Azipod® VI Series Product Introduction

Power and productivity
for a better world™

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.

Helsinki, March 2010

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Abbreviations not clarified within the document

ABS	American Bureau of Shipping
BV	Bureau Veritas
DNV	Det Norske Veritas
ESWB	Emergency Switchboard
IACS	International Association of Classification Societies
GA	General Arrangement
kVA	kilovolt Amperes
LRS	Lloyd’s Register of Shipping
MSWB	Main Switchboard
MW	Megawatts of power
RMRS	Russian Maritime Register of Shipping
RPM	Revolutions Per Minute

1 General

The first Azipod® installation onboard was commissioned in 1990. By February 2010, the milestone of 5,2 million cumulated operating machinery hours has been reached.

1.1 Azipod propulsion and steering

Azipod is a podded electric main propulsion and steering device driving a fixed-pitch propeller at a variable speed setting. The Azipod VI series main propulsion and steering system is the ice-operating variant of the classic Azipod product.

Azipod propulsion is designed for the preferential use of the (directly driven) pulling propeller when driving in the Ahead direction. The Azipod V family of products is azimuthing (steering around its vertical axis) infinitely by 360° and is available generally for power ratings of between 6 and 21 MW, depending on the platform size, ice application and 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.

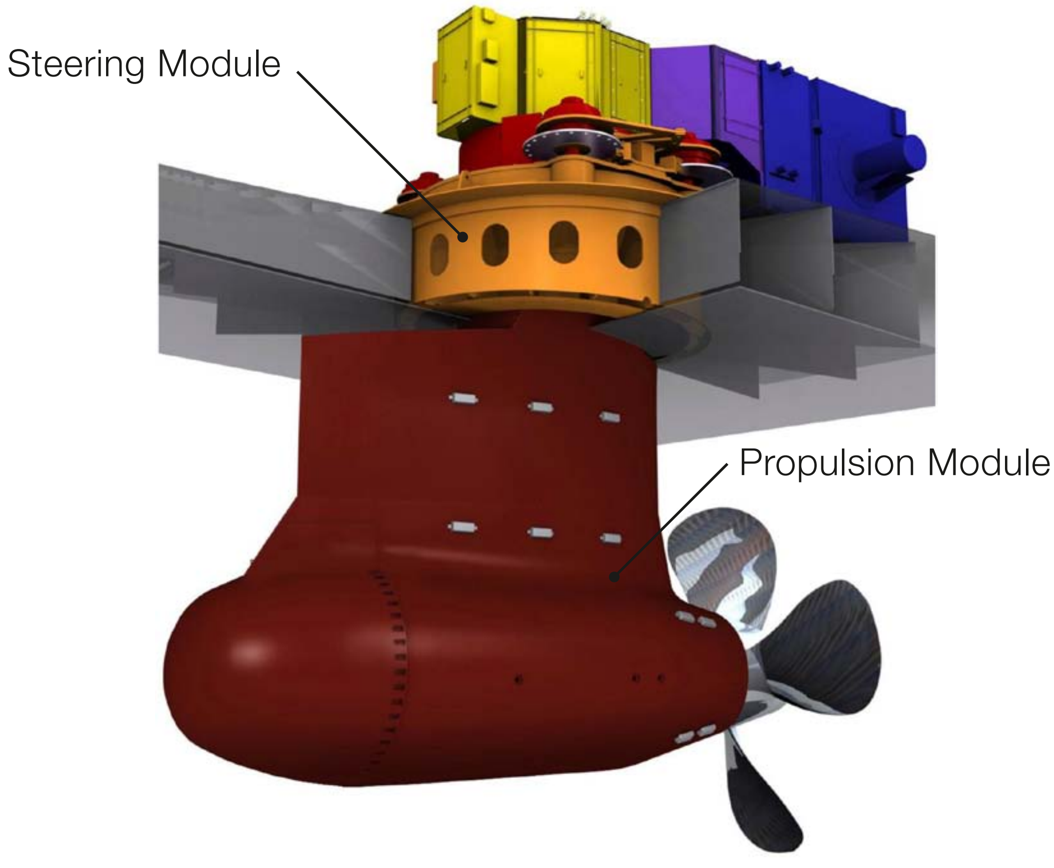


Figure 1-1 Basic arrangement of the Azipod VI

1.2 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).

V = ”Classic” Azipod
X = Next generation Azipod (in dedicated publications)
C = ”Compact” Azipod (in dedicated publications)

I = Design for operation in ice conditions
O = Design for operation in open water (in dedicated publications)
C = “Counter-Rotating Propellers” design (- ” -)

The diameter of the propulsion motor (mm)

“S”, “M” or “L” = Lenght of the (synchronous) propulsion motor
“A” = Synchronous propeller motor

Azipod® ☐☐ xxxx y

Example: Azipod® VI 1600 A

...being an ice-operating Azipod with a shaft power in the lower end of the range (e.g. 5 MW) and built with an asynchronous propeller motor.

1.3 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.

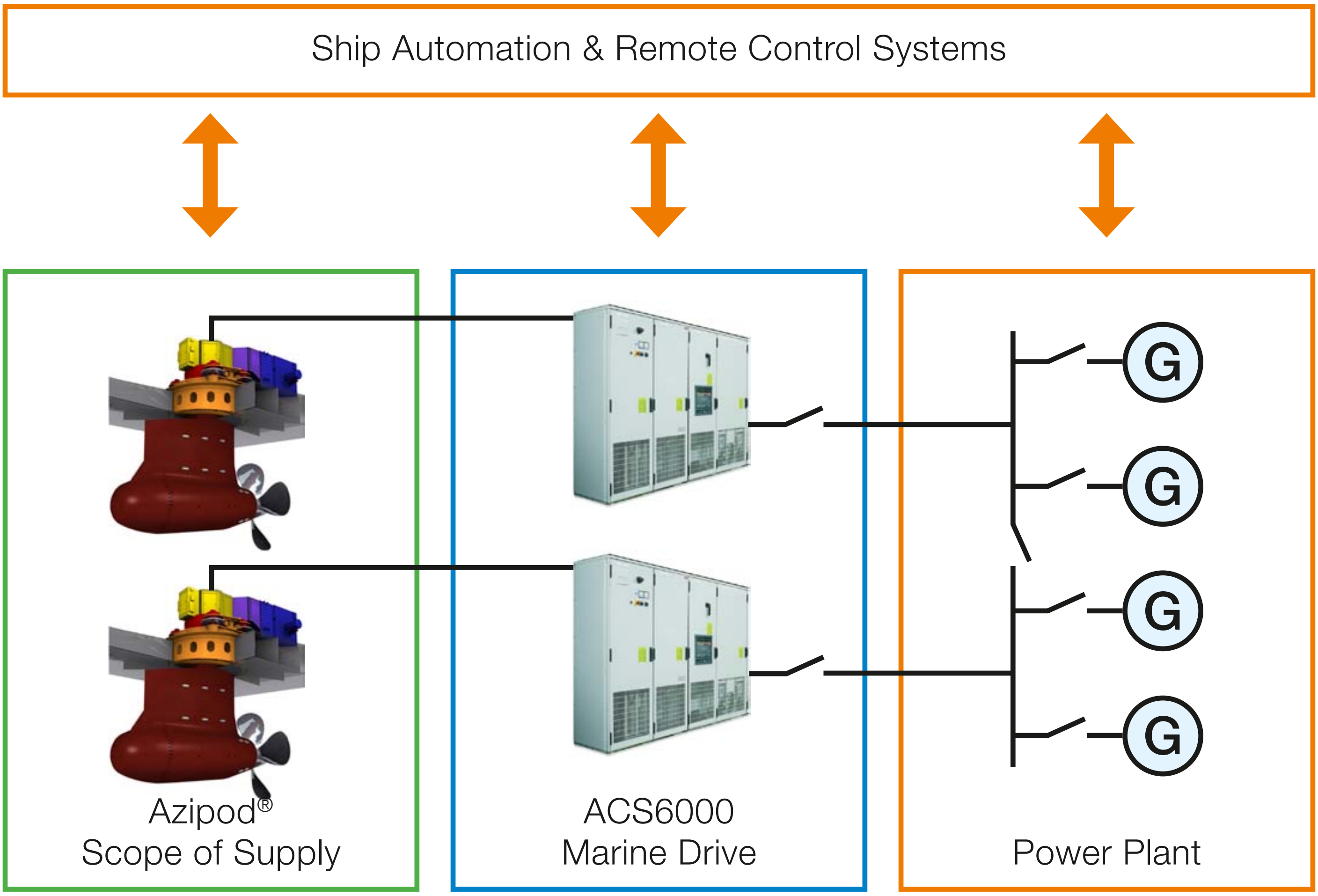


Figure 1-2 Simplified single-line diagram of the power plant with a propulsion system.

2 Azipod in ice-going ships

2.1 General

Ice-going ships can generally be divided into two main groups:

- Ice-strengthened ships
- Icebreaking ships

Icebreakers and ice management ships are sub-cases of icebreaking ships.

Ice-strengthened ships are designed for open water operation, but their hulls are strengthened and machineries often have more power compared to normal open water ships. The ability to move in ice is usually not the main objective for these ships, but open water characteristics is generally a very important part in the design. An ice class is chosen to guarantee the ship sufficient strength and power so that it can be safely assisted by an icebreaker in ice covered waters. Examples of such ships are all the ships currently operating in the Northern Baltic Sea during the winter, such as ferries, bulk carriers, and ro-ro ships.

For icebreaking ships an ice-going capability is crucial from a performance point of view. Independent operation, i.e. operation without further icebreaker assistance, is generally a part of their operational profile. Ice-going capability has been defined, usually in very demanding ice conditions, by the technical requirements for the ship. In addition, these ships typically have the shipyard's guarantee for performance in ice, performance that is often verified in full-scale ice tests. Examples of this type of ships are icebreakers, multi-purpose icebreakers and some tankers, cargo ships and research ships which have been specially designed for operation in ice-covered waters.

2.2 Azipod and Double Acting ship operation

It has been common knowledge for a long time that running a ship astern in ice enables improved ice-going capability. This is due to the flushing effect on the aft body by the propeller wake. It is also common knowledge that rudders can often be damaged and steering can be difficult when running astern in ice conditions.

Azipod propulsion makes it possible to design a ship with superb icebreaking performance while retaining full steering capability when going astern in ice. Now the bow can be designed for optimal performance in open water the ship can combine excellent icebreaking and open water characteristics – a task traditionally considered impossible. This concept is called the Double Acting (DA) ship, patented by Aker Arctic Technology Inc.

Running astern with the propeller(s) first is particularly effective when it comes to penetrating areas with severe ice ridging. The propeller(s) mill and flush the underwater part of the ridge into pieces of ice that are dispatched by the propeller wash and the ship moves slowly through the ridge field.

2.3 Azipod VI design principles

The most obvious benefit of electric propulsion in icebreaking ships is the torque performance of an electric motor. An electric motor and the associated variable frequency drive can be designed to provide maximum torque at low propeller speeds, and even when the propeller is stopped. The absence of a mechanical connection between the power plant and the electric motor driving the propeller enables an ideal icebreaker propulsion system.

The propulsion motor used in the Azipod VI series is capable of delivering 100% propeller power in the bollard pull condition. If required in icebreaking, the propulsion motor can also be dimensioned for cyclic over torque operation. The figure below presents a typical torque - RPM characteristic diagram.

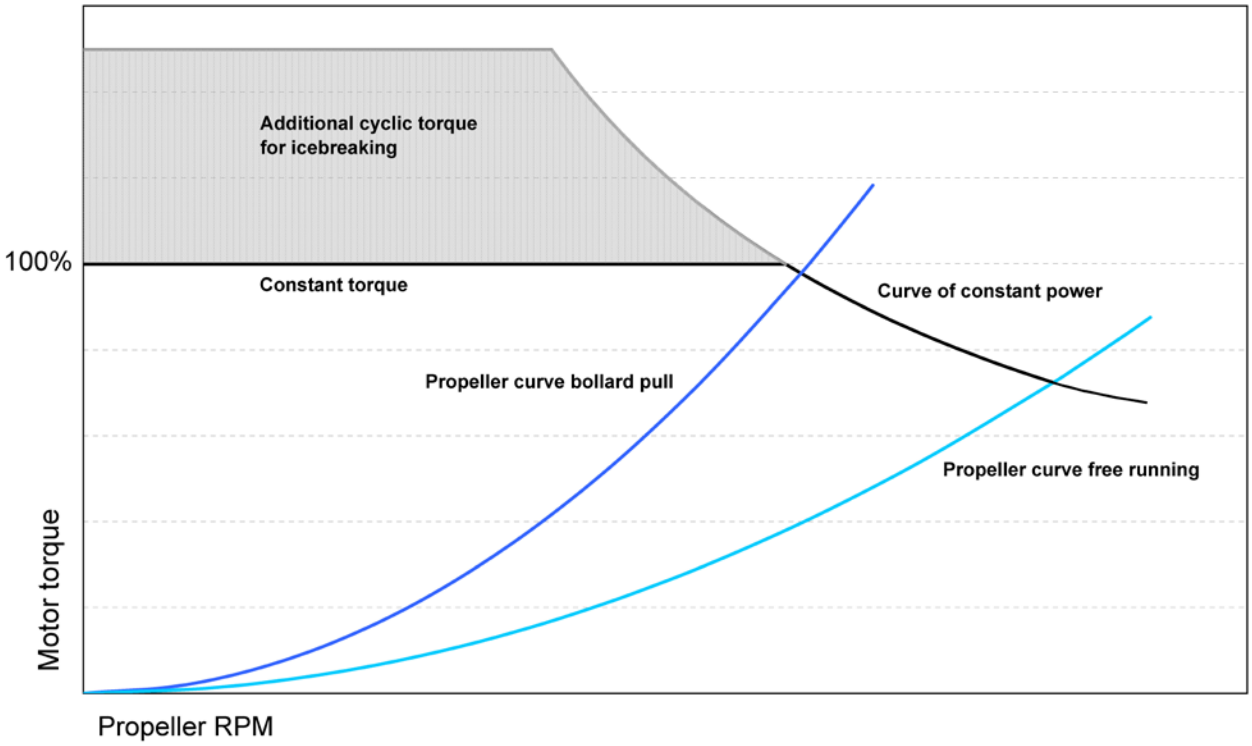


Figure 2-1 Drive and propeller motor torque - RPM capacity

The ultimate performance for the Azipod VI is usually expressed as a relationship between the propeller power and the available thrust in the bollard pull condition. Therefore, the actual frame size specific available performance, which vary depending on, eg. propeller strengthening and diameter, is shown on the following figure:

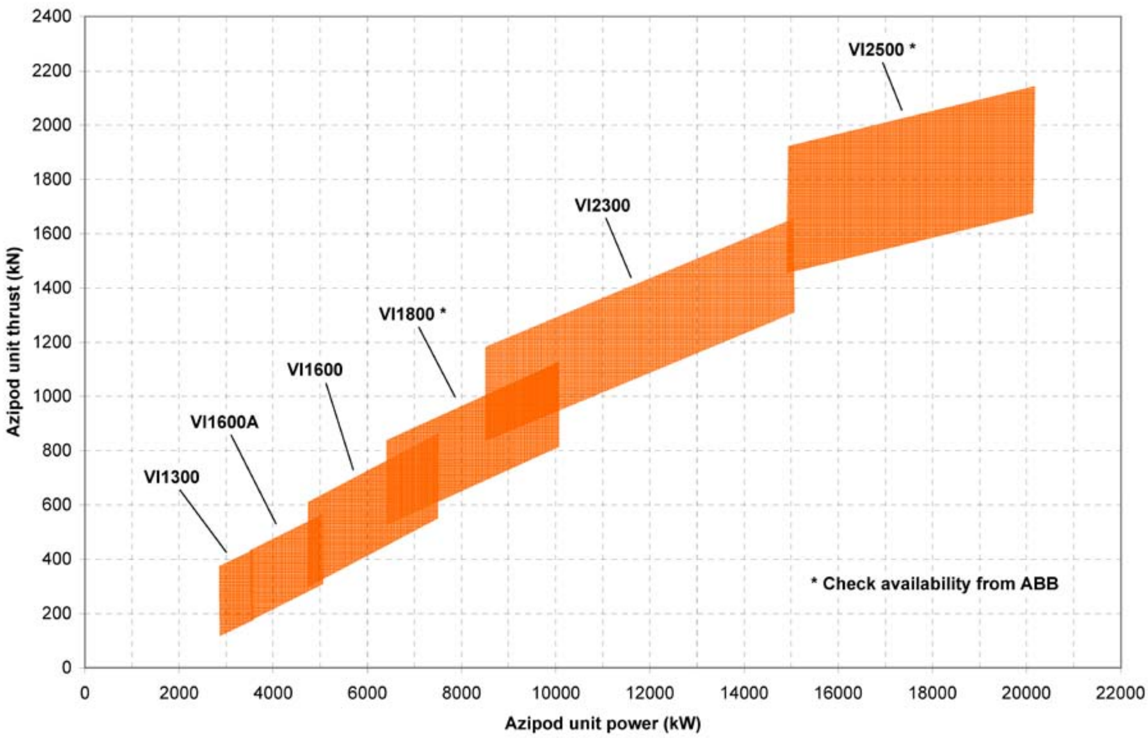


Figure 2-2 Propeller power – bollard pull thrust diagram for the different frame sizes

The benefits of electric propulsion are known to include:

- Appropriate torque characteristics
- Dynamic response
- Redundancy
- Ship dynamic positioning capability (where applicable)

Further, the Azipod VI design offers the following benefits:

- Enhanced maneuverability in heavy ice conditions – 360° steering provides full torque and thrust in any direction, full torque also available in reverse RPM
- Robust mechanical design – single short shaft and absence of bevel gears means that the torque capacity of the electric motor can be fully utilized without mechanical limitations
- Strength and stiffness – the Azipod hull with a framed structure withstands high impact loads during ice interaction. The stiff shaft line reduces the risk for resonance during ice milling
- Freedom in ship design – Azipod provides great design flexibility and space saving possibilities in the aft ship

2.4 Dimensioning to different ice rules

The major classification societies have their own ice rules with ice classes for various ice conditions. With a few exceptions, the classification societies use the Finnish-Swedish Ice Class Rules (FSICR) for lighter ice classes in sub-arctic ice conditions. For Arctic operations, the major classification societies have their own rules and all have now adopted the unified IACS “PC” rules.

Azipod VI product range is generally intended for ice classes 1A Super and higher. Azipod VI products have been classified to ice classes of all major classification societies, including, e.g. ABS, BV, DNV, LRS and RMRS. Important factors that define the highest available ice class for a certain project are, e.g. Azipod size, propeller diameter and power. Please, contact ABB Marine to check the availability of a specific ice class notation.

2.5 Reference list for ice applications

Name of ship	Ship type	Class	Ice class	No. of units and power [MW]
Seili	Waterway service	-	1A Super	1 x 1.5
Uikku	Arctic tanker	DNV	1A Super	1 x 11.4
Lunni	Arctic tanker	DNV	1A Super	1 x 11.4
Röthelstein	Icebreaker	GL	E4	2 x 0.6
Botnica	Icebreaker	DNV	Icebreaker ICE-10	2 x 5.0
Arcticaborg	Icebreaker	BV	IA Super	2 x 1.6
Antarcticaborg	Icebreaker	BV	IA Super	2 x 1.6
Svalbard	Patrol vessel	DNV	Icebreaker POLAR-10	2 x 5.0
Tempera	Arctic tanker	LRS	1AS	1 x 16.0
Mastera	Arctic tanker	LRS	1AS	1 x 16.0
Suomenlinna II	Ferry	DNV	1A Super	2 x 0.5
Mackinaw	Icebreaker	ABS	Icebreaker A2	2 x 3.4
Fesco Sakhalin	Icebreaker	DNV RMRS	Icebreaker ICE-10 Icebreaker 7	2 x 6.5
Vladislav Strizhov	Icebreaker	DNV	Icebreaker ICE-15	2 x 7.5
Yury Topchev	Icebreaker	DNV	Icebreaker ICE-15	2 x 7.5
Polar Pevek	Icebreaker	DNV	Icebreaker ICE-10	2 x 5.0
Norilsk Nickel	Container vessel	RMRS	Arc7	1 x 13.0
Vasily Dinkov	Shuttle tanker	RMRS, ABS	Arc6	2 x 10.0
Kapitan Grotskiy	Shuttle tanker	RMRS, ABS	Arc6	2 x 10.0
Nadezhda	Container vessel	RMRS	Arc7	1 x 13.0
Zapolyarnyy	Container vessel	RMRS	Arc7	1 x 13.0
Talnahk	Container vessel	RMRS	Arc7	1 x 13.0
Monchegorsk	Container vessel	RMRS	Arc7	1 x 13.0
Timofey Guzhenko	Shuttle tanker	RMRS, ABS	Arc6	2x 10.0
Mikhail Ulyanov	Shuttle tanker	RMRS, LRS	Arc6	2 x 8.5
Kiril Lavrov	Shuttle tanker	RMRS, LRS	Arc6	2 x 8.5

3 Scope of supply

3.1 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 thirteen items: two (2) modules and eleven (11) auxiliaries. They are built internally ready for separate deliveries, for shipyard installation, as follows:

3.2 Azipod-specific delivered items

- Propulsion Module
- Steering Module

- One (1) Hydraulic Power Unit (HPU)
- One (1) Cooling Air Unit (CAU)
- One (1) Slip Ring Unit (SRU)
- Two (2) Oil Treatment Units (OTU)
- One (1) Gravity Tank (GTU)
- One (1) Air Control Unit (ACU)
- One (1) Azipod Interface Unit (AIU)
- One (1) Local Backup Unit (LBU)
- Two (2) adapting Air Ducts (AD-In), (AD-Out)

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.

3.3 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

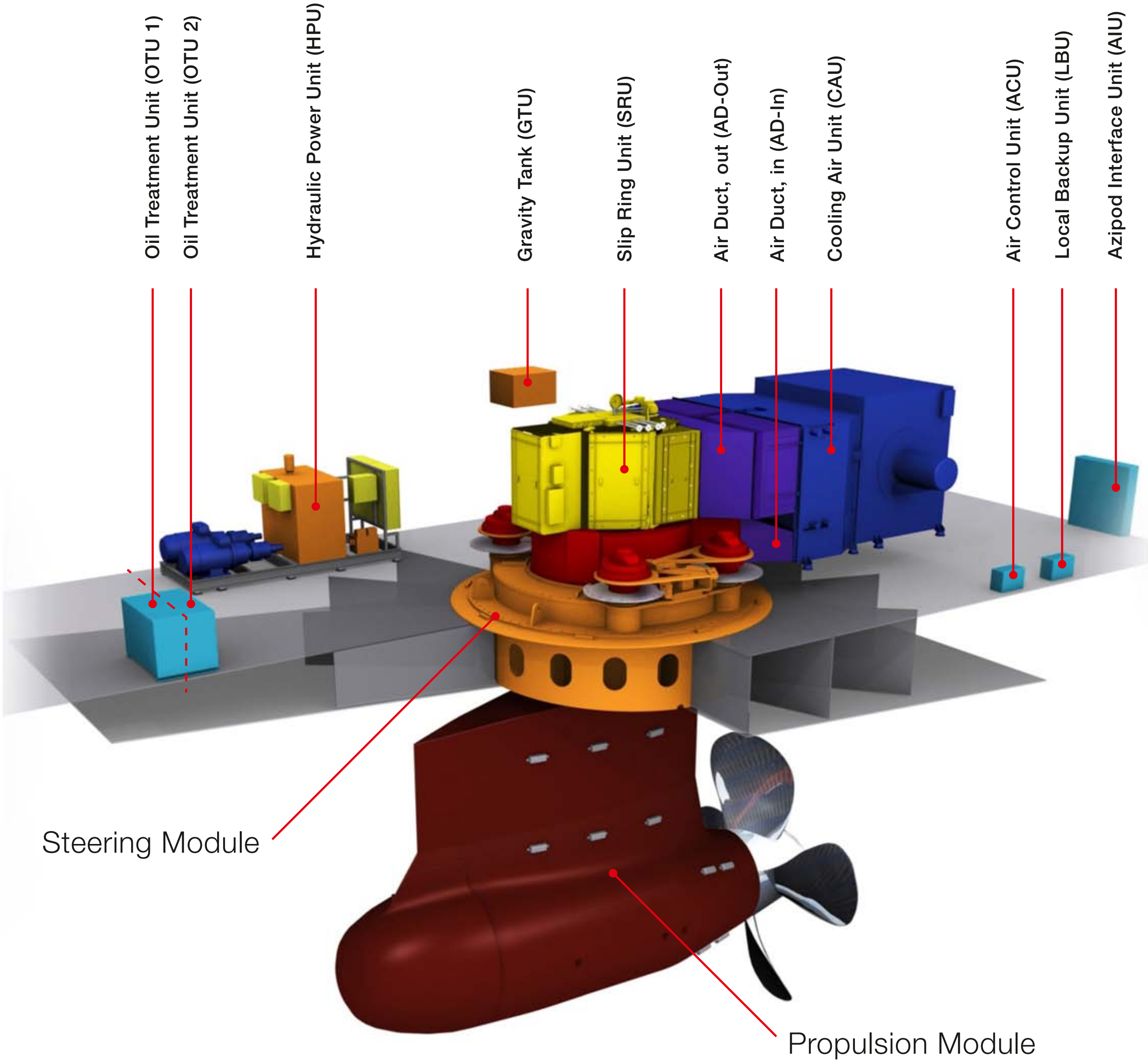


Figure 3-1 Layout example of Azipod modules and auxiliaries

4 Technical details

4.1 Dimensions and weights

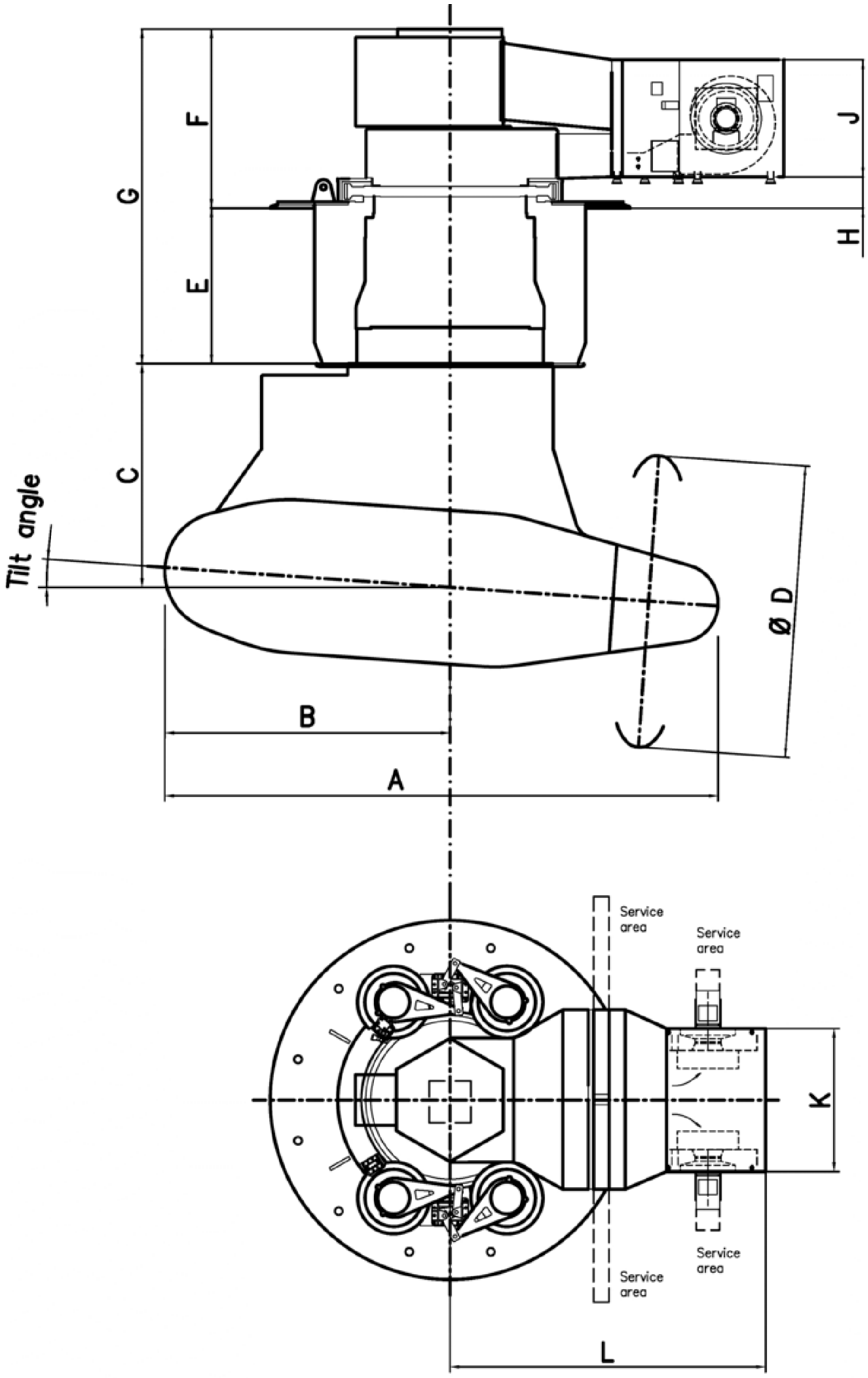


Figure 4.1 Dimensional nominations for the Azipod

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 obtainable vertical measure ("C") for the Propulsion Module is ship specific, and subject to the calculated hydrodynamic forces and ice loads.
- The ship's double bottom fit standard thickness ("E") can be altered under special consideration on a ship-specific design basis.
- The eventual Cooling Air Unit detail selection may slightly alter the related dimensions. ("J", "K" and "L").

	VI1300	VI1600	VI1800	VI2300	VI2500
A (m)	7.0	7.5 / 8.5 Note 1	9.4	10.6	11.7
B (m)	3.6	4.1 / 4.5 Note 1	4.8	5.5	6.0
C (typical) (m)	2.3	2.4 / 3.2 Note 1	3.5	4.3	5.5
ØD (range) (m)	3.1 – 3.5	3.5 – 4.5	4.2 – 5.0	4.5 – 5.6	5.1 – 7.8
E (m)	1.9	1.5 / 1.9 Note 1	1.9	3.0	3.1
F (m)	3.2	2.3 / 2.9 Note 1	2.9	3.4	3.4
G (m)	5.0	3.7 / 4.8 Note 1	4.8	6.4	6.5
H (m)	0.2	0.3 / 0.4 Note 1	0.4	0.6	0.6
J (m)	2.8 Note 2	1.7 / 2.0 Note 1	2.0	2.3	3.0
K (m)	4.5 Note 2	2.5	2.8	2.8	4.0
L (m)	3.5 Note 2	5.8	6.0	6.1	7.5
Tilt (deg.)	0	3	4	4	0

Figure 4-2 Dimensions for the Azipod VI

Note 1: asynhcronous / synchronous motor,

Note 2: special shape of the CAU

	VI1300	VI1600	VI1800	VI2300	VI2500
Propulsion Module (excluding propeller) [tonnes]	67	116	148	220	270
Steering Module [tonnes]	16	86	90	160	165
SRU (Slip Ring Unit) [tonnes]	4	3	3	4	3
CAU (Cooling Air Unit) [tonnes]	4.5	8.5	8.5	10	11
HPU (Hydraulic Power Unit) [tonnes]	4.5	4.5	4.5	4.5	4.5
OTU (Oil Treatment Unit) [tonnes]	2 x 0.3	2 x 0.3	2 x 0.3	2 x 0.3	2 x 0.3
GTU+AIU+LBU+ACU [tonnes]	0.5	0.5	0.5	0.5	0.5

Figure 4-3 Weights (metric tons) per each Azipod

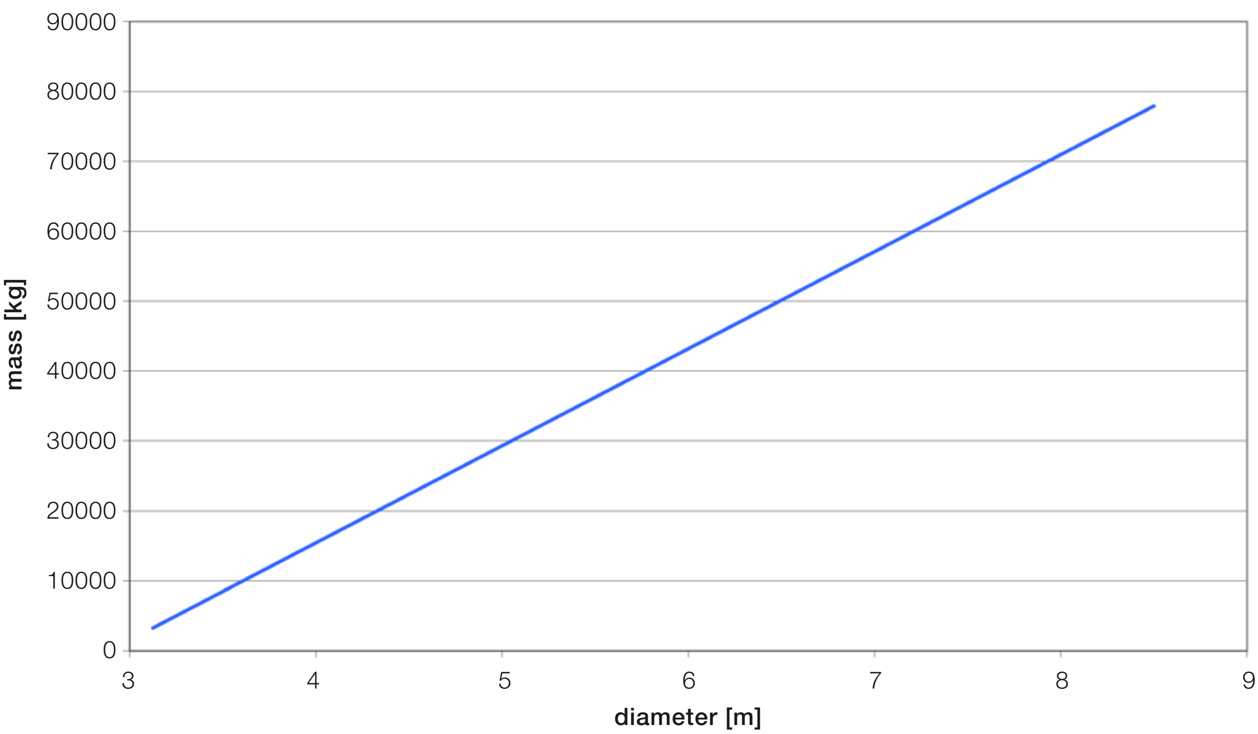


Figure 4-4 Estimated propeller weights (NOTE: always specific to the application)

4.2 Typical oil fill volumes per each Azipod

Propeller bearing, shaft seal oil + gravity tank	0.2 ... 0.6	m^3
Thrust bearing	0.1 … 0.5	m^3
Slewing bearing and steering gear	0.3 … 0.9	m^3
Steering hydraulics	0.3 … 1.0	m^3

4.3 Typically required auxiliary power supplies per each Azipod

Consumer	**Number of supplies from the ship's switchboards**	**Typical voltage (AC)**
Cooling fans	2	400 … 690
HPU	2 (1 through ESWB)	
Flushing pump (steering)	1	
Drainage pumps	2 or 3	
Lube oil pumps	3 or 4	
Navigational priority supplies	2	230

Figure 4-5 Propulsion power dependable low voltage consumers

LOW VOLTAGE CONSUMERS OF AZIPOD			
Only informative data and valid for typical installations			
[MW]	S [kVA]	P [kW]	P [kW]
AZIPOD TYPE	**Propulsion exciter**	**Cooling Air Unit (CAU)**	**Hydraulic Power Unit (HPU) Nominal/ Scantling S1/S6**
VI2500	600	2x 75/88	210/350
VI2300	500	2x 45/52	180/300
VI1800	450	2x 37/43	130/215
VI1600	450	2x 37/43	75/125
VI1300	350	2x 37/43	75/125

Note: power ratings for especially fast steering rates are not listed here

Figure 4-6 Approximated list of related power consumers

4.4 Heat emissions causing the heating of the Azipod room

The air conditioning for the Azipod room is to be designed according to the heat losses inside the room. Estimated heat emissions are presented in the attached figure. Final values will be determined during the project.

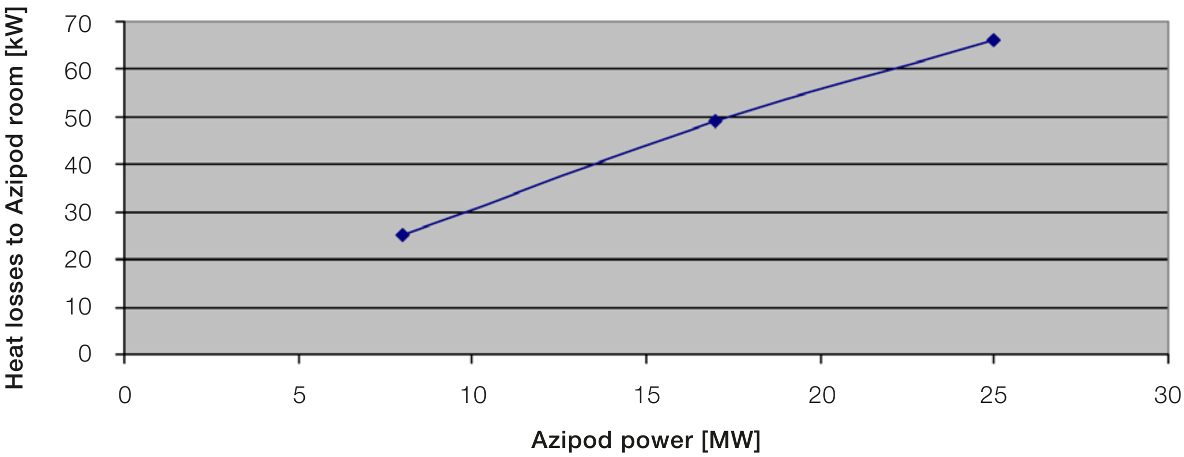


Figure 4-7 Heat losses into the Azipod room

4.5 Steering gear

The steering gear technology used on Azipod VI has been originally developed from traditional hydraulic steering gear technology. However, the following particular features can be noted on the design:

A. Operation with closed circuit fluid hydraulics, generally in the high pressure area.

B. Infinite rotatable steering through 360 degrees by use of marine-approved rotating hydraulic motors as the actuating components. Actuation of the steering gear, via evolvent pinions, through the gear rim.

C. Directional control by proportional servo band control.

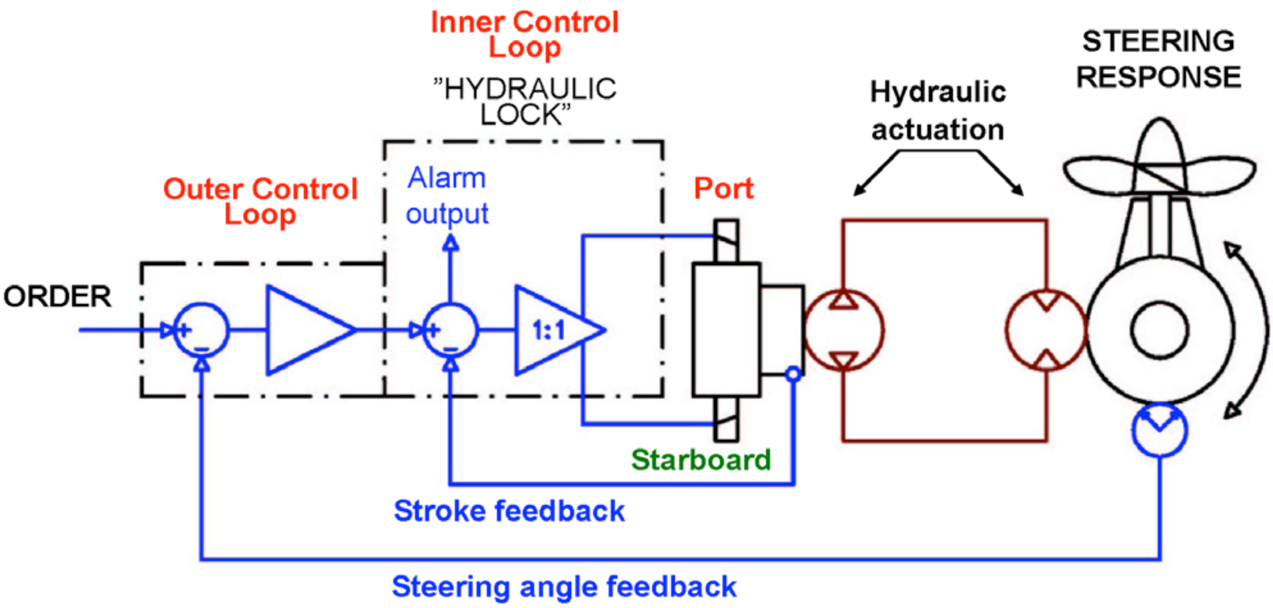


Figure 4-8 Steering control principle

The Azipod VI is steered with an electro-hydraulically powered steering gear. The Hydraulic Power Unit (HPU) produces the steering oil flow with either one or two pumps. The pumps actuate rotating hydraulic motors (2 … 6 pcs) through **PORT** and **STARBOARD** pressure piping in a closed hydraulic circuit. The hydraulic motors, in turn, rotate the gear rim via pinion shafts.

The steering pumps in the HPU are driven by their dedicated electric motors. Each steering pump incorporates on the same shaft a main pump (for steering) and a boost (so-called “charge”) pump for securing the volumetric fill of pressure piping. The motor starters (2 pcs), servo boxes (2 pcs) and the steering alarm box (1 pc) are also built onto the HPU.

The shipbuilder should note that as in ordinary rudder steering systems, one pump unit should be supplied from a main low voltage switchboard and the other pump from the ship's emergency switchboard.

Standard steering rates for the Azipod VI are as follows:

With 1 pump:	2.5 degrees/second	for open sea and ice operations
With 2 pumps:	5.0 degrees/second	for maneuvering

On single Azipod ship set deliveries, in the event of an external hydraulic leakage, the steering gear will be split automatically with a dedicated failure control subsystem.

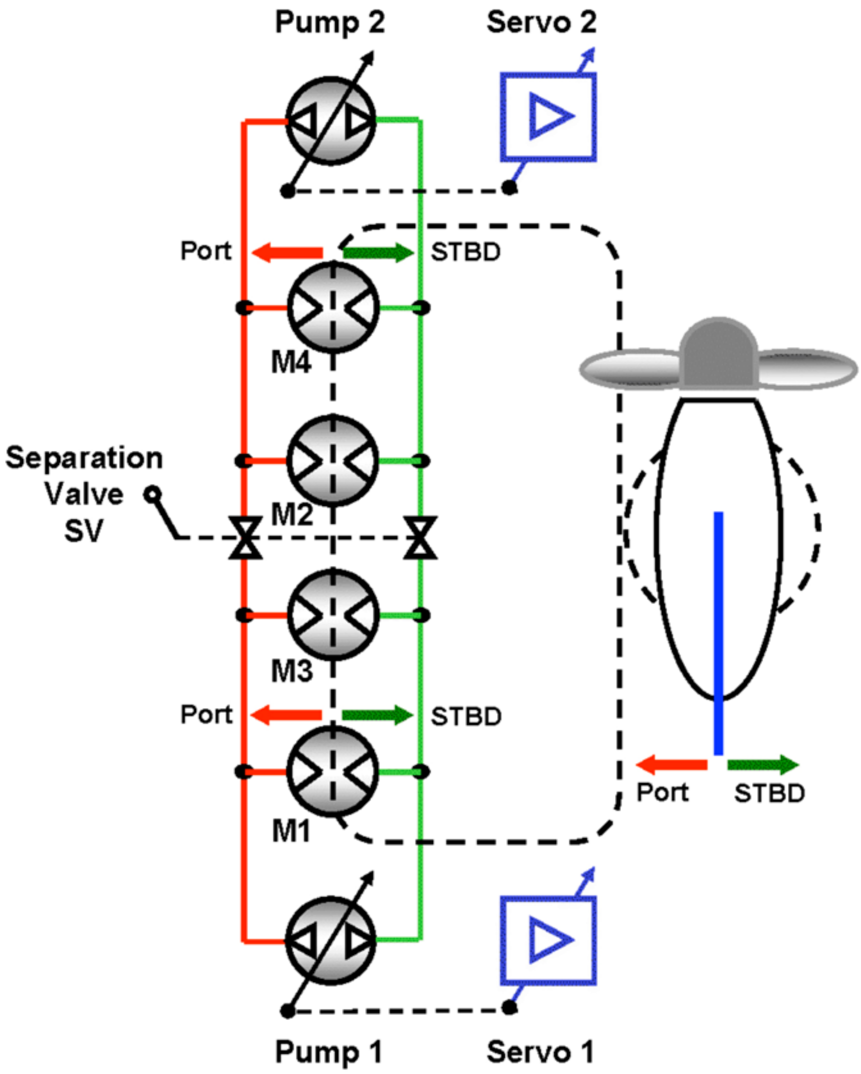


Figure 4-9 Hydro-mechanical principle of the steering gear

The steering gear hydraulics can be manually split into two independent sections. However, the pumps isolate themselves from the hydraulic circuit when they are stopped. In a failure situation the actuating hydraulic motors that remain in the ”faulty” part of the steering gear need to be freewheeled. This will cut the available steering torque to half. Single failure fault isolation is therefore performed manually by the ship personnel, or automatically, depending on the particular failure control arrangement ordered with the Azipod.

Steering action is controlled by the pump-specific servo boxes. directly to the **PORT** or **STARBOARD** stroke of the pump by proportional control. No actual control valves, as such, are needed. The servo unit will rotate the steering angle of the Azipod by the shortest way. This is relevant especially when a steering command change of approximately 180 degrees (or more) is given from a lever, or from an external control device.

The dimensions and layout of the HPU may vary, according to the hydraulic power capacity needed for the project.

Each steering motor is equipped with a safety release valve. These valves provide mechanical protection by opening, and allowing the propulsor to turn, under excessive ice loads

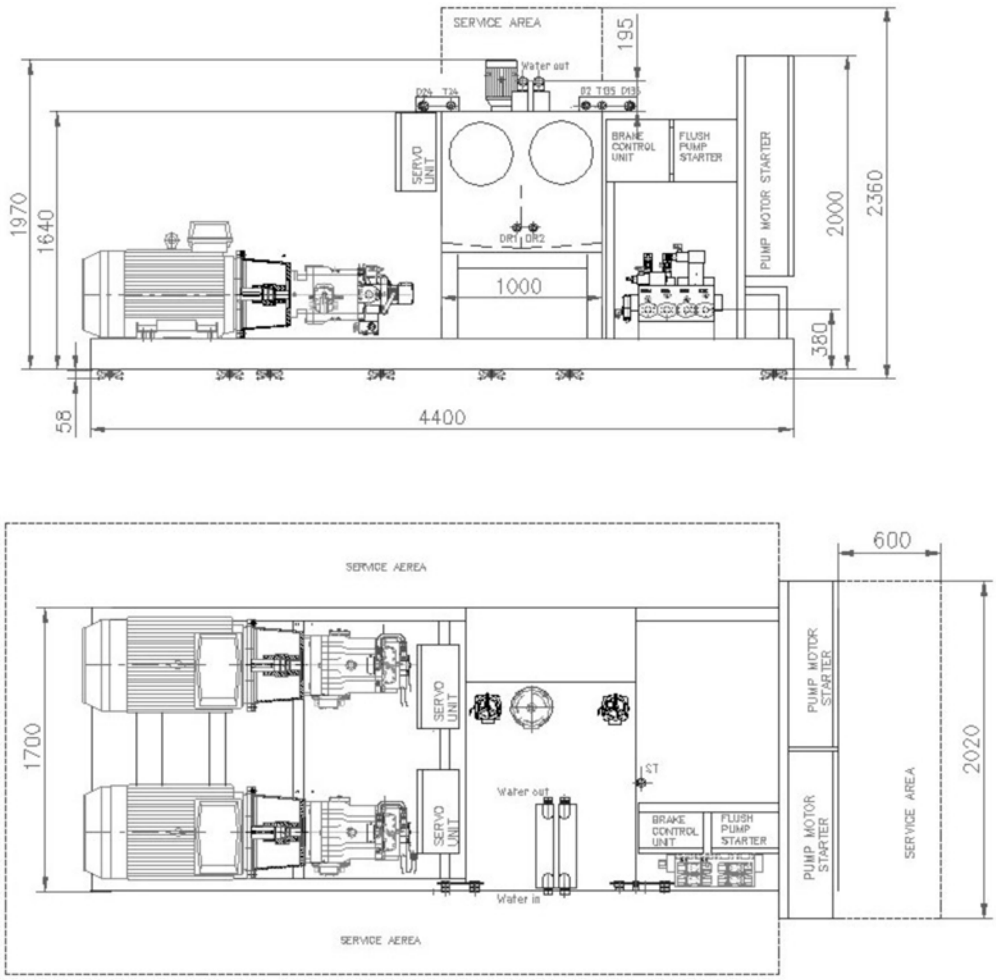


Figure 4-10 Example of a steering gear Hydraulic Power Unit (HPU)

4.6 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.

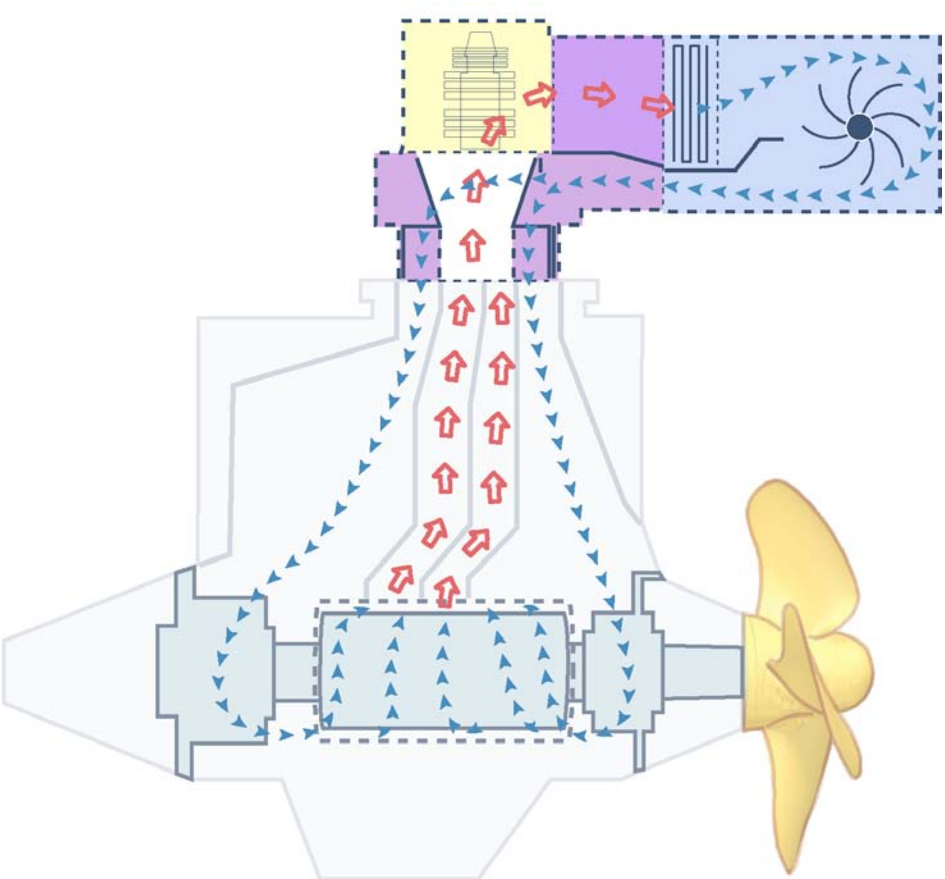


Figure 4-11 The air cooling arrangement of the propeller motor

4.7 Shaft line arrangement

The shaft line roller bearings (thrust and propeller bearings) are partly filled with lube oil, and sump lubricated with pumped oil circulation. On-line oil treatment is performed by the two Oil Treatment Units (OTU). Oil treatment consists of filtering and temperature stabilization. Both Oil Treatment Units also monitor the relative water contents in the lube oil by means of a detective device.

Oil circulation pipelines are led through the fluid swivel to the OTU and returned back to the bearings. Information on oil levels and temperatures is sent to the ship's machinery automation system (MAS).

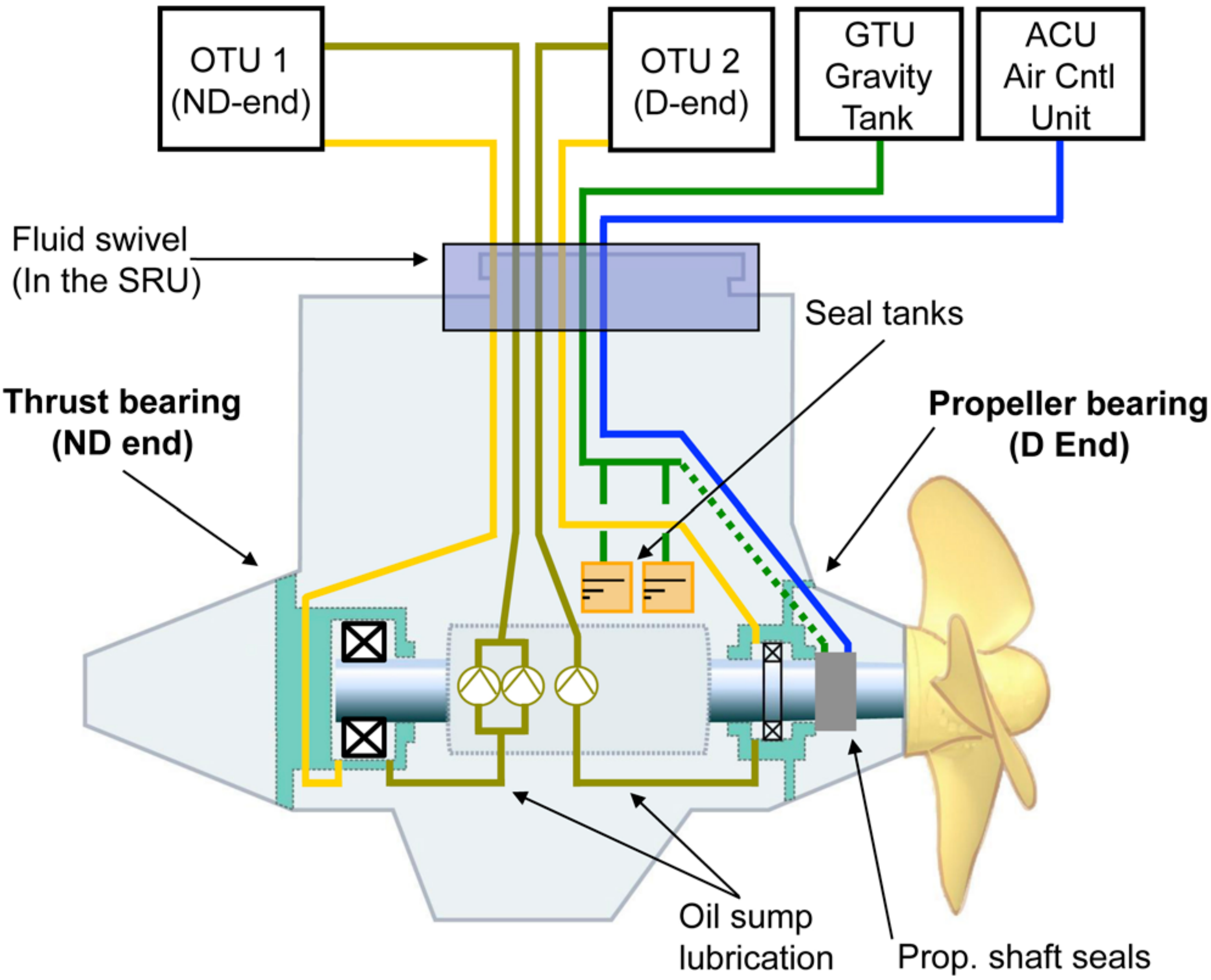


Figure 4-12 Overview of the shaft line arrangement

The Azipod shaft seal subsystem consists of the seals for propeller shaft line, thrust bearing and propeller bearing. Seal oil tanks, the Gravity Tank (GTU) and the Air Control Unit (ACU) are included in the shaft seal subsystem as well.

A hydraulic disc brake is provided for holding the propeller shaft during maintenance. The brake is connected manually and activated from the HPU. The holding capacity depends on the propeller design. The maximum allowed water speed of the ship while braking the shaft depends on the design of the propeller. The brake cannot be used (generally) in ice operation.

4.8 Drainage functionalities

The Azipod Propulsion Module has a built-in drainage subsystem for the drainage of the shaft lube oils and for draining eventual oil or water leakages from the Propulsion Module.

Two drainage pumps are located at the lowest practical point of the Azipod Propulsion Module. One of the pumps is fitted to drain a discharge tank provided at the bottom of the pod. The other pump is fitted to drain directly from the bottom of the Propulsion Module itself. The pumps are connected via one-way valves to a discharge line, which is led through the fluid swivel to the Azipod room and into the ship's discharge system. The power supply for the pumps is to be arranged from the ship's emergency switch-board. Status information from level switches inside the pod is led via the AIU into the ship's machinery automation system (MAS).

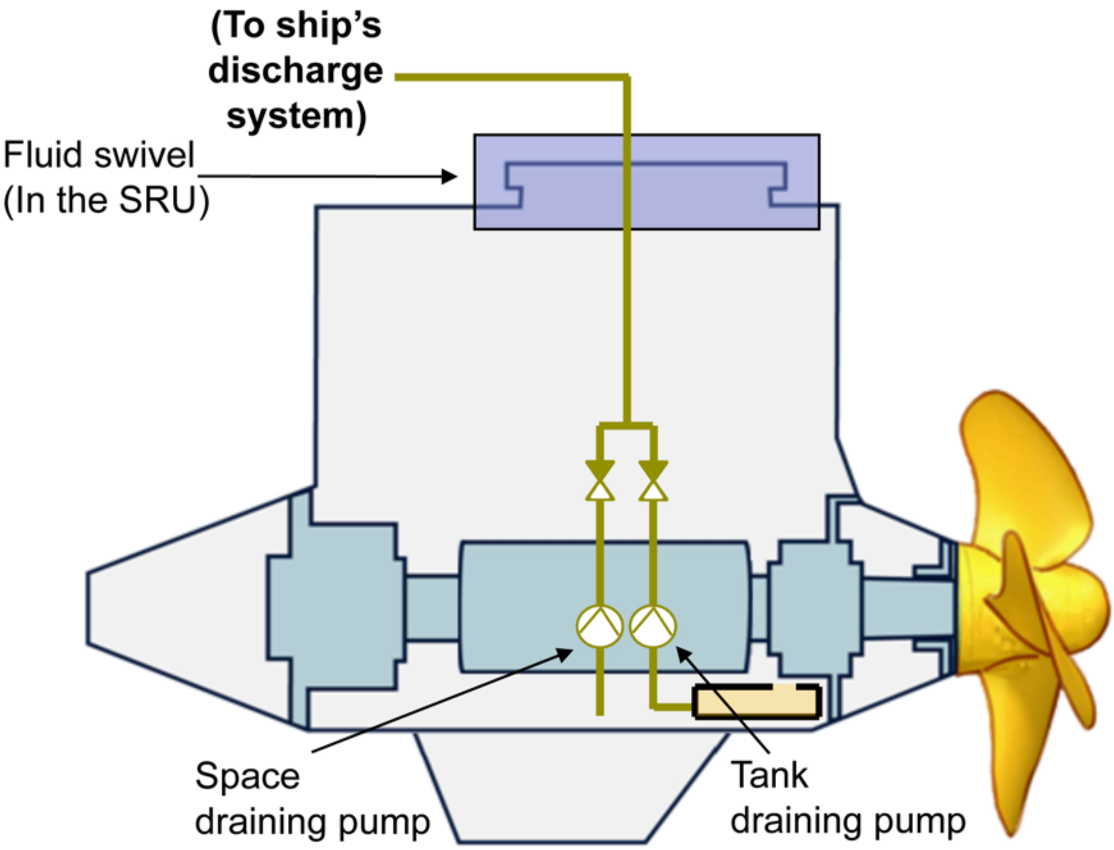


Figure 4-13 Drainage arrangement

5 Ambient reference conditions

5.1 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°
- 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.

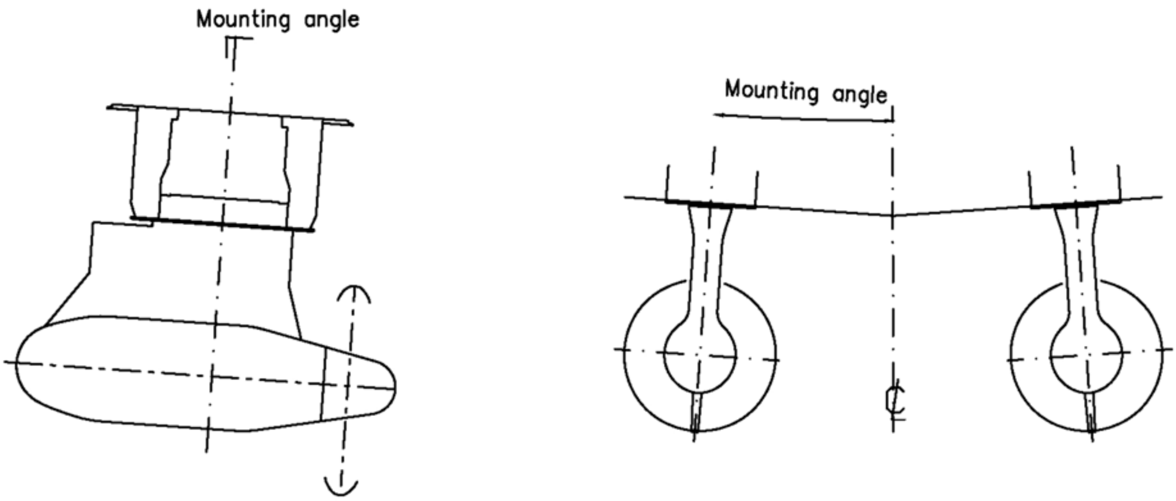


Figure 5-1 Mounting angles (longitudinal and lateral)

5.2 Azipod room requirements

- Machinery area rating with sufficient air conditioning
- Rated normal ambient temperature +2 …+ 45°C,
- Ambient relative humidity No condensation allowed on any parts

6 Ship system interface

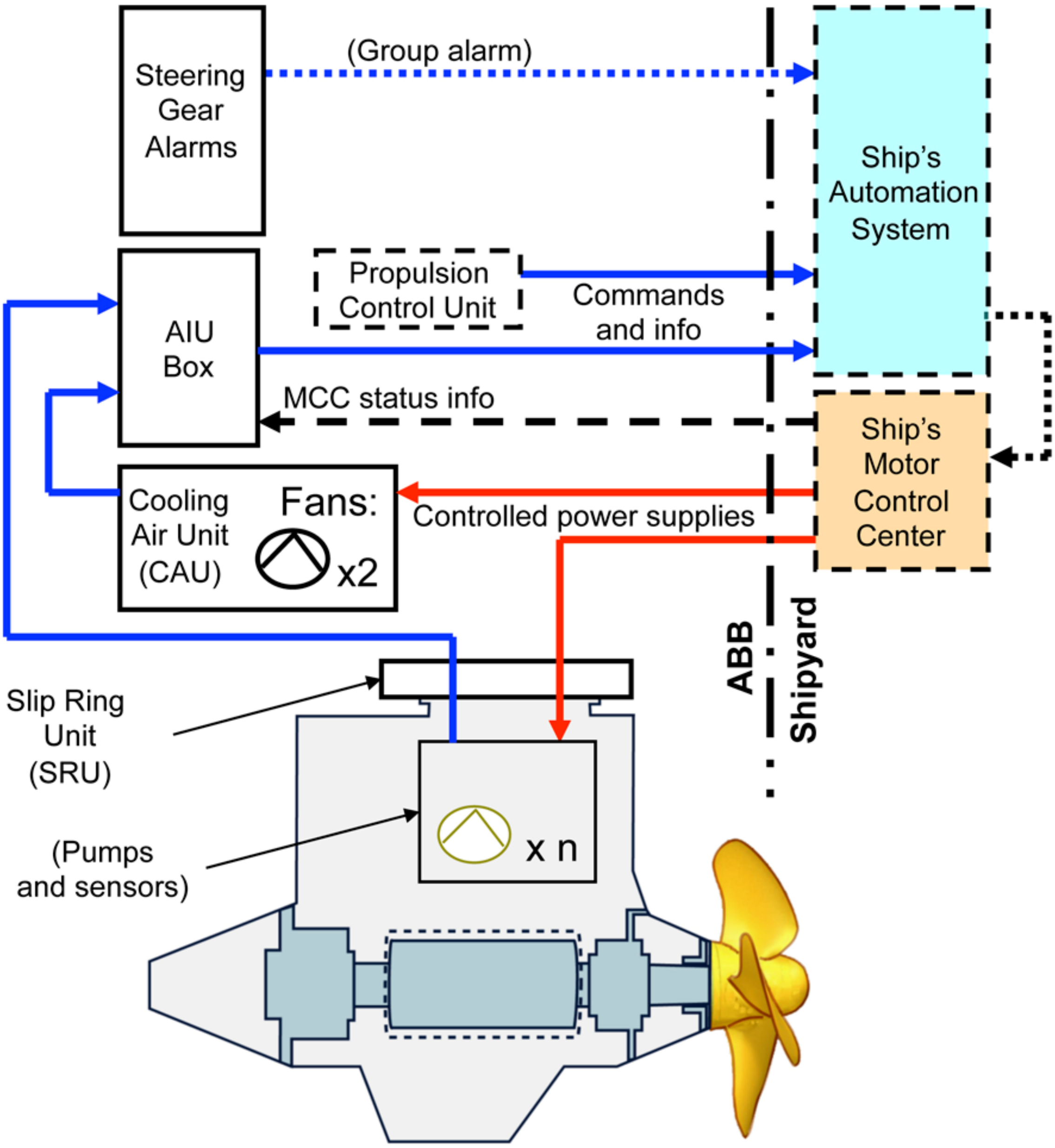


Figure 6-1 Typical interface with the ship's systems

6.1 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. 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.

6.2 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.

7 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. The manual 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.

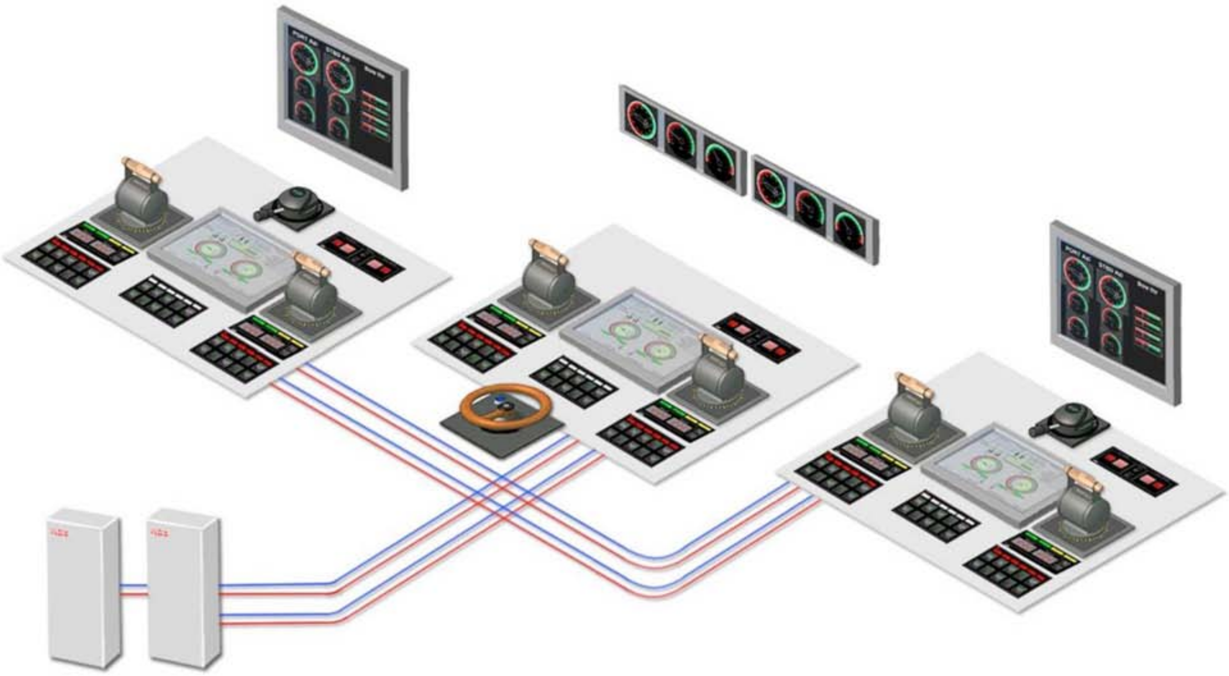


Figure 7-1 Typical remote control outfit

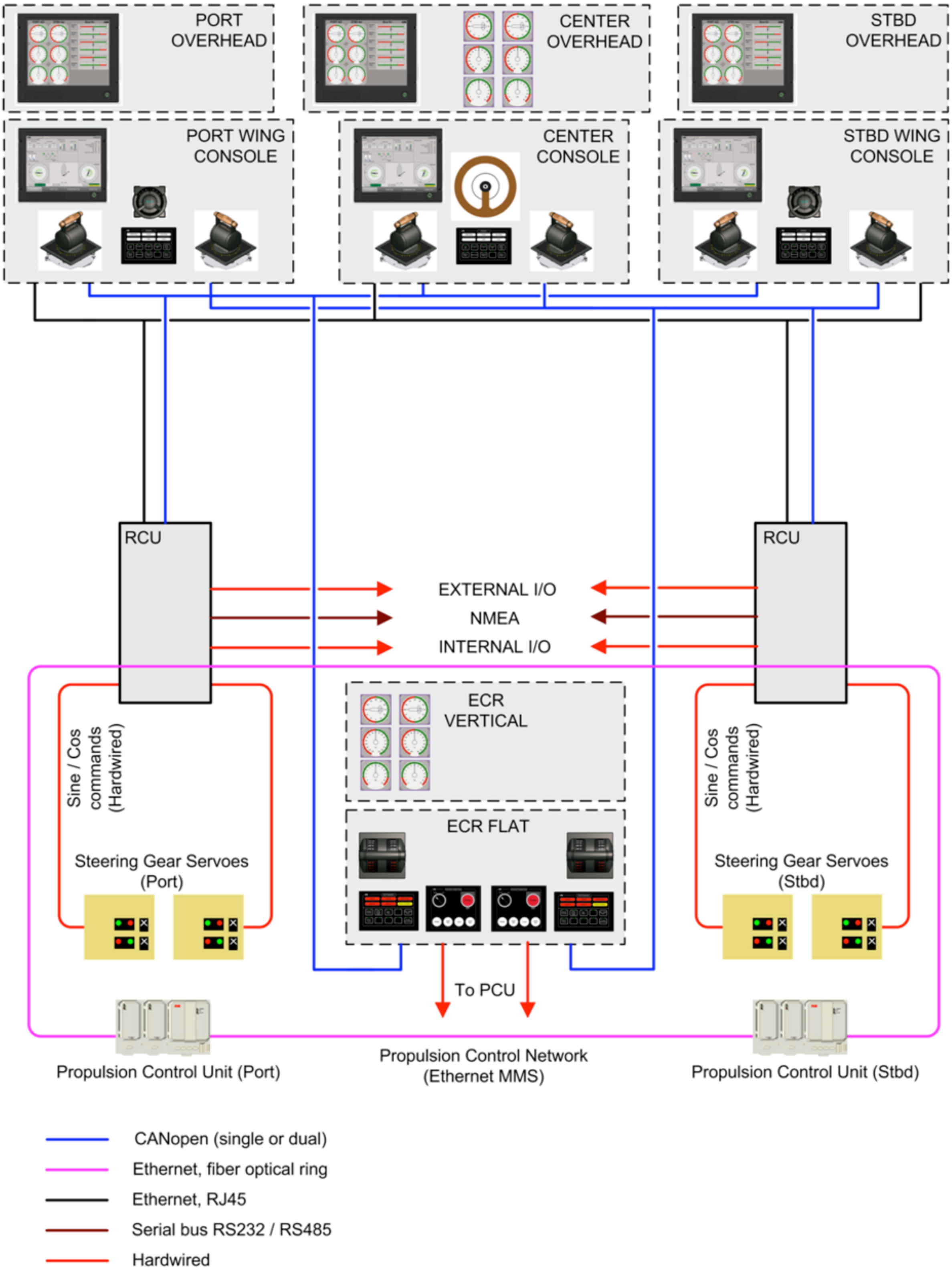


Figure 7-2 Typical example of remote control architecture

8 Ship design

The following paragraphs describe the usual shipyard design process with Azipod:
Reference is also made to chapter 2.

8.1 Design flow

A. After defining the basic ship layout, the Azipod Propulsion Module is chosen based generally on the thrust or propeller torque requirements.

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.

8.2 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 interfacer (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).

8.3 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

8.4 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.

8.5 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.

8.6 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 to be connected to ship’s hull by the Steering Module. The Steering Module is to be welded to the ship’s hull as a structural member.

8.7 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 8-1
"Ahead sailing" concept:
(steering to Starboard)

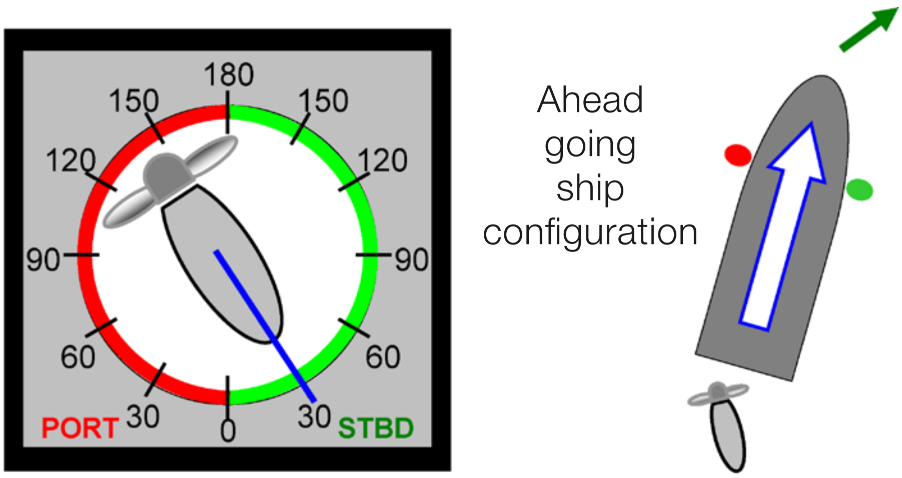
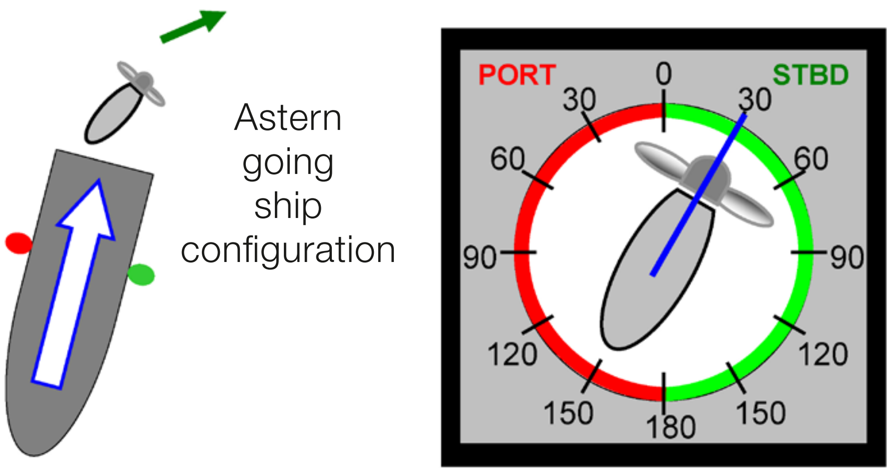


Figure 8-2
"Astern sailing" concept
(steering to Starboard)



9 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.

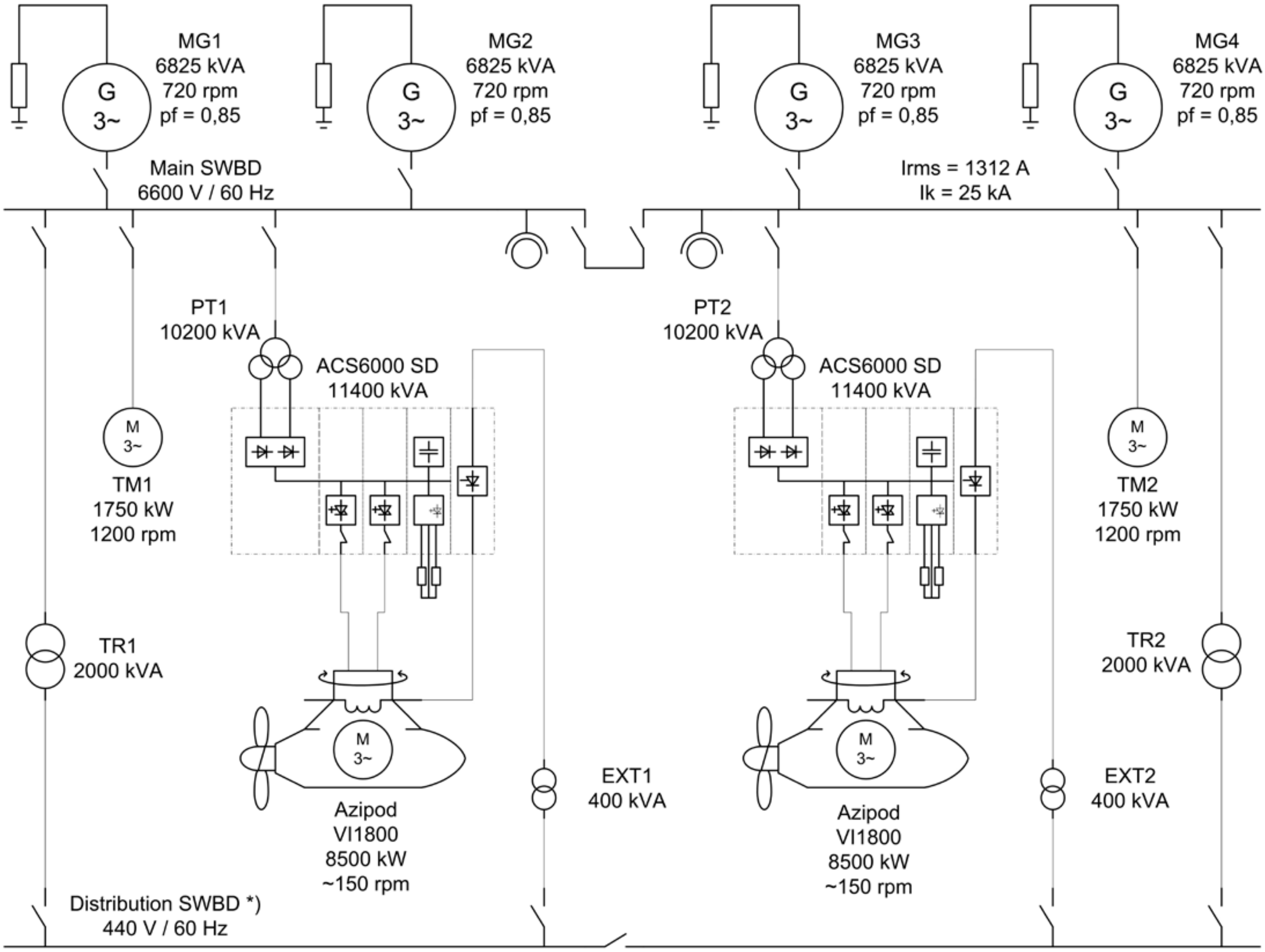


Figure 9-1 Typical single line diagram of the onboard power plant

10 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 (bare 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,ice breaking, etc.)	

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