

Azipod® XO2100 Product Introduction

Power and productivity
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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 redesigned according to the technology development 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.

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1 General

The first Azipod® installation onboard was commissioned in 1990. By April 2009, the milestone of 4,5 million cumulated operating machinery hours has been reached.

1.1 Azipod Propulsion and Steering

The Azipod XO2100 main propulsion and steering system has been developed as the successor to the classic “V21”-series Azipod product. Azipod is a podded electric main propulsion and steering device driving a fixed-pitch propeller at a variable speed setting.

Azipod propulsion is designed for the preferential use of the (directly driven) pulling propeller when driving in the Ahead direction. The type 2100 Azipod is azimuthing (steering around its vertical axis) infinitely by 360° and is available generally for power ratings of between 13 and 18 MW, depending on the propeller design.

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

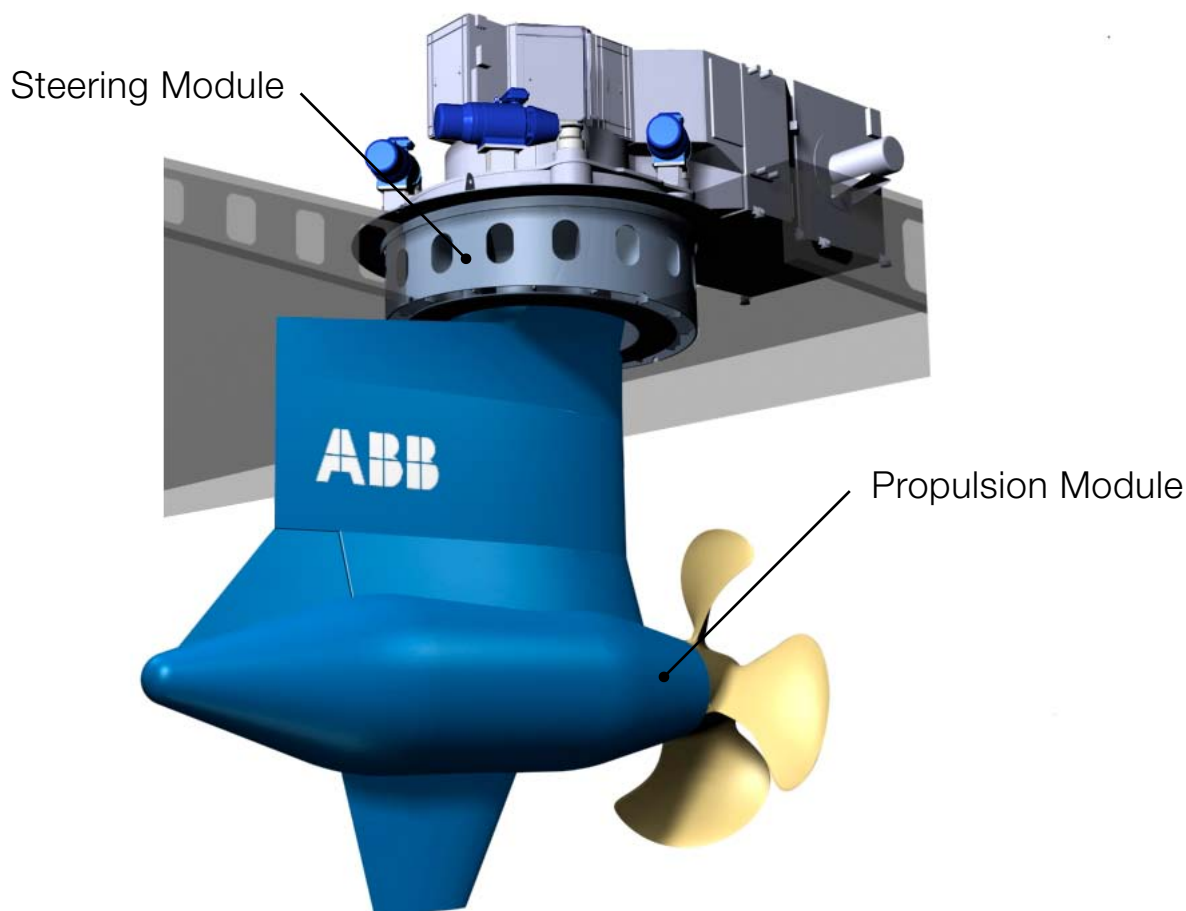


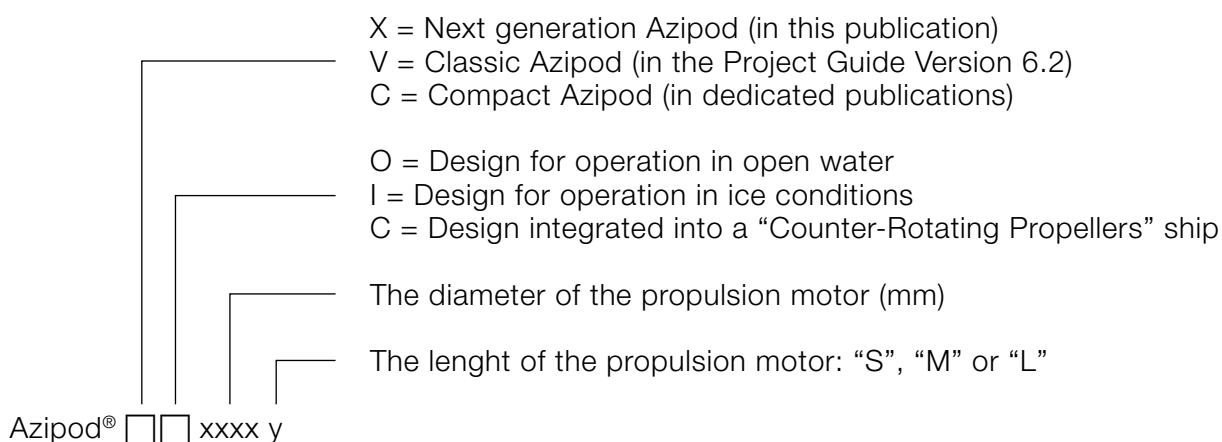
Figure 1-1 Basic arrangement of the Azipod XO2100

1.2 Main points in the Azipod XO2100 evolution

Subject	Highlights
A. Re-designed access and work arrangements inside the Propulsion Module	Safer work with extended possibilities for inspections and preventive maintenance
B. More streamlined design of the Propulsion Module, and the new propeller blades and hub	Better hydrodynamic efficiency. Improved versatility for propeller installation procedures
C. Re-design of the propeller shaft bearings and seals to improve the life cycle cost prognosis	Possibility to change shaft seals while in port. New 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 integrated manual 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).



Example: Azipod® XO 2100 S

...being an open water design Azipod with a shaft power in the lower end of the range (e.g. 13 MW)

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). Alternator 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.

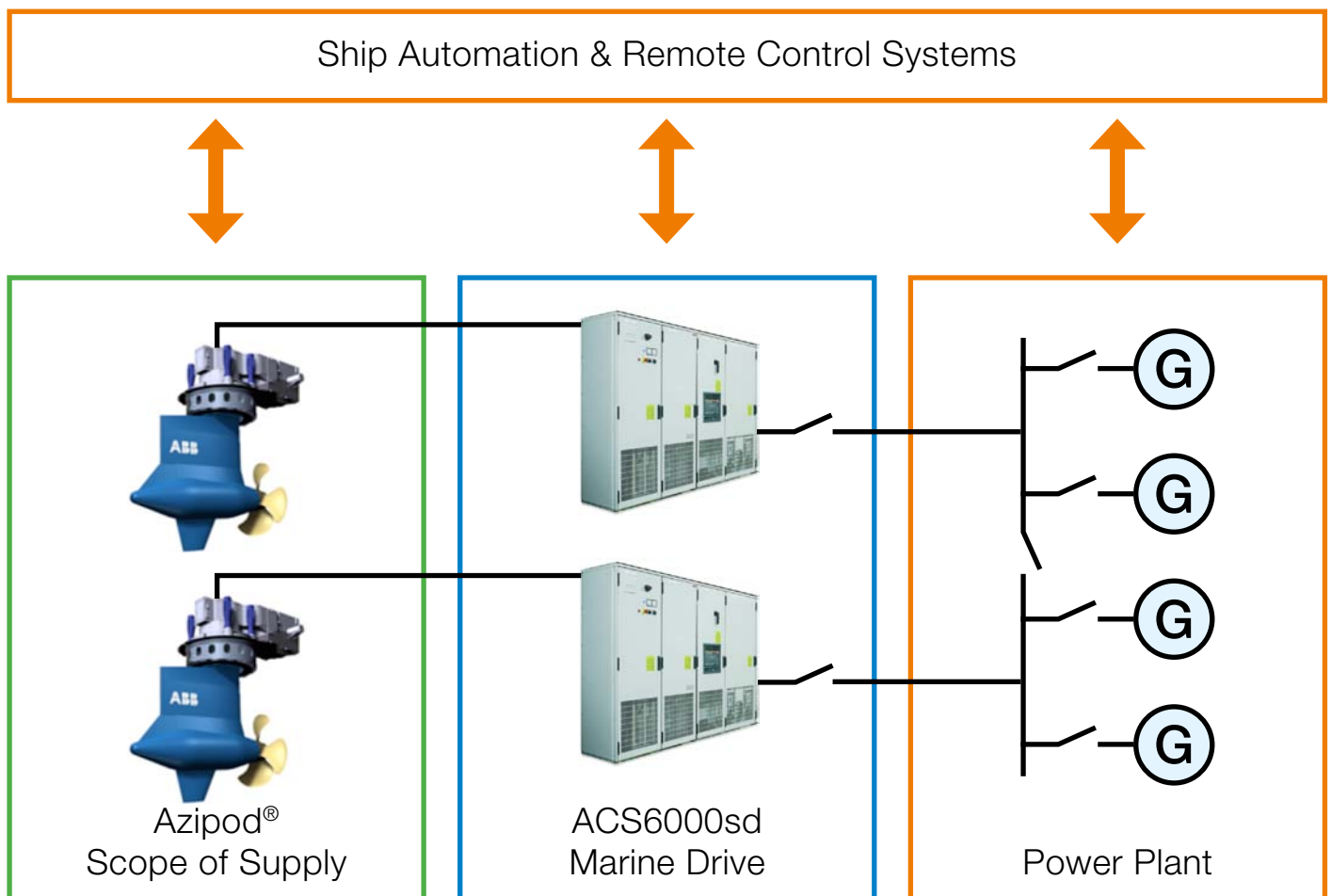


Figure 1-2 Simplified single line diagram of the power plant with a propulsion system.

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
- (Usually four) 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)

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.

2.3 Ship-specific delivered items

In addition to the above listed delivery, the ABB scope of supply typically includes all or most of the following items:

- A. One Propulsion Power Drive per each Azipod
- B. Remote Control System
- C. The Generator and Switchboard power network outfit

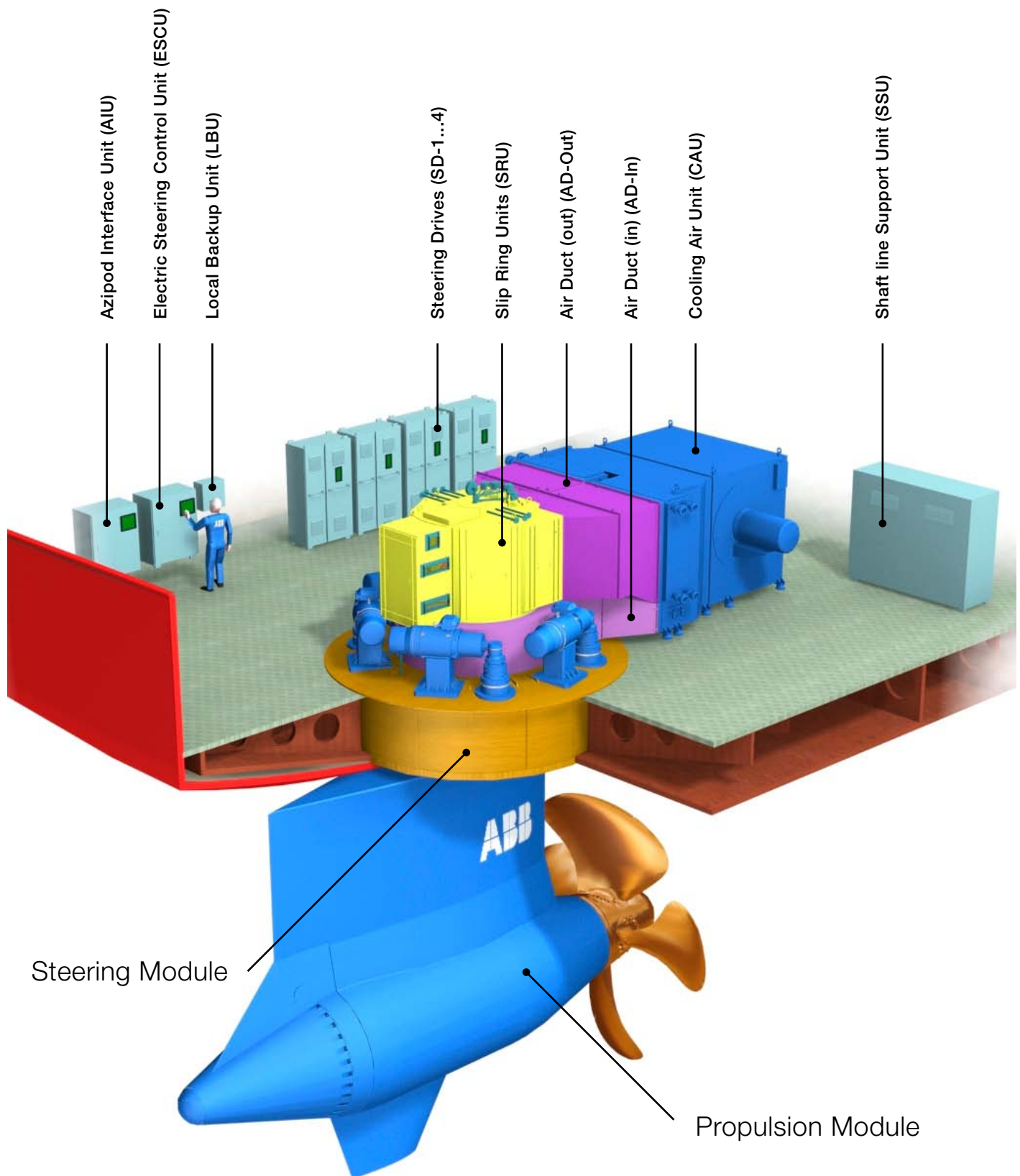


Figure 2-1 Layout example of Azipod modules and auxiliaries

2.4 Main dimensions

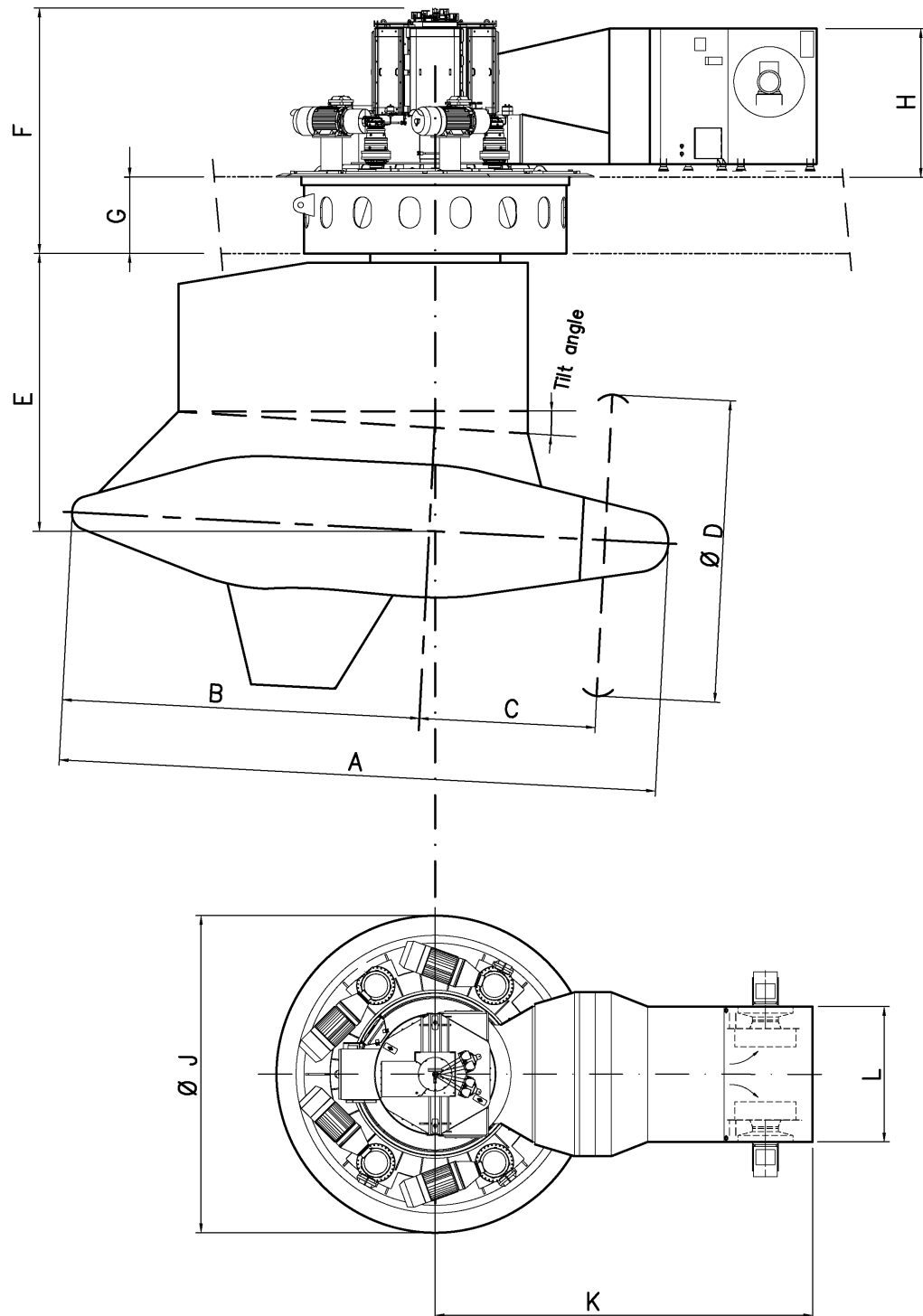


Figure 2-2 Dimensional nominations for the Azipod

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”) can be altered under special consideration on ship-specific design basis.
- The eventual Cooling Air Unit detail selection may slightly alter the related dimensions. (“H”, “K” and “L”).

Code	Subject	Dimensions	Unit	Status
	Tilt angle	0...6	Degr.	Variable
A	Total length	11,5	m.	Fixed
B	Tail extension from the azimuth	6,9	m.	Fixed
C	Propeller disk extension from the azimuth	3,4	m.	Fixed
ØD	Propeller diameter	4,4...6,4	m.	Variable
E	Vertical measure from the shaft line cross	4,3...7,1	m.	Variable
F	Height of Steering Module	4,6	m.	Fixed
G	Double bottom fit thickness	1,5	m.	Fixed
H	Room height for the Cooling Air Unit	3,0	m.	Fixed
ØJ	Steering module flange diameter	6,1	m.	Fixed
K	Hard outfit horizontal from the azimuth	6,3	m.	Fixed
L	Width of the Cooling Air Unit frame	2,6	m.	Fixed

2.5 Weights

Propulsion Module (excluding the propeller)	135 000 – 170 000 kg
Propeller	22 000 – 35 000 kg
Steering Module	50 000 – 70 000 kg
Slip Ring Unit (SRU)	4 000 kg
Steering Drives (SD)	4 x 360 kg
Electric Steering Control Unit (ESCU)	95 kg
Cooling Air Unit (CAU)	9 000 – 12 000 kg
Shaft line Support Unit (SSU)	500 kg
Air Ducts (AD-In), (AD-Out)	Project-specific, typically 2 x 300 kg
Azipod Interface Unit (AIU)	100 kg
Local Backup Unit (LBU)	20 kg

2.6 Technical parameters: Propulsion Module

Rated output power	13 000 – 18 000 kW
Nominal propeller speed at rated output power	122 – 170 rpm
Maximum nominal (ahead) torque	To be defined
Main motor supply voltage	Approx. 3000 V
Motor current	To be defined
Insulation / temperature rise class	F / F
Propeller design	4 or 5 blades
Propeller blade type	Built-on blades / Monoblock
Propeller material	Ni-Al Bronze
Propeller manufacturing and balancing	ISO 484 class 1
Propeller state when delivered (always pre-fitted):	Mounted on / un-assembled
Shaft brake holding capacity	4.5 – 6 knots bypass water flow
Shaft locking capacity	10 – 12 knots bypass water flow
Non-drive-end lube oil pump power	2 x 2.7 kW at 400 V / 50 Hz – 440 V / 60 Hz
Drive-end lube oil pump power	2 x 1.3 kW at 400 V / 50 Hz – 440 V / 60 Hz
Diaphragm drainage pumps capacity	2 – 3 x 1.0 m ³ /h
Drainage pump air supply requirement	15m ³ /h with 6–8 bar per pump
Standstill heater resistance elements	4 x 800 W
Displacement	55 – 70 m ³
Outside painting area	115...150 m ²

2.7 Technical parameters: steering and support systems

Steering motors	4 x 75...90 kW
Steering motors Supply voltage	400 V / 440 V / 690 V / 50/60 Hz
CAU water supply inlet temperature	36°C
CAU water supply pressure, nominal	6 bar
CAU Supply voltage	400 V / 50 Hz – 440 V / 60 Hz - 3 phases
CAU Fan Motor Power	2 x 55/63 kW
CAU cooling LT water requirement	100 m ³ /h
LT water requirement, non-drive-end bearing	4.2 m ³ /h
Heat losses to LT water, non-drive-end bearing	Max. 30 kW
LT water requirement, drive-end bearing	2.1 m ³ /h
Heat losses to LT water, drive-end bearing	Max. 13 kW
Protection class for electrical enclosures	IP 44

2.8 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.

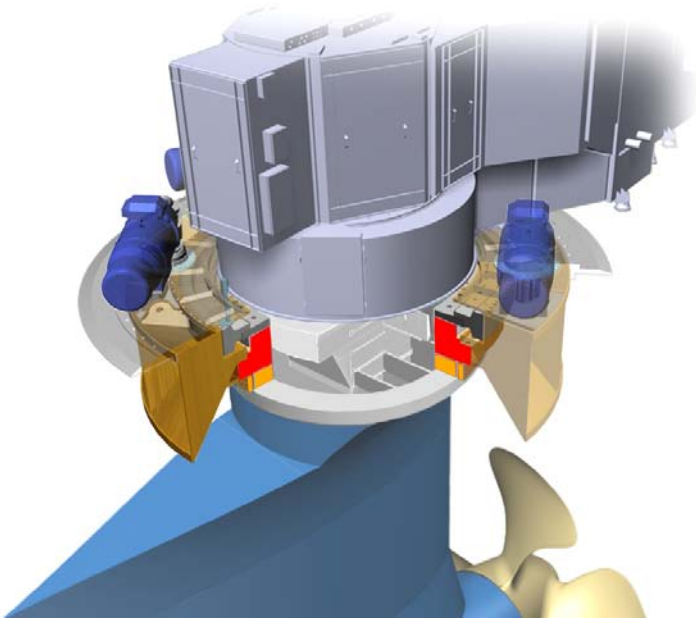


Figure 2-3 Split view of the top delivery showing the steering gear mechanics

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 tapered 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 double 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.

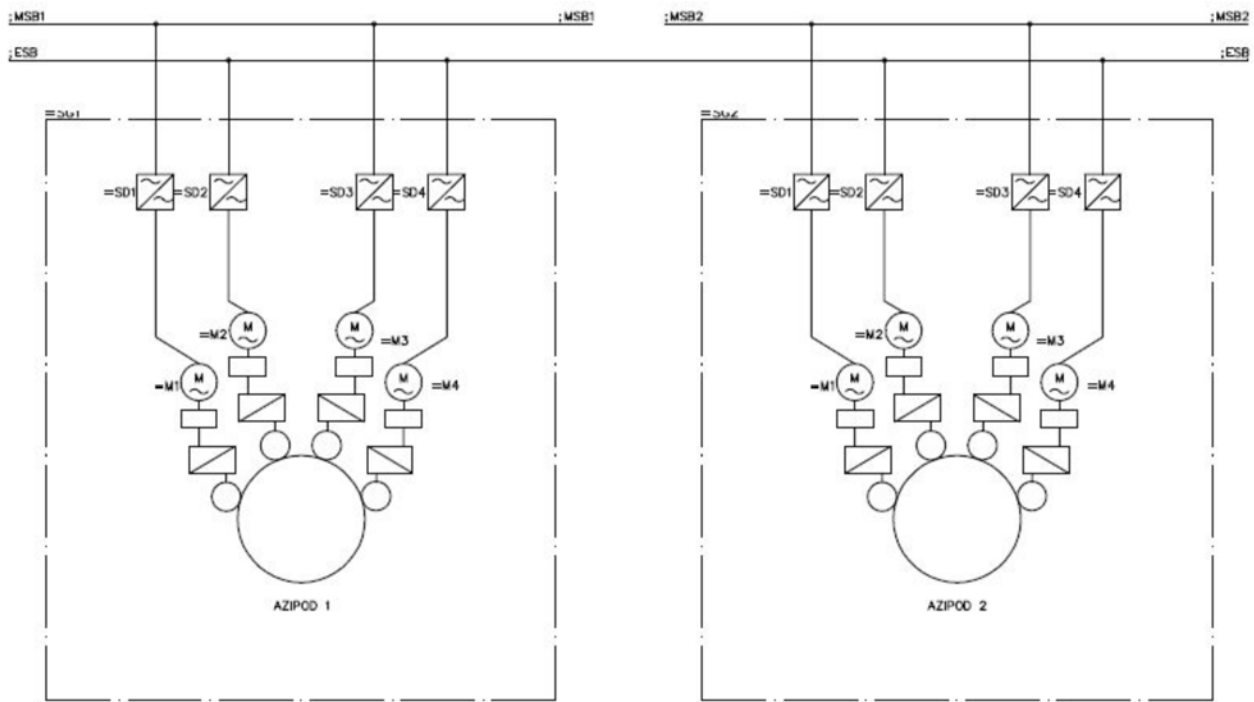


Figure 2-4 Example of the usual steering power supply arrangement for a twin Azipod ship

2.9 The cooling arrangement for the propeller motor

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

When both fans run together with the two heat exchangers, 100% cooling capacity is obtained. Air cooling ducts are provided with inserted air filter elements.

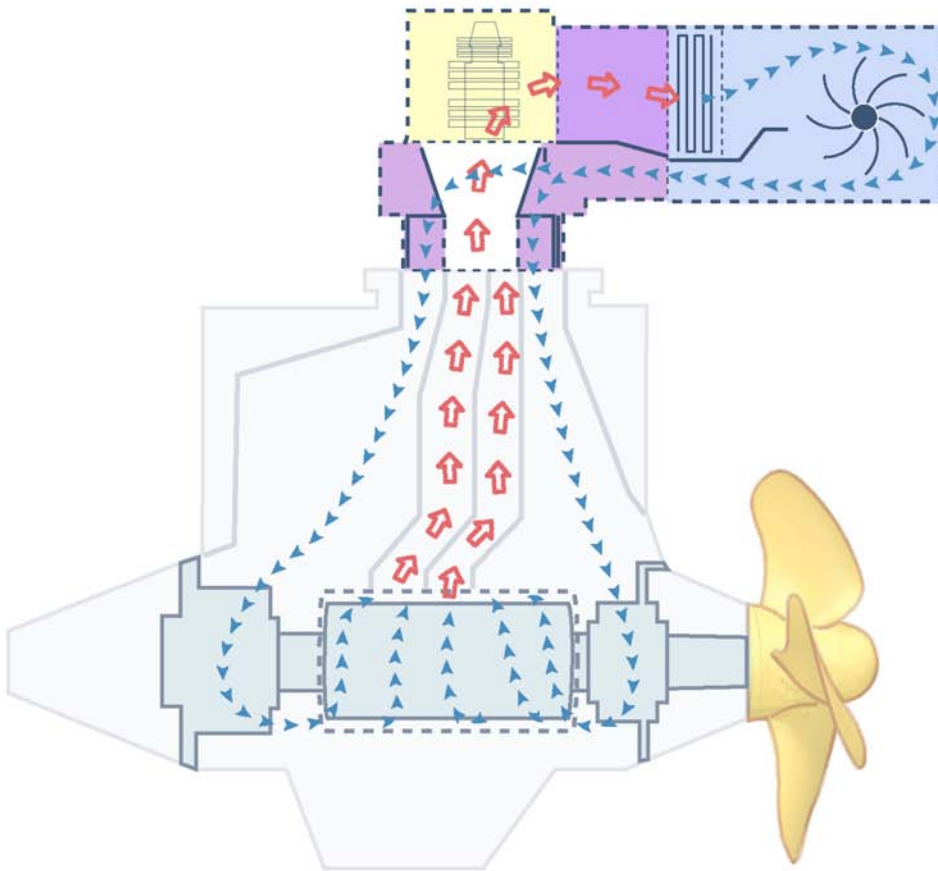


Figure 2-5 The air cooling arrangement of the propeller motor

2.10 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 (= tail cap end) bearing assembly consists of a slide pad thrust block (twelve pads for Ahead thrust and twelve pads for Astern thrust) and an axially free roller support bearing.

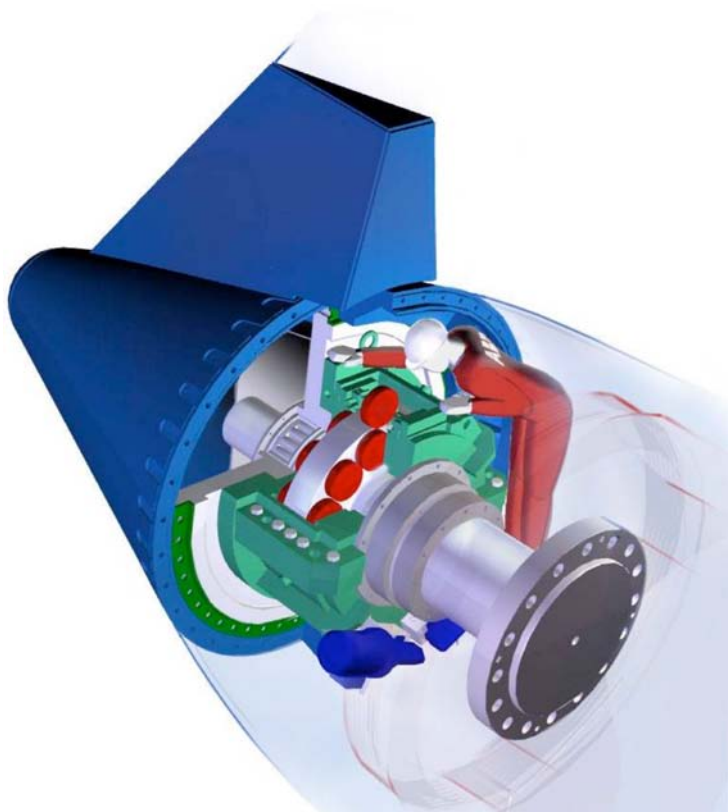


Figure 2-6 Thrust block pad exchange work in port

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.

Two (2) gear rims operate the absolute positional encoder transmitters on the shaft. One encoder operates and the other is provided for backup. Two (2) shaft earthing assemblies are provided on the shaft, one in the drive end and the other in the non-drive end.

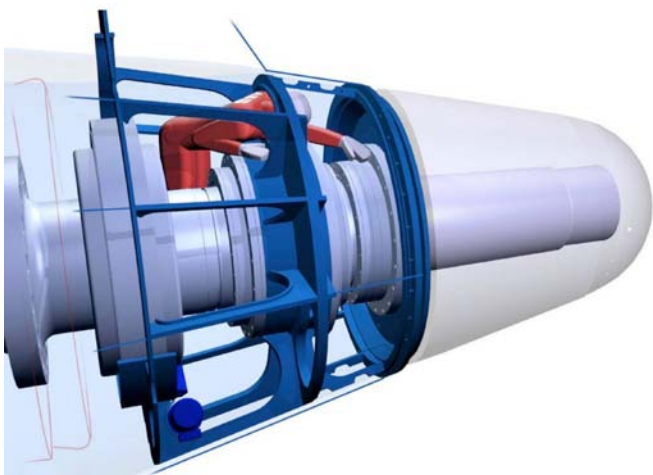


Figure 2-7 Shaft water seal exchange (work in port) through the interspace

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.

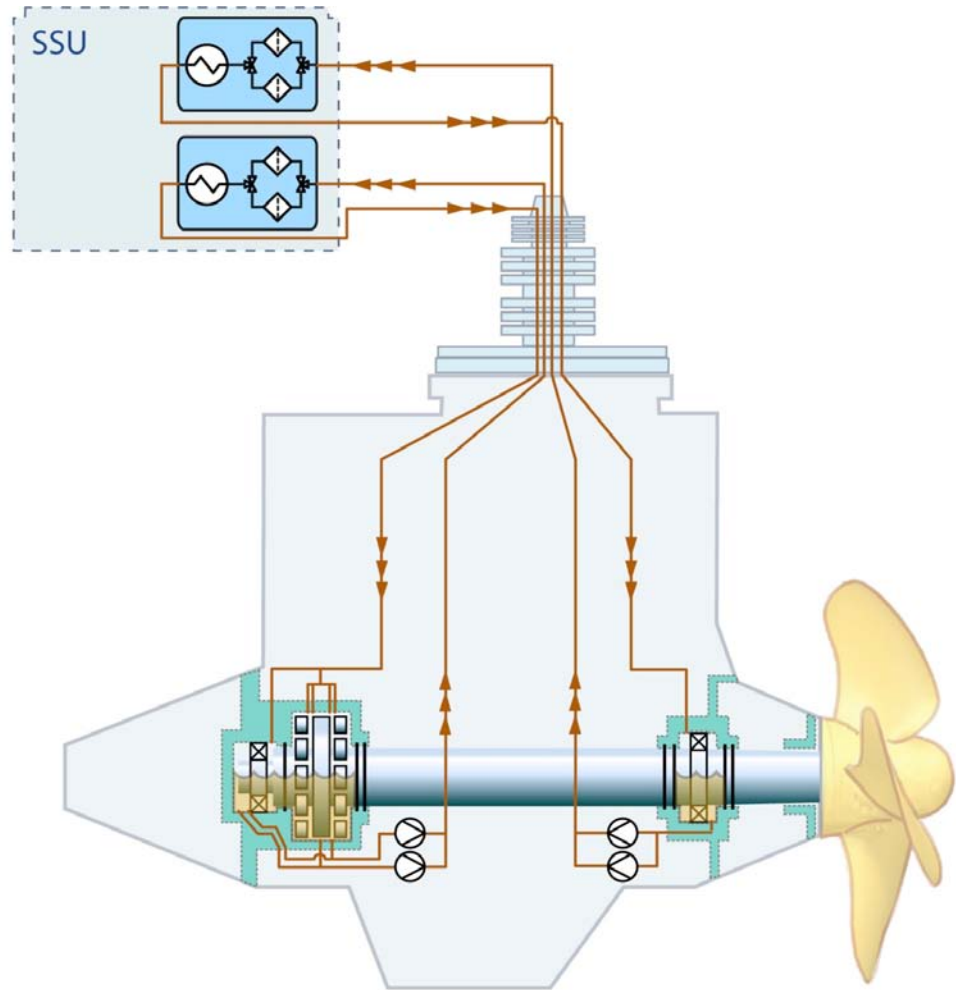


Figure 2-8 The shaft line lube oil arrangement

3 Ambient reference conditions

3.1 Azipod

- Rated sea water temperature -2...+32°C
- Maximum resultant mounting angle (longitudinal and lateral) 4°
Note: The maximum allowed combined resultant of the mounting angle and of the tilt angle (see the Azipod dimensional nominations) is 6°.
- The 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.

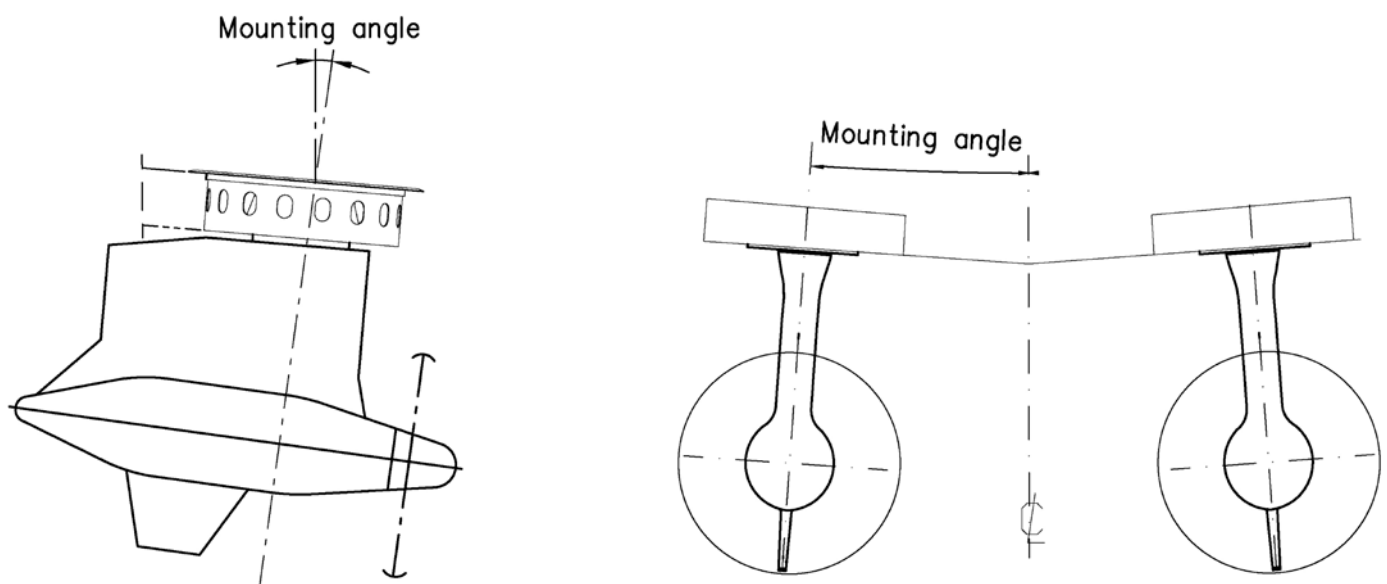


Figure 3-1 Mounting angles (longitudinal and lateral)

3.2 Azipod room requirements

- Machinery area rating with sufficient air conditioning
- Rated normal ambient temperature +10 ...+ 45°C
- Ambient relative humidity No condensation allowed on any parts

4 Ship system interface

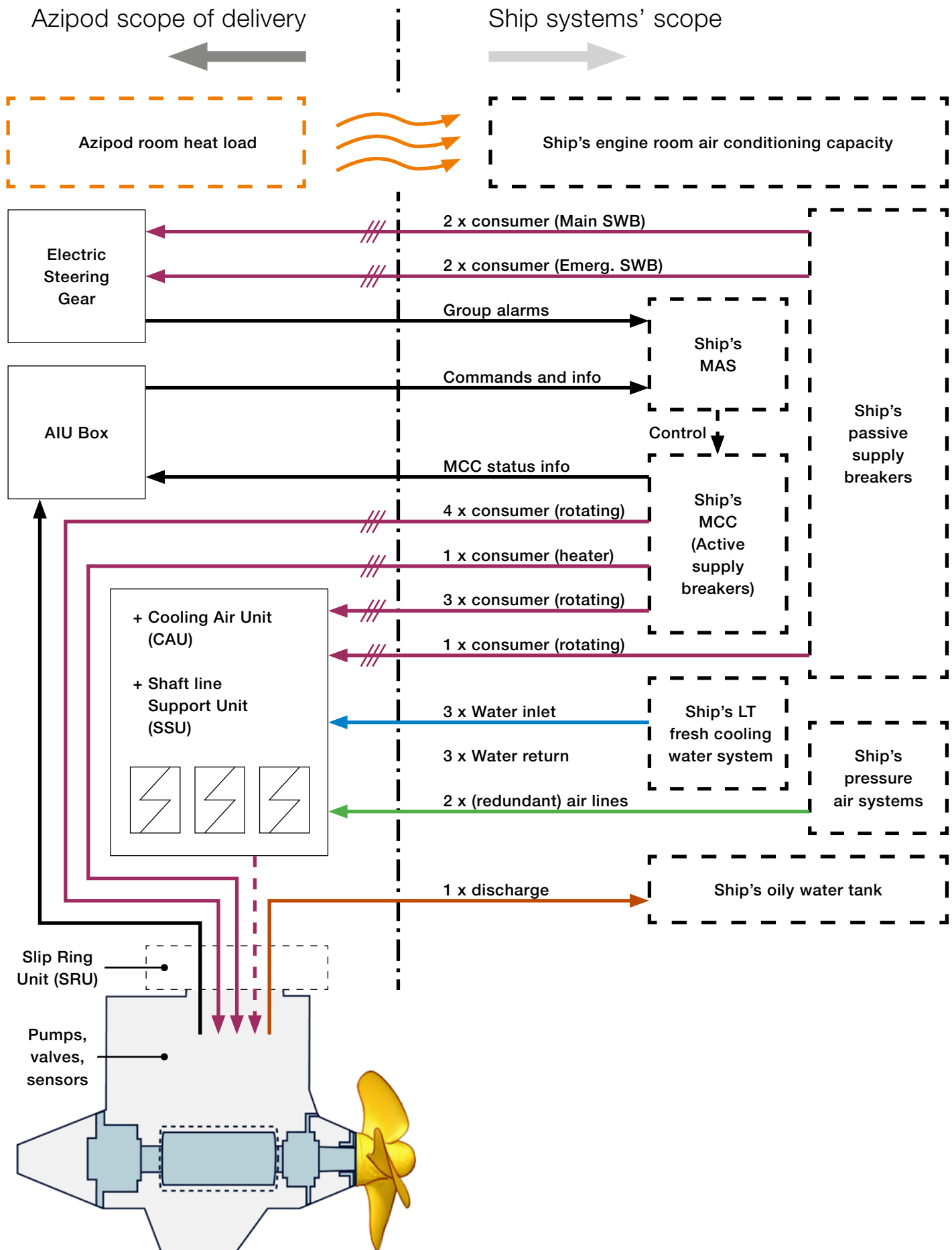


Figure 4-1 Typical interface with the ship's systems

4.1 Ship automation interface

The auxiliary functions of the Azipod delivery are controlled by the ship's machinery automation system (MAS). Therefore, an interface has to be created. The MAS 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 MAS.

The MAS 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

The Azipod interface to the ship automation is based on Modbus RTU protocol, where ABB works as the master.

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 manual remote control system

The Azipod scope of supply is enhanced with the ABB “IMI” (= Intelligent Maneuvering Interface) manual remote control and operator guidance indication system. This provides an up-to-date manual 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.

This remote control system also provides on-line operator guidance and feedback for optimal use of the Azipod. 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 backup 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.

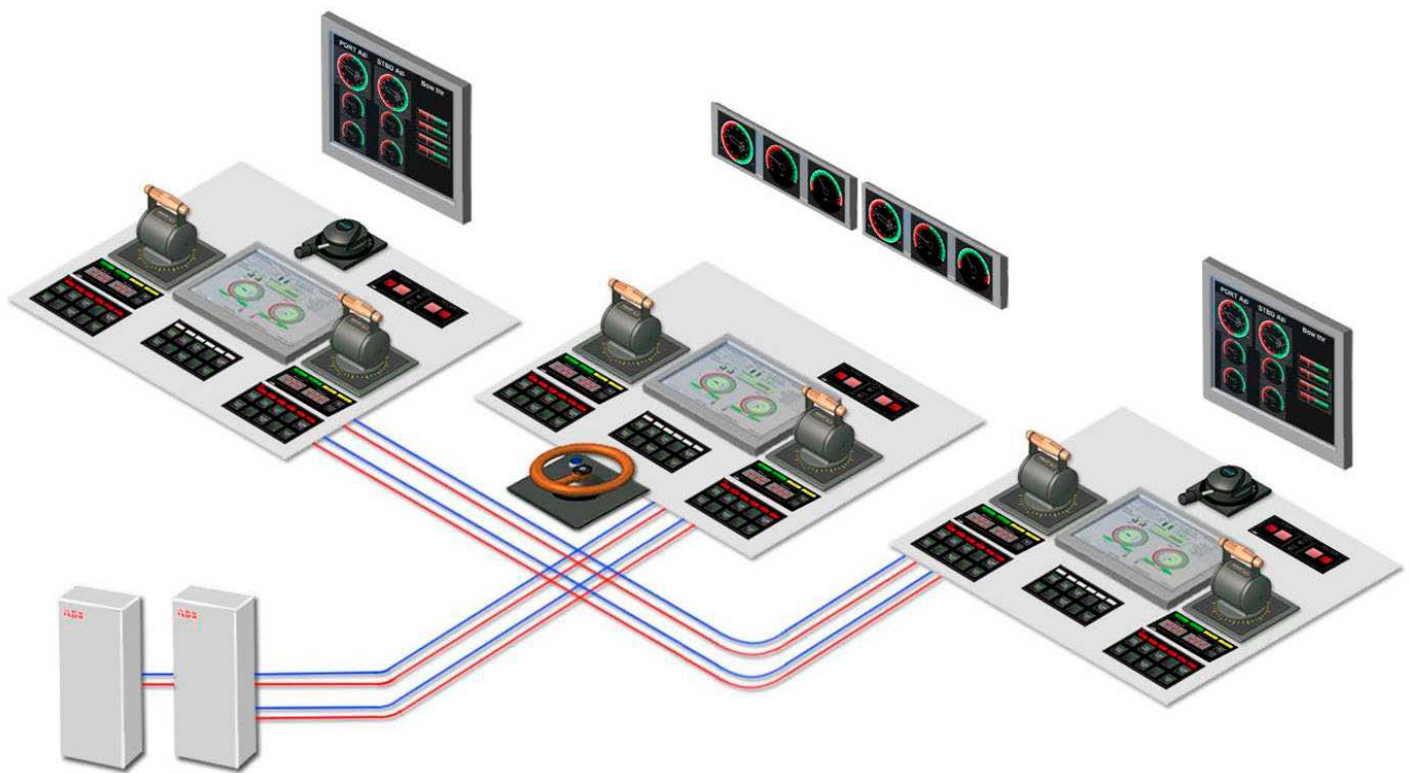


Figure 5-1 Typical remote control outfit

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.

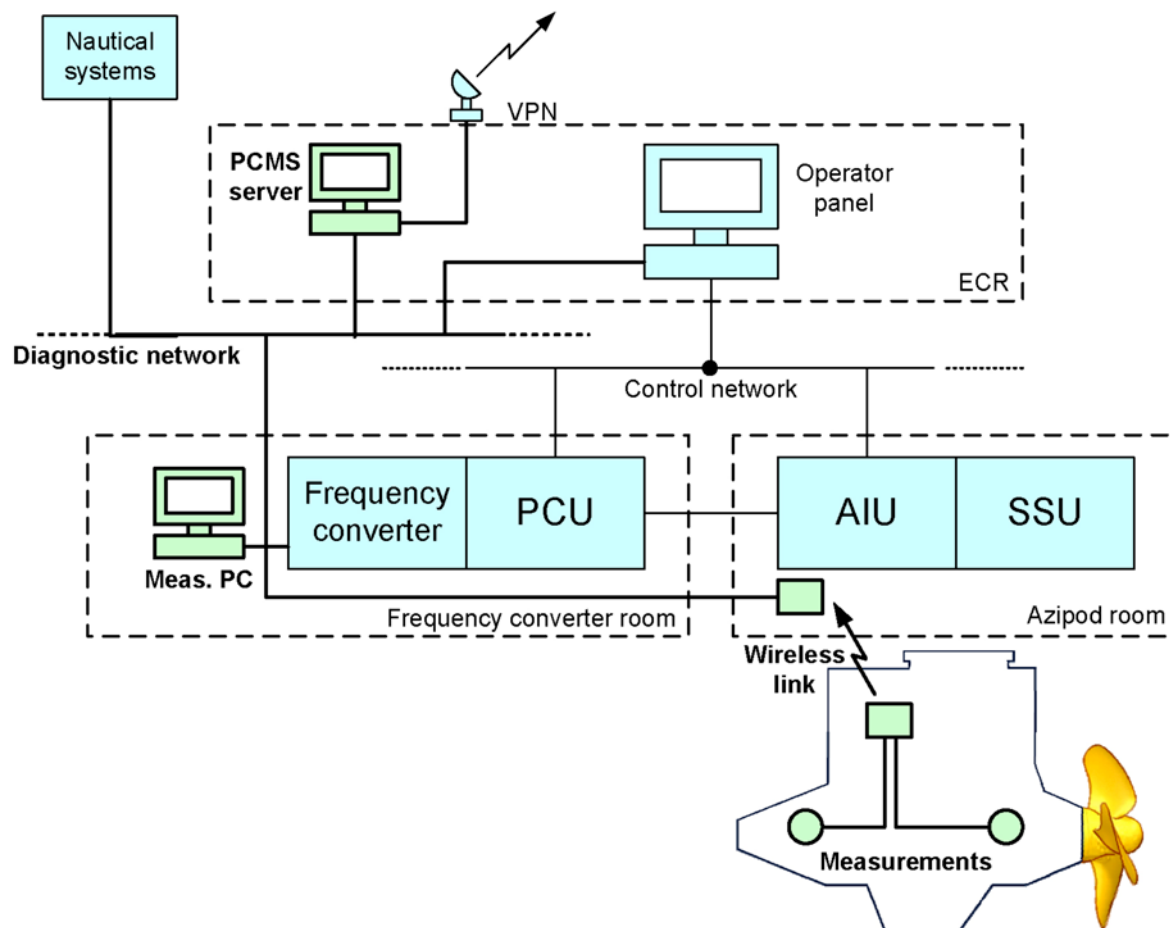


Figure 6-1 Layout of the PCMS

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. The analysis functions comprise:
 - Traditional methods based on time and frequency domain characteristics and different filtering functions
 - Advanced, patented methods combining adaptive filtering, likelihood ratios and binary decision evaluation
- 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 defined Propulsion and Steering Modules. As above, any special redundancy requirements must be checked 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 Running the Azipod engineering delivery

Generally the shipbuilder will need to have similar engineering resources as for the full integration of e.g. a fin stabilizer system, although the overall amount of integration work will be greater. A suggested ideal resourcing portfolio is given below. Several of the listed tasks may be run by the same person:

- A. Coordinating engineer (general purpose propulsion, steering and outfitting).
- B. Structural designer for the hull interface (steel / scantlings' engineer).
- C. Power plant interfacier (generally power electrical knowledge).
- D. Machinery engineering / commissioning control (ship or mechanical engineer).
- E. Automation coordinator (in charge for the ship automation interface).
- F. Navigational / controls interface (electronics or applied deck officer work).

7.3 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(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

7.4 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.

7.5 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.

7.6 Forces on ship's hull

Forces from the Propulsion Module must be transferred to the ship's hull steel structure. After the contract has been signed and during the design period, ABB delivers the calculated forces and bending moments and produces the recommended principle drawing for mounting the Azipod. The Azipod is connected to ship's hull by the Steering Module. The Steering Module is welded to the ship's hull as a structural member.

7.7 Steering Angle Convention

The traditional ship steering convention of **PORT** (signal Red) and **STARBOARD** (signal Green) is used. Therefore, two main ship control configurations are to be considered:

- A. Ahead going ships
- B. Astern going ships

The steering equipment on double-ended ships (e.g. river ferries) usually needs to be outfitted as an appropriately configured combination of these two cases.

NOTE: The terms Port and Starboard refer to ship steering. The angle indicator instrument will show the actual rotational direction of the Azipod propulsor.

Figure 6-1
“Ahead sailing” concept:
rear pointer helm angle
indication

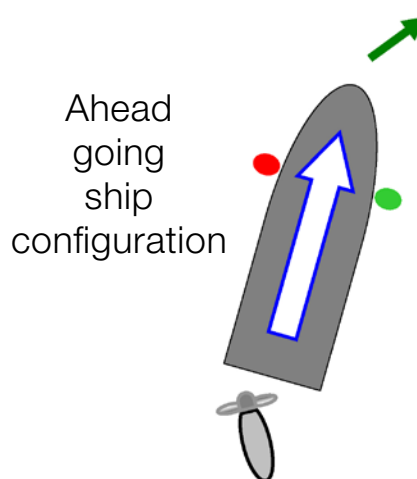
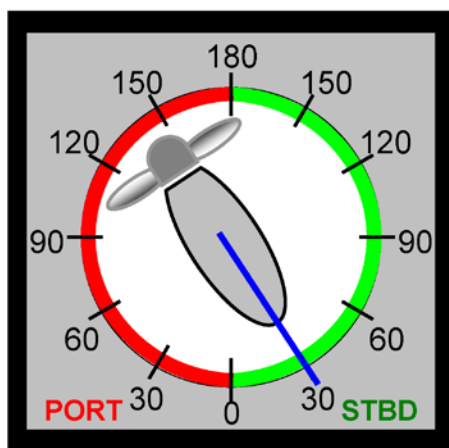
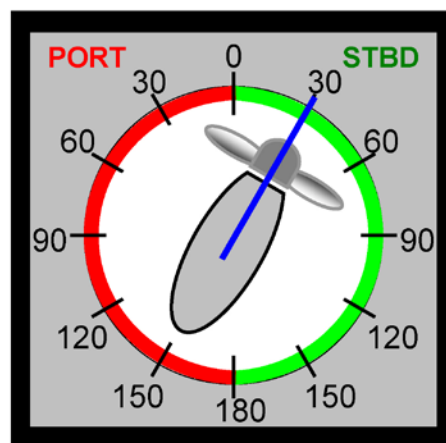
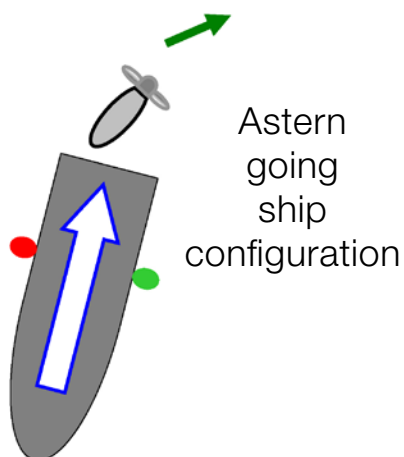


Figure 6-2
“Astern sailing” concept:
front pointer helm angle
indication



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.

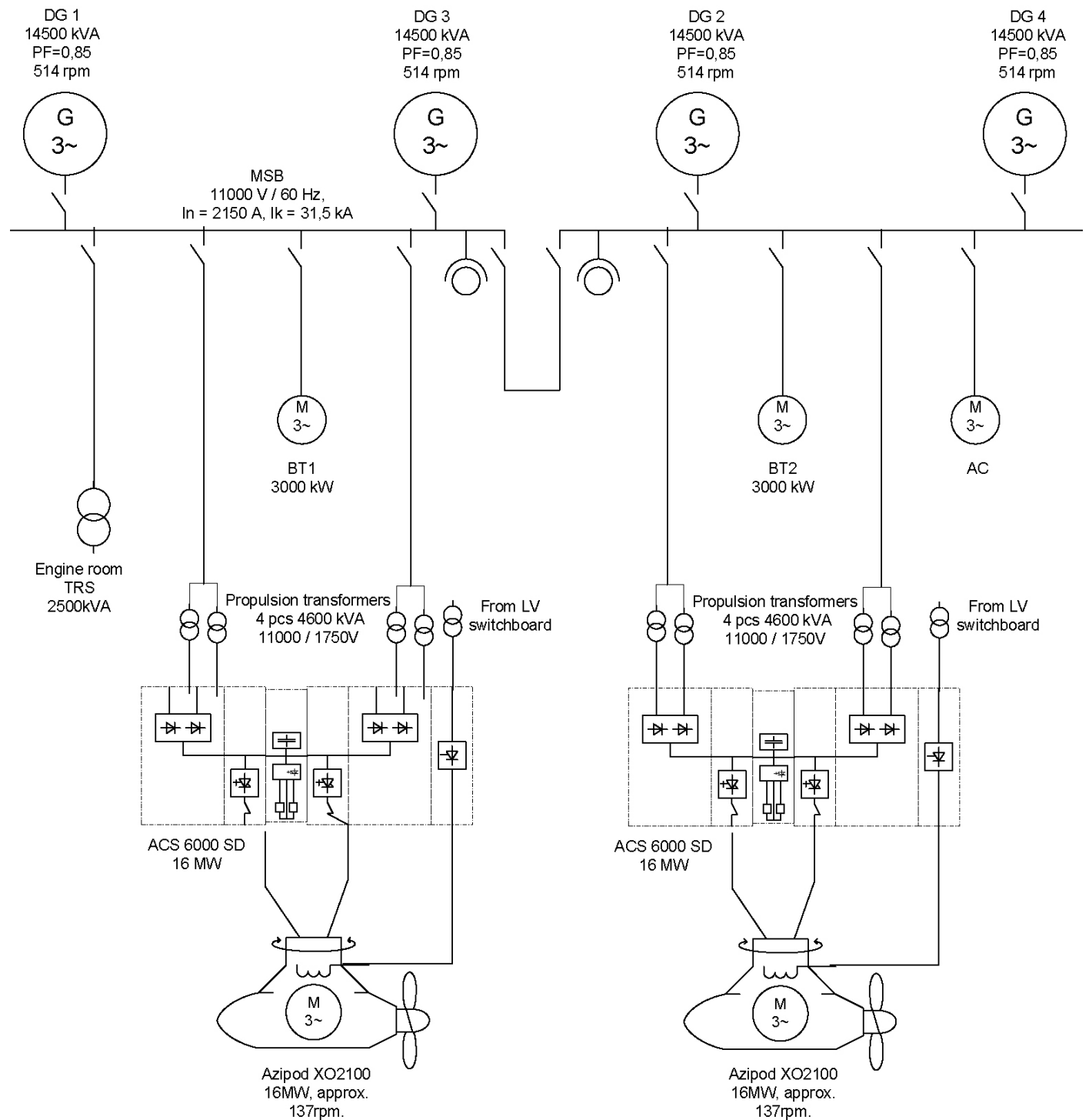


Figure 7-1 Typical single line diagram of the onboard power plant

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:	$L_{pp} =$ $B =$ $T =$ $GT/DWT =$
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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