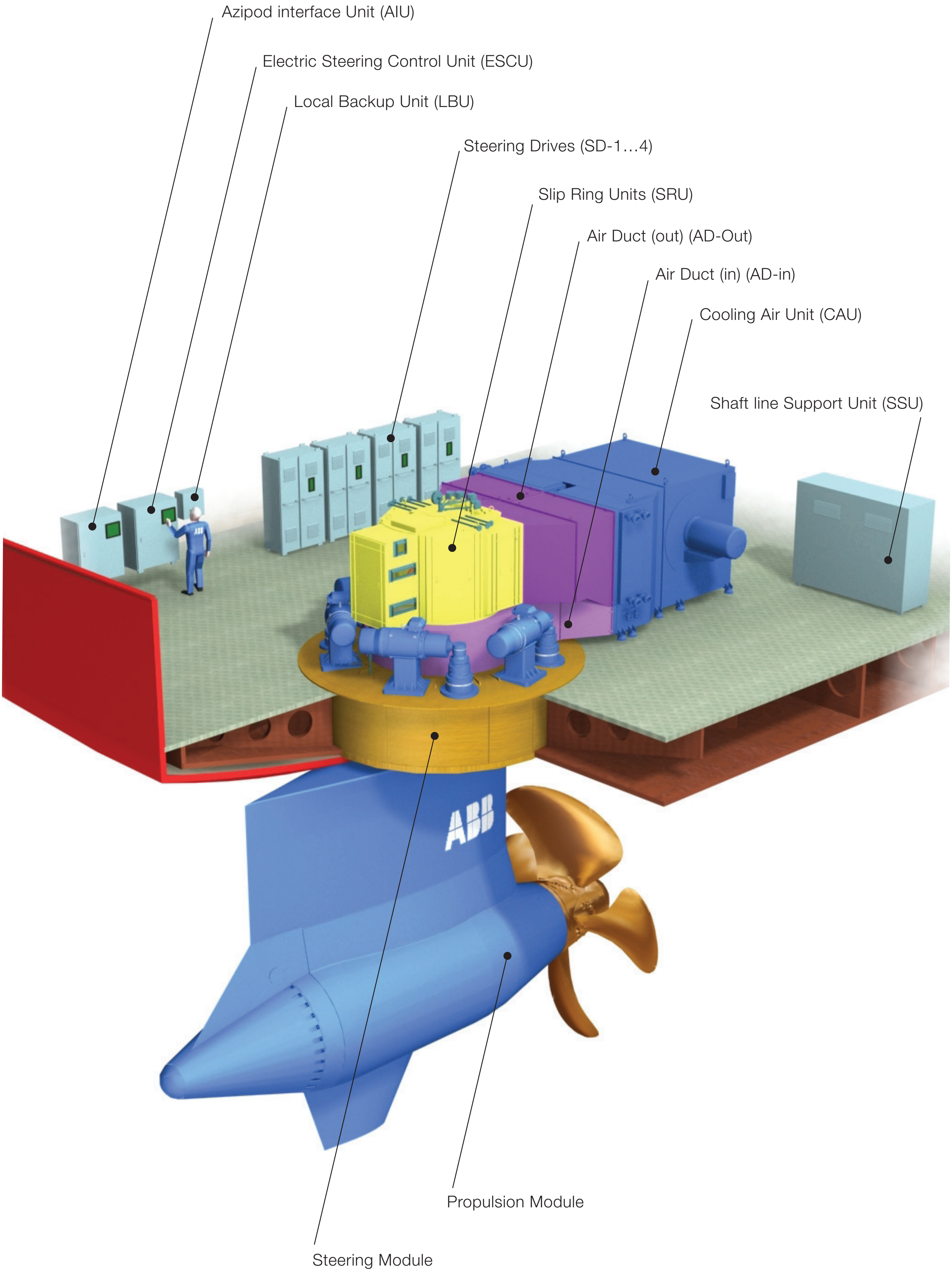

Figure 2-1 Layout example of Azipod XO series modules and auxiliaries

2.3 Main dimensions

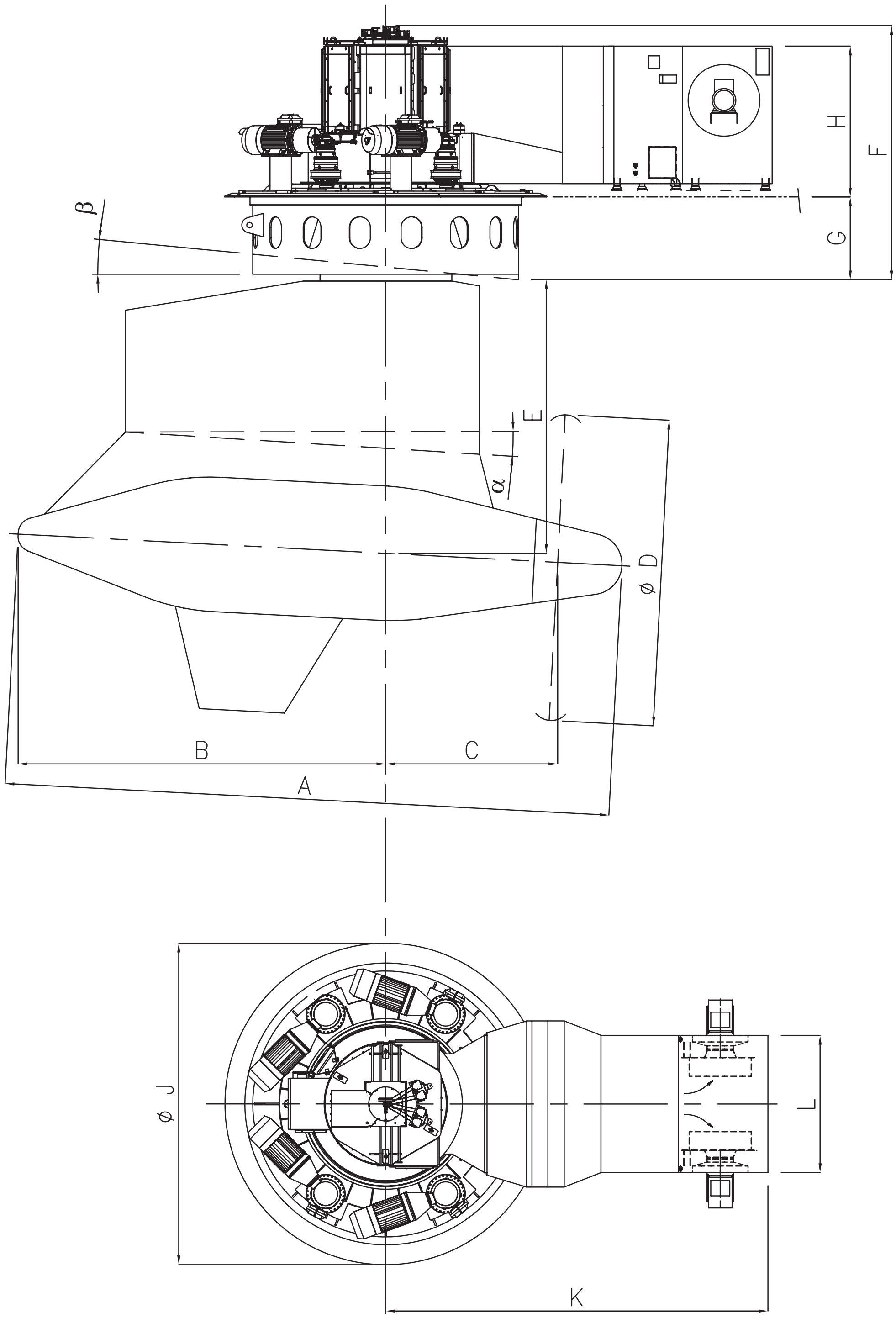

Figure 2-2 Dimensional nominations for the Azipod XO series

The following preliminary values (or applicable ranges) of dimensions are to be used in the early stages of a ship project study. These dimensions have to be checked during the technical drafting process with regard to the applied ship fit:

- The maximum obtainable vertical measure (“E”) for the Propulsion Module is ship specific, and subject to the calculated hydrodynamic forces.

- The double bottom fit standard thickness (“G”) is fixed but within certain limits the Steering Module bottom can be cut out on ship-specific design basis.

- The eventual Cooling Air Unit detail selection may slightly alter the related dimensions. (“H”, “K” and “L”).

Code	Subject	Dimension XO2100	Dimension XO2300	Unit	Status
α	Tilt angle	0...6	0...6	Degr	Variable
β	Bottom formability angle	0...7	0...7	Degr	Variable
A	Total length	11,5	11,7	m	Fixed
B	Tail extension from the azimuth	6,9	7,0	m	Fixed
C	Propeller disk extension from the azimuth	3,4	3,4	m	Fixed
ØD	Propeller diameter	4,4 ... 6,4	4,6 ... 6,6	m	Variable
E	Vertical measure from the shaft line cross	4,3. ... 7,1	4,4. ... 7,1	m	Variable
F	Height of Steering Module	4,9 *)	4,9 *)	m	Fixed
G	Double bottom fit thickness	1,5	1,5	m	Fixed
H	Room height for the Cooling Air Unit	3,0	3,0	m	Fixed
ØJ	Steering module flange diameter	6,1	6,1	m	Fixed
K	Hard outfit horizontal from the azimuth	6,7	6,7	m	Fixed
L	Width of the Cooling Air Unit	3,0	3,0	m	Fixed

*) Height can be reduced with project specific design

2.4 Weights

Propulsion Module (excl. propeller):	
XO2100	135 000 – 155 000 kg
XO2300	157 000 – 180 000 kg
Propeller:	
XO2100	22 000 – 30 000 kg
XO2300	25 000 – 36 500 kg
Steering Module	65 000 – 70 000 kg
Slip Ring Unit (SRU)	4 000 kg
Steering Drives (SD)	4 x 360 kg
Electric Steering Control Unit (ESCU)	140 kg
Cooling Air Unit (CAU)	6 000 – 11 800 kg
Shaft Line Support Unit (SSU)	1 300 kg
Air Ducts (AD-In), (AD-Out)	Project specific, typically 2 x 400 kg
Azipod Interface Unit (AIU)	200 kg
Local Back Up Unit (LBU)	20 kg

2.5 Technical parameters: Propulsion Module

Rated output power:	
XO2100	13 000 – 18 000 kW
XO2300	16 000 – 23 000 kW
Nominal propeller speed at rated output power:	
XO2100	122 – 170 rpm
XO2300	112 – 155 rpm
Maximum nominal (ahead) torque	To be defined
Main motor supply voltage	Approx. 3000 V
Motor current	To be defined
Insulation / temperature rise class for stator and rotor	F / F
Propeller design	4 or 5 blades
Propeller type	Medium skew and fixed pitch
Propeller material	Ni-Al Bronze
Propeller manufacturing and balancing	ISO 484 class 1
Propeller state when delivered	Hub mounted on, blades loose
Shaft brake holding capacity	Approx. 3.0 knots of water flow
Shaft locking capacity	Approx. 10 knots of water flow
Non-drive-end lube oil pump power	2 x 2.2 kW
Drive-end lube oil pump power	2 x 1.1 kW
Diaphragm drainage pumps capacity	2 – 3 x 1.0 m^3/h
Drainage pump air supply requirement	2 – 3 x 400 Nl/min
Drainage pump air pressure requirements	7 bar
Standstill heater resistance elements	4 x 800 W
Displacement	59 – 71 m^3
Outside painting area	115 – 164 m^2

2.6 Technical parameters: steering and support systems

CAU water supply inlet temperature	Max. 36 °C
CAU water supply pressure	Nominal 6 bar
CAU supply voltage	400V / 440V / 690V / 50/60 Hz
CAU fan motor power	2 x 45 – 2 x 185 kW
Cooling water requirement	100 - 180 m^3/h
Cooling losses to cooling water	560 - 980 kW
CAU pressure drop	Max. 50 kPa
CAU standstill heater resistance elements	2 x 50 W
CAU standstill heater supply voltage	230 V / 50 Hz / 60 Hz
Steering rates:	
Normal duty mode	2,5°/s
Fast mode	5,0°/s
Steering Drives supply voltage	400V / 440V / 690V / 50/60 Hz
Steering Drives power requirement:	one drive / four drives
P_{ref}, Normal duty autopilot:	13 - 27 kW / 52 - 108 kW
P_1, Solas turn in Normal duty mode	21 - 50 kW / 84 - 200 kW
P_{max}, Pod-way crash stop in Fast mode	62 - 118 kW / 248 - 472 kW
AIU supply voltage	230 V / 60 Hz
ESCU supply voltage	230 V / 60 Hz
Heat losses to the Azipod room	40 – 65 kW
SSU water supply inlet temperature	Max. 36 °C
SSU LT water requirement	5.4 m^3/h
SSU supply voltage	400V / 440V / 690V / 50/60 Hz
Seal system frequency converter supply voltage	230 V / 50 Hz / 60 Hz
SSU heat losses to LT water	Max. 40 kW
SSU pressure drop	Max. 20 kPa
Protection class for electrical enclosures	IP 44

2.7 The steering gear

The fully electro-mechanic steering gear allows unlimited steering of the Propulsion Module. The main components of the system are: Electric Steering Control Unit (ESCU), inverter Steering Drives (SD1...4) steering motors, reduction gears, pinions, gear rim, slewing bearing and slewing seals.

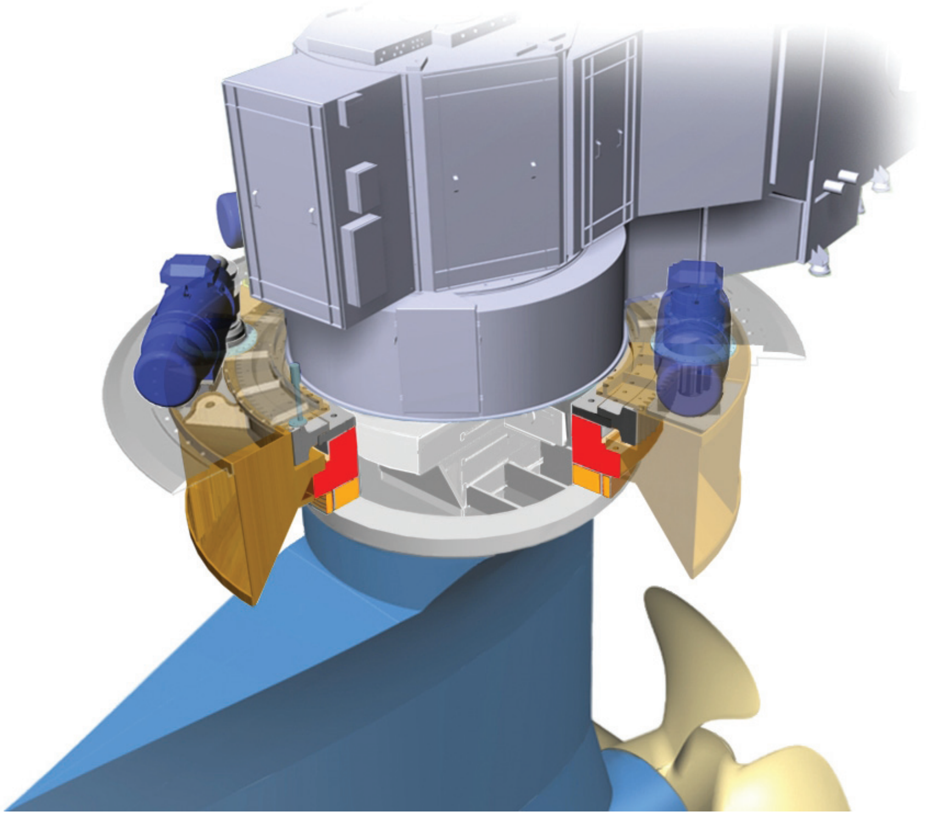

Figure 2-3 Split view of the top delivery showing the steering gear mechanics

The steering motors are of the asynchronous induction type and each is driven by its own (inverter type) steering frequency converter. The typical Steering Module configuration includes four motors, depending on the ultimate torque requirements.

A self-arming torque overload clutch is provided on the shaft between each steering motor and reduction gear. The planetary reduction gear transfers the torque from each electric steering motor to the respective pinion. Each steering motor is fitted with a fail-to-safe (normally spring shut) steering brake to prevent unwanted motion of the pod in case of a technical eventuality or when all the steering drives are off.

Each pinion is made of hardened steel and the gear teeth are machined directly to the shaft of the pinion. The pinion bearing arrangement consists of two roller bearings. The gear rim transfers the torque from the pinions to the Propulsion Module and is made of hardened steel and bolted to the slewing bearing. The bearings and the whole gear assembly are lubricated with oil by bath and splash lubrication. The three-row roller type slewing bearing supports the weight of the Propulsion Module and enables it to steer around its vertical axis.

Each Steering Drive cabinet consists of two separate sections, one for the converter and the other for the braking resistors. Both of these main sections are air cooled by their own fans.

The ESCU is a doublicated controller that commands the Steering Drives via control network and steers the Propulsion Module according to the reference angle signal given by the remote controls. The ESCU is hot-standby redundant by design. The I/O ports and the communication buses necessary for steering are capable of handling a single failure in any part of the system.

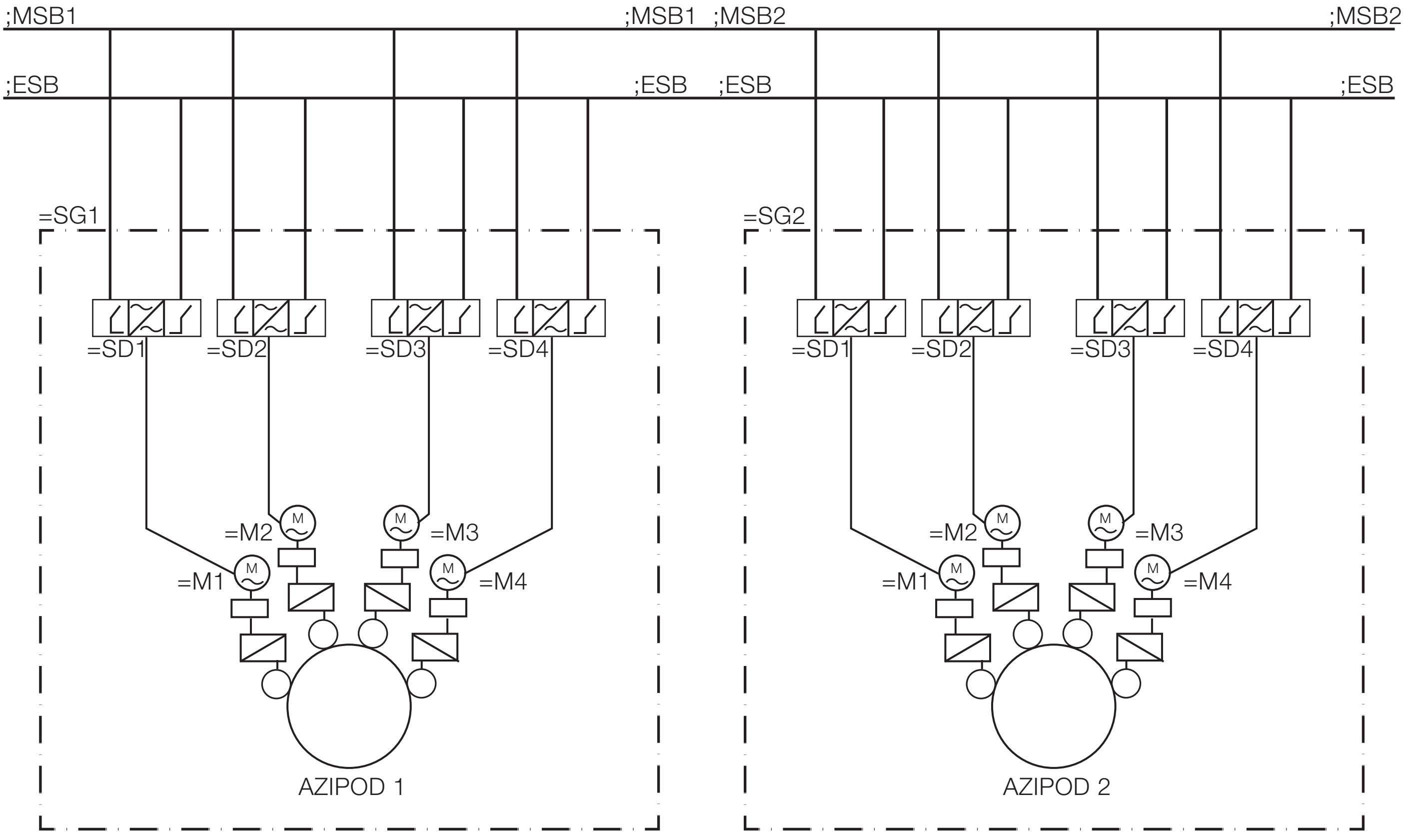

Figure 2-4 Typical steering power supply arrangement with automatic changeover supply units

2.8 The cooling arrangement for the propeller motor

The Cooling Air Unit is provided with radial type fans and double tube type fresh water heat exchangers for connection into the ship's LT water system.

The Cooling Air Unit is provided with the following components and accessories:

- Leakage detector per each cooler
- Air cooling ducts with inserted air filter elements
- Flexible bellows with counter flanges for the ship's LT technical fresh water supply

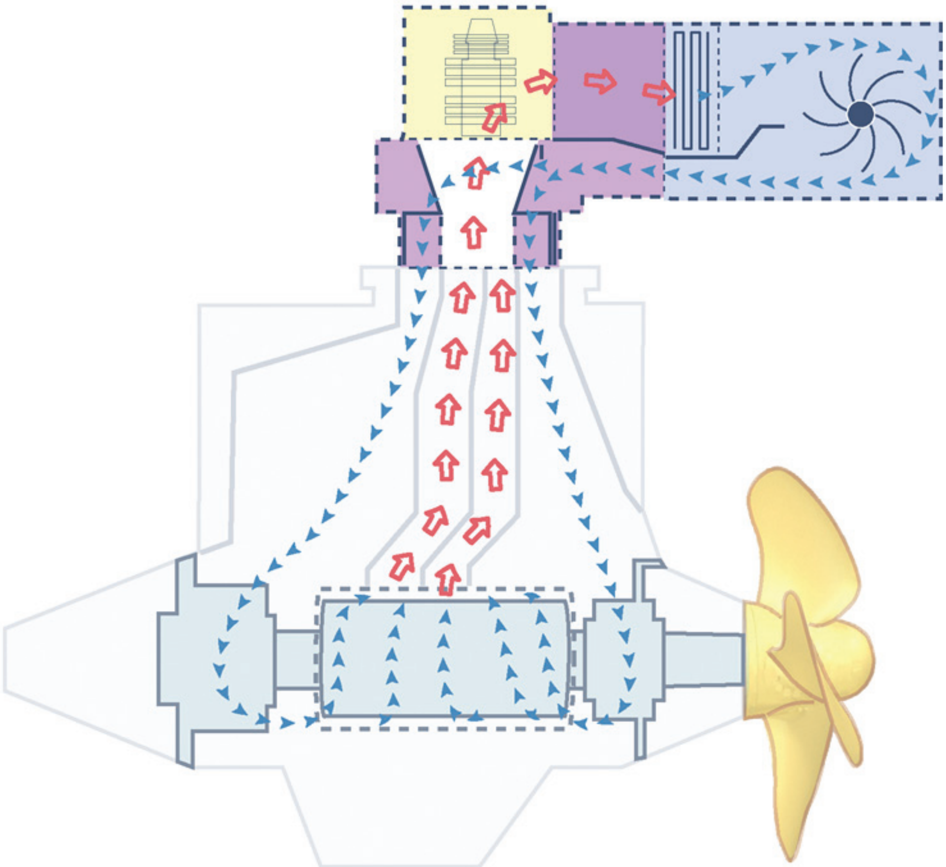

Figure 2-5 The air cooling arrangement of the propulsion motor

2.9 The shaft line bearing arrangement

The drive end (propeller end) of the shaft line is supported by an axially free roller bearing.

The non-drive-end bearing assembly (by the tail cap) consists of a slide pad thrust bearing and an axially free roller support bearing.

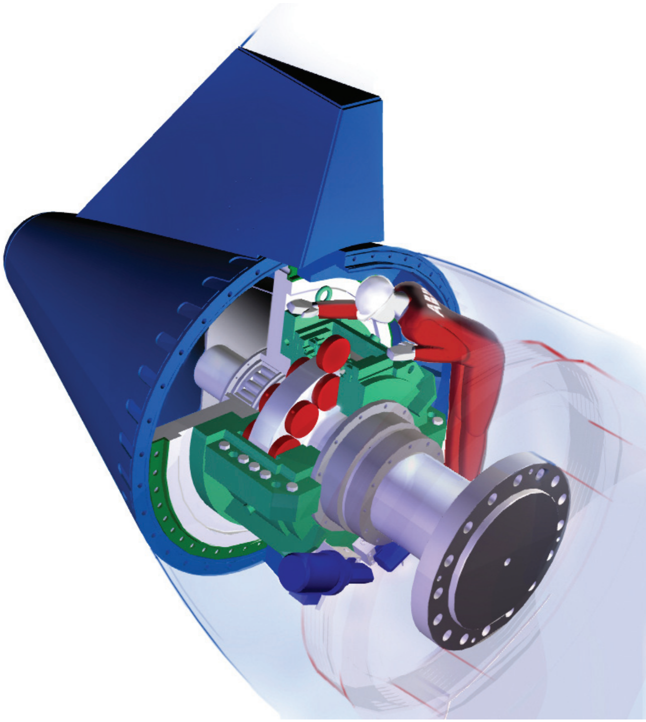

Figure 2-6 Thrust bearing pad exchange work in port

Both ends of the shaft line are splash lubricated and are built as oil sumps. The drive-end and the non-drive-end bearing sub-systems are separate from each other. The oil sumps are partly filled and the lubrication oil is circulated. Both ends have two lubrication oil pumps. One pump is to run and the other one is started automatically if the pressure in the lubrication system drops under a pre-determined limit. Both oil sumps for the bearings are sealed with a two-lip seal package.

The oils are circulated to Shaft line Support Unit (SSU) located in the Azipod room. There the oil is filtered and cooled down. Also several condition monitoring functions are provided at the SSU, depending on the selected delivery options.

The propeller shaft is provided with a four-lip oil lubricated sealing ring package against the sea. ABB-approved seals are compatible with ABB-approved bio-degradable lubrication oils. These sealing rings can be changed without dry-docking, through the Interspace void inside the Azipod. The sealing rings are in contact with a chrome steel liner fitted on the propeller shaft.

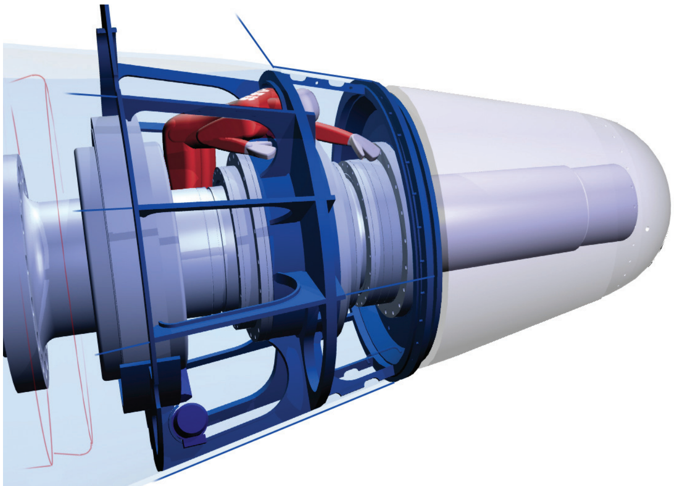

Figure 2-7 Shaft water seal exchange (work in port) through the Interspace

A hydraulic disc brake is provided for holding the propeller shaft during maintenance. The brake is connected manually and activated by a hydraulic hand pump. The holding capacity depends on the propeller design. Mechanical locking is provided for an emergency situation. Locking action is achieved with a mechanical locking piece. The maximum allowed water speed of the ship while locking the shaft depends on the design of the propeller.

A gear rim operates the absolute positional encoder transmitters on the shaft. One encoder operates and the other is provided for backup. Four (4) shaft earthing assemblies are provided on the shaft, two in the drive end and two in the non-drive end.

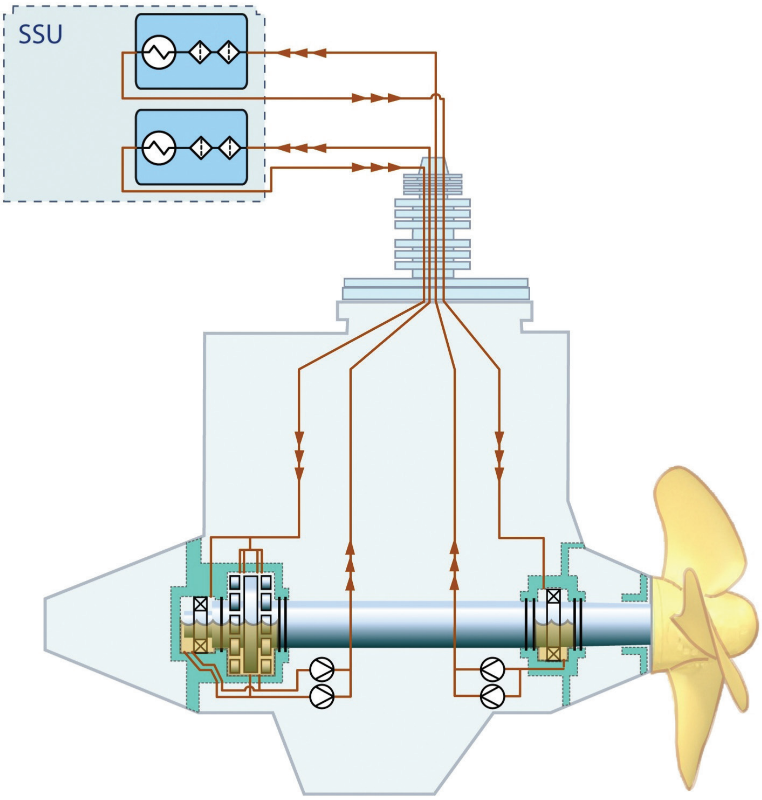

Figure 2-8 The shaft line lube oil arrangement

3 Ambient reference conditions

3.1 Azipod

Rated sea water temperature	-2…+ 32°C
Maximum resultant mounting angle (longitudinal and lateral)	4°
The maximum allowed combined resultant of the mounting angle and of the propulsion module tilt angle α *) is	6°

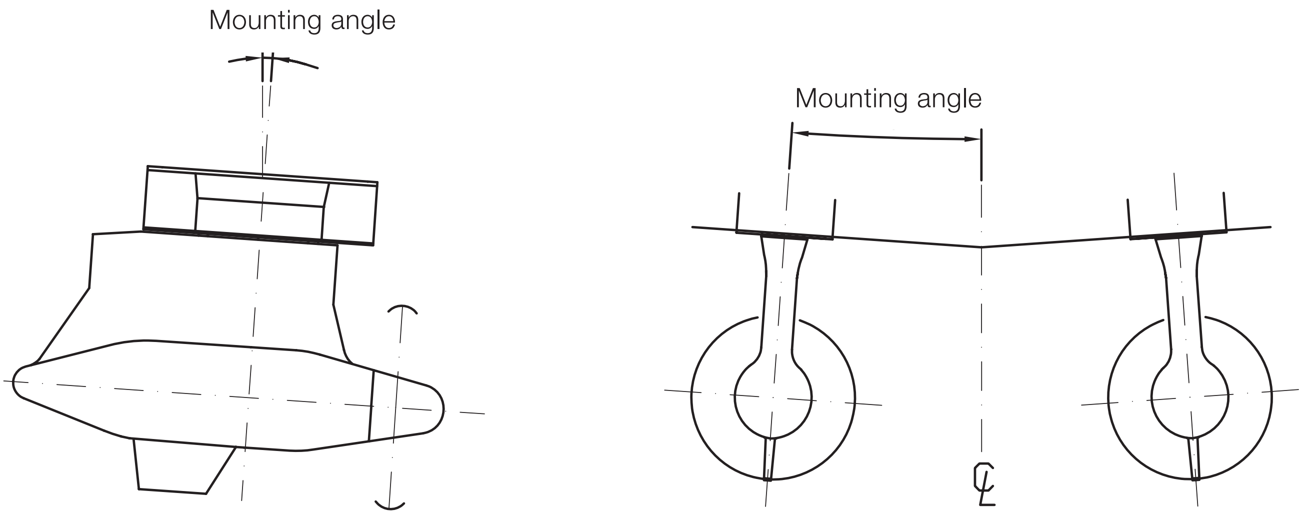

Figure 3 1 Mounting angles (longitudinal and lateral)

Azipod is rated as a Permit Required Confined Space for personnel entry. Asphyxiating fire-fighting media may not be released into the Azipod Propulsion Module, if physical personnel entry is possible.

3.2 Azipod room requirements

The Azipod room needs to be rated as a Machinery area with sufficient air conditioning. The humidity inside the room needs to remain at a level were no condensation occurs on any parts. The rated normal temperature is between +10 …+ 45°C,

*) see section 2.3 Main dimensions

4 Ship system interface

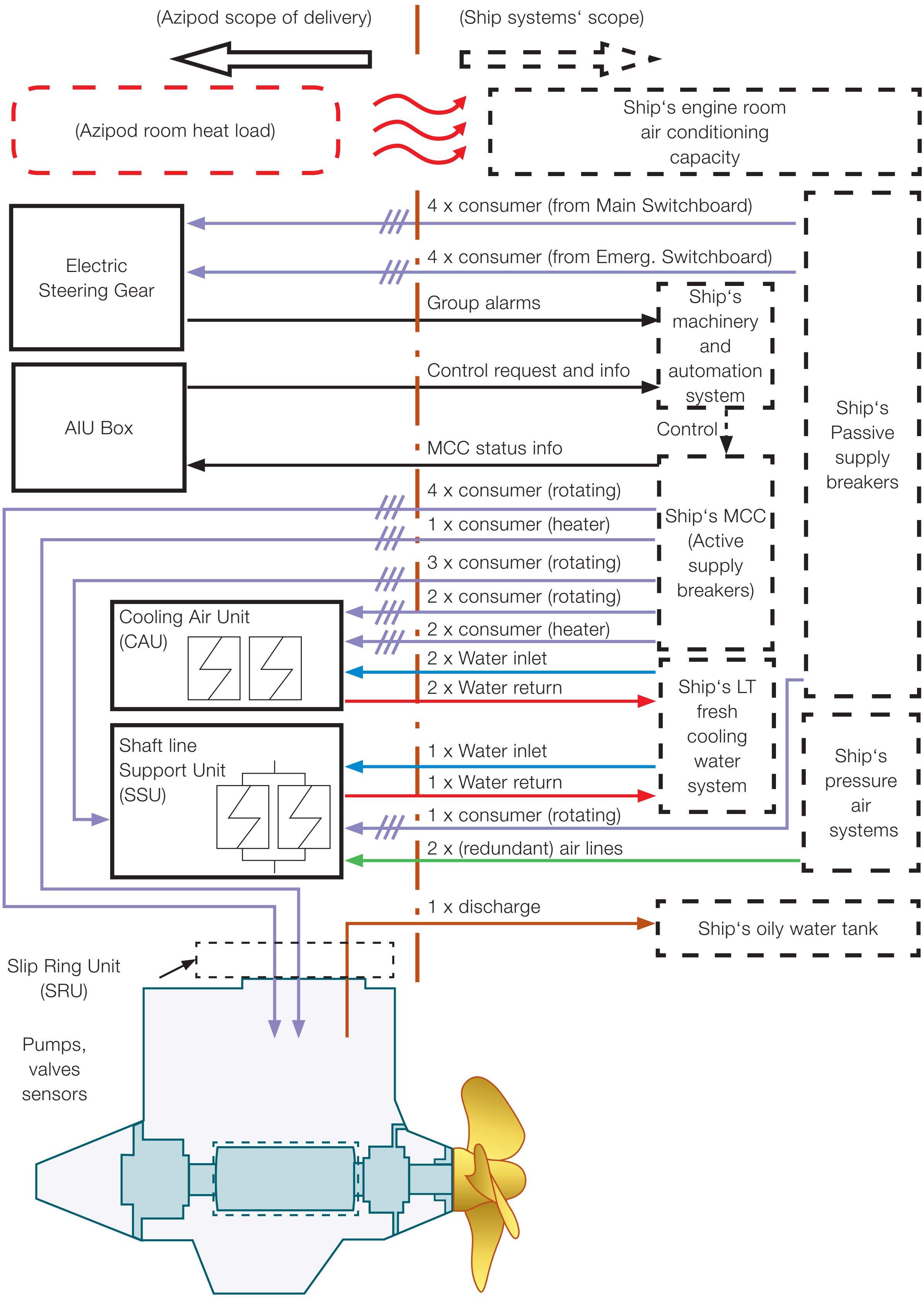

Figure 4-1 Typical interface with the ship’s systems

4.1 Ship automation interface

The auxiliary functions of the Azipod delivery are controlled by the ship's machinery and automation system. Therefore, an interface has to be created. The ship's machinery and automation system supplier and the shipyard, as well as ABB, need to define together the related I/O specification and also the appropriate visual screen display views that are provided from the ship's machinery and automation system. The Azipod interface to the ship automation is based on Modbus RTU protocol, where ABB works as the master.

Azipod Interface Unit (AIU) sends control request to the ship's machinery and automation system. The ship's machinery and automation system is in charge of the following functions:

1. Control of propulsion auxiliaries
2. Control of cooling air subsystem
3. Control of shaft line oil circulation
4. Group monitoring and alarms imported from independent ABB sub-systems, to a detail and to an extent that need to be defined during the project design stage

4.2 Ship auxiliary power supply interface

The shipyard delivers the motor starter functionalities for the electric motors of the Azipod auxiliaries. Potential free (closing relay) binary contacts are required by ABB from the shipyard's motor control center functionality (MCC) as output status information in hard wiring.

5 The remote control system

The Azipod scope of supply is enhanced with the ABB “IMI” (= Intelligent Maneuvering Interface) remote control and operator guidance indication system. This provides an up-to-date control outfit for the Bridge and for the Engine Control Room and can be elegantly installed into the various externally supplied Bridge console deliveries seen on the commercial shipbuilding market today. The control items are intended for consoles that are located indoors.

The remote control system provides on-line operator guidance and feedback for optimal Azipod use. The purpose of this functionality is to promote economical and smooth ship operation.

This bus-based system is designed redundant and is engineered in-house at ABB Marine. A hard-wired back-up sub-system is included. Many different modular control configurations can be provided, also including optional command and control post change functions for an external bow thruster system.

The usual industrial standard interfaces are provided for external Autopilot, external Joystick / DP and external Voyage Data Recorder.

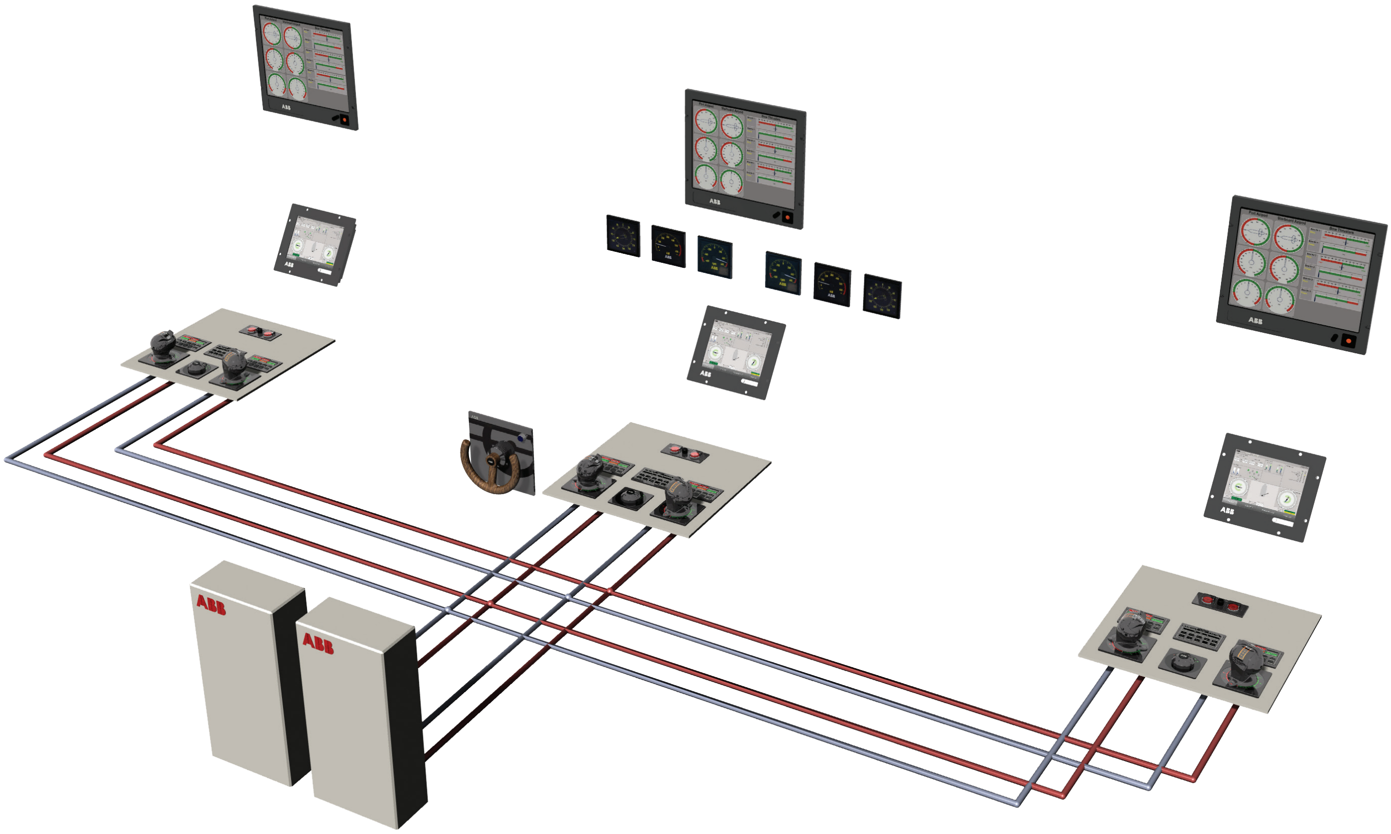

Figure 5-1 Typical remote control outfit

6 The Propulsion Condition Management System

6.1 General

The Propulsion Condition Management System (PCMS) is the technical solution for condition monitoring of the critical components of the Azipod and propulsion system. The PCMS acquires and stores data continuously from several sources and provides functions for:

- Condition monitoring
- Wear and lifetime analysis
- Remote diagnostics
- Troubleshooting
- Scheduled audits and reporting

The PCMS functions implemented onboard are tailored specifically to the agreed extents and requirements of the ship project.

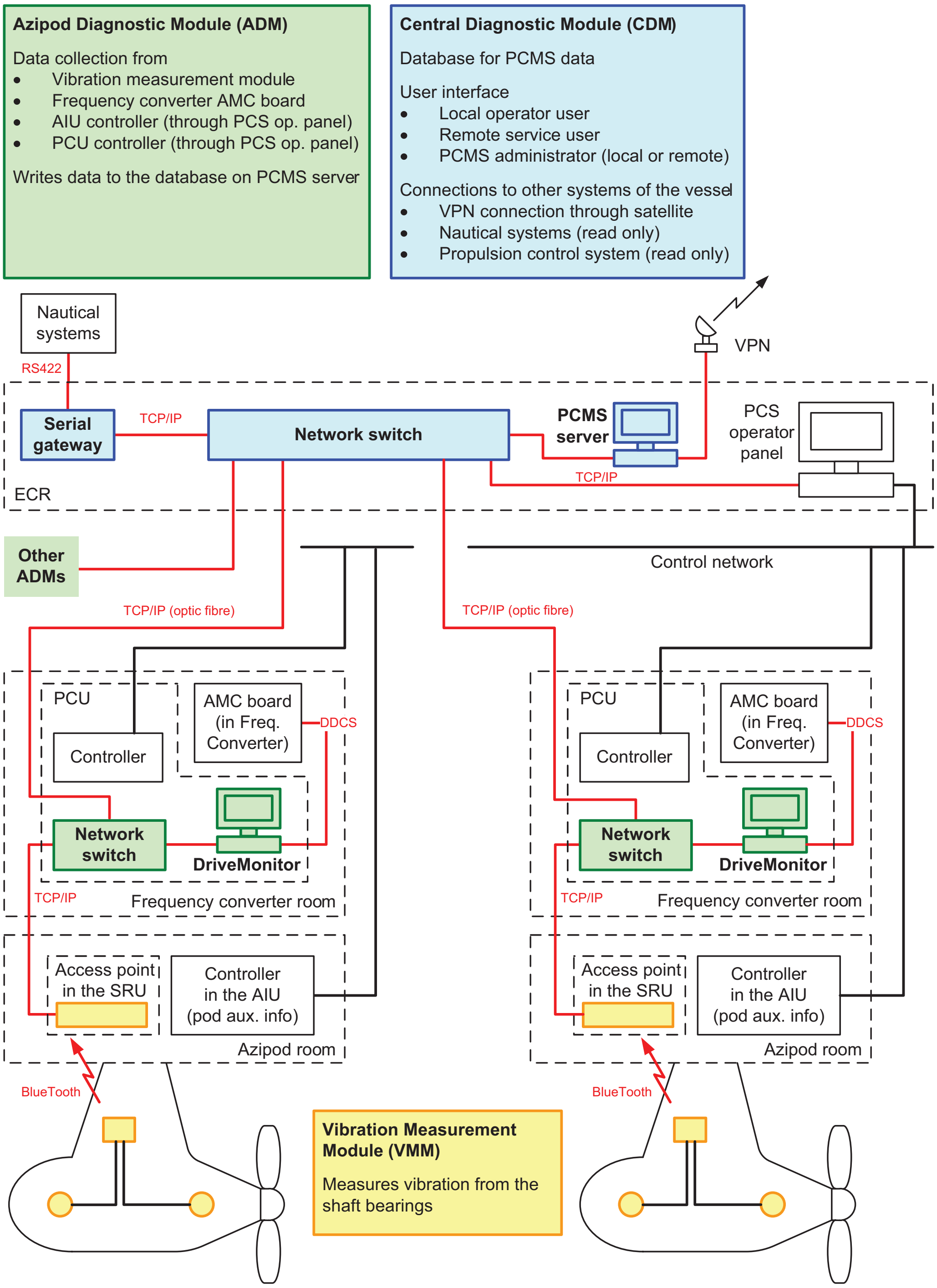

Figure 6-1 Layout of the PCMS

6.2 Shaft bearing monitoring

Condition monitoring of the shaft bearings is based on recorded vibration, temperature and lubrication oil properties. The analysis functions provide information for the operator to monitor the bearing condition. All analyses are performed for both drive end and non-drive end bearings.

A. Vibration: Bearing vibrations are measured by acceleration transducers at wide bandwidth. Several analysis functions are performed on the results in order to detect wearing, lubrication problems or possible other operational defects.
B. Temperatures: Bearing and lubrication oil temperatures are measured by several sensors. The resulting trends are stored in the PCMS.
C. Lubrication oil properties: the following attributes are monitored by means of various sensors installed in the Shaft Line Support Unit (SSU):
   - Humidity
   - Contamination
   - Metal particles

6.3 Propulsion system monitoring

A. The alarms and events from the propulsion system are recorded. This enables following and tracking faults or alarms also after they have been cleared from the system. The PCMS itself does not generate alarms for other systems in the ship. The events are read from:
   - The Azipod Interface Unit (AIU)
   - The Propulsion Control Unit (PCU)
   - The Propulsion Power Drive
B. Trends are also recorded from the main quantities that define the operation point of the propulsion system. These include data from the Azipod, frequency converter, propulsion motor and propulsion control system.

6.4 Nautical data interface

Data from external nautical systems is acquired in conjunction with the bearing vibration measurements in order to account for environmental factors in the vibration levels. PCMS does not introduce new measurements, but the data is read from the ship's systems.

7 Ship design

The following paragraphs describe the usual shipyard design process with Azipod:

7.1 Design flow

A. After defining the basic ship layout, the Azipod Propulsion Module is chosen based on the thrust or propeller torque requirements (generally ruled by the ship's speed vs. resistance curve).

B. The Steering Module is selected in function of the steering torque, usually defined by the propeller power, strut height, and the speed of the ship. The ship's power plant dimensioning is checked to match the performance of the two modules.

C. The auxiliaries are chosen to fit the Propulsion and Steering Modules. As above, any special redundancy requirements must be agreed on within the limits of specified options.

D. Azipod room design work (with the appropriate fire area definition) is carried out.

E. System interfaces are detailed with the allocation of ship automation points.

F. The ship control layout is configured.

7.2 Hydrodynamics

The shipbuilder begins the hydrodynamic design of the ship with the following steps:

A. Sketching the after lines of the podded ship, locating the Azipod unit(s)

B. Estimating the propeller diameter and tip clearance (head box configuration, if required)

C. Defining the speed vs. thrust curve for the ship on given draught conditions

D. Selecting the required power and rpm value for the propeller(s)

E. Contacting ABB with an inquiry

7.3 Azipod location on the ship's hull

It is important to place the Azipod at the correct location on the ship's hull. Typically any part should not come out by the side or by the transom. According to experience in the twin Azipod solution it is recommended that the pods are located as far astern and as close to the ship's sides as possible. Azipod Propulsion Modules have to be located so far from each other that sufficient clearance between is maintained at all steering angles (recommended minimum 300…500 mm, depending on the case). For more accurate design, the hull shape of the ship and water flow must be considered.

7.4 Propeller

Azipod propellers are always fixed-pitch propellers (FPP) because of the control of propeller speed and torque by a frequency converter. The typical Azipod has a pulling-type propeller as a monoblock or with built-on blades. The optimized propeller is tailored for the ship. ABB is in charge of the propeller design, and it is done in close co-operation with the designers of the shipbuilder.

7.5 Forces on ship's hull

Forces from the Propulsion Module are transferred to the ship's hull steel structure trough the steering module. The Steering Module is to be welded to the ship's hull as a structural member. ABB delivers the calculated support loads and the recommended installation instructions for the mounting of the steering module.

8 Example of Azipod propulsion with the power plant

In this typical example four main generators are connected to the main switchboard, and the low voltage switchboard is supplied by ship service transformers. The main switchboard can be divided into two separate networks by means of the tie breakers to increase the redundancy of the power plant.

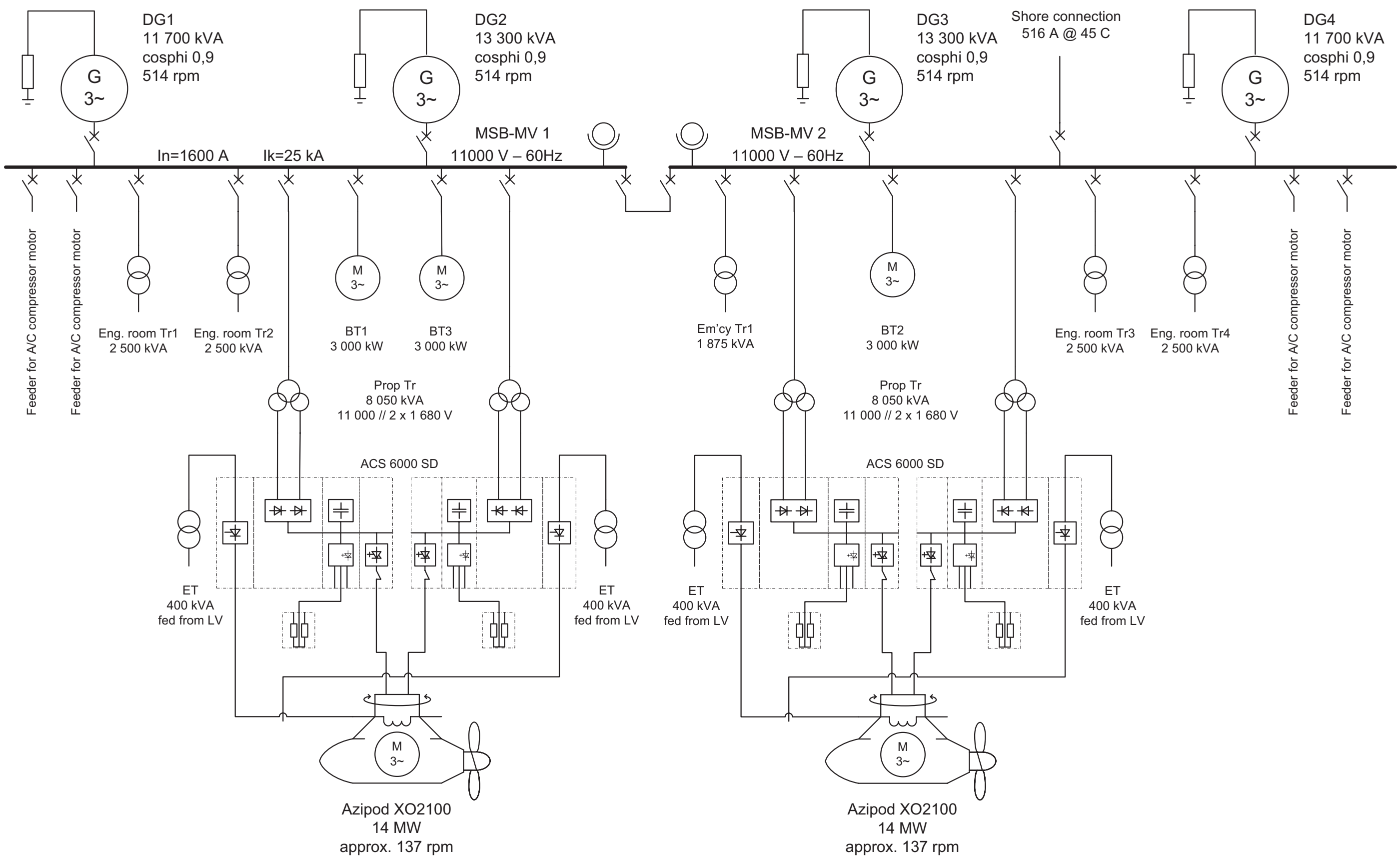

Figure 7-1 Typical single line diagram of the onboard power plant

9 Information sheet for system quotation

Our intention is to work together with our customers to optimize ship design related to the total building concept. All additional information related to the ship's operating profile and other special requirements will also be helpful.

Shipyard:	
Owner:	
Type of ship:	
Main dimensions of the ship:	Lpp= , B= T= , GT/DWT =
Block coefficient or displacement:	
Estimate of the resistance (naked hull):	
Speed of the ship:	
Classification society:	
Special notations (Ice class, DP, etc.):	
Number of Propulsion Modules per ship:	
Estimated Propulsion Module power:	
Estimated propeller diameter and rpm:	
Bollard pull requirement:	
Main generator sets: (type, rpm, number and power of units)	
Main switchboard voltage and frequency:	
Auxiliary switchboard voltage:	
Bow thruster power:	
Ship's electrical auxiliary and hotel load:	
Number of ships to be built:	
Delivery time for the equipment:	
Delivery time of the ship:	
Attachments: (GA drawing, etc...)	

Contact us

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